# Black Square

# CARAVAN PROFESSIONAL

## OPERATIONS MANUAL

For Microsoft Flight Simulator

Published By:

Just Flight

Black Square

*"Virtual Aircraft. Real Engineering."*

# Caravan Professional User Guide

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

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# Introduction

The 208B Caravan is one of the most capable, multifunction, utility aircraft in the skies, available in configurations for executive transport, passenger airline service, cargo operations, and even amphibious options. The Caravan's high ground clearance and robust fixed gear makes it ideal for flight into unimproved airports, and a great asset to developing parts of the world. One of the most popular single engine turboprop aircraft on the market, the Caravan has enjoyed many upgrades and expansions over the years.

Black Square's Caravan Professional brings you one of the most technically advanced aircraft simulations for Microsoft Flight Simulator, with 100+ possible failures, 12 hot-swappable radio configurations, Black Square's turbine engine simulation with beta range implementation, and the most advanced cabin temperature simulations in MSFS. 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 3D gauges are affected by physics, and can even become stuck without engine vibration, requiring a tap on the glass to free them. Radionavigation systems are available from several eras of the C208's history. Fly without GPS via a Bendix KNS-80 RNAV system, or with the convenience of a Garmin GTN 750/650 (PMS50 or TDS). Other radio equipment includes KX-155 radios, KLN-90B, GNS 530/430, KFC 150 Autopilot, and an RDR1150XL Weather Radar. A 145+ page manual provides instruction on all equipment, and 42 in-game checklists with control highlighting are included for normal and emergency procedures. **These two products include four airframes**: The passenger Grand Caravan with and without cargopod, the Caravan Amphibian with floats and retractable landing gear, and the Super Cargomaster, all with a 675 shaft-horsepower PT6A-114A engine, and an improved de-icing system.

**Analog Caravan Owners:** While the panel of the Caravan Professional might look familiar, almost all other aspects of the aircraft have been rebuilt with Black Square's current technology and high standards of quality. The major additions include a **custom exterior model**, **custom sound package** from Boris Audio Works, **higher quality materials** with modifications for each model of aircraft, **fine tuned performance tables**, **tablet visualizers** with all the systems required to drive them, **more avionics options**, and the turbine **engine simulation that debuted with the Turbine Duke and TBM 850**, and has been improving ever since. This expansion of the Analog Caravan represents 1,000+ hours of dedication, and roughly a doubling of the aircraft's code complexity. Once you experience Black Square's latest technology in your favorite C208, the difference will be clear!

Primarily analog instrumentation augmented with modern avionics is still the most common aircraft panel configuration in the world. Challenge your piloting skills by flying IFR to minimums with a fully analog panel, and no GPS. You'll be amazed at the level of skill and proficiency you can achieve to conquer such adversity, and how it will translate to all your other flying.

**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](http://www.JustFlight.com).**

## What's new since the Analog Caravan?

**Every feature listed below with *NEW* or *IMPROVED* has been added or significantly improved since the Analog Caravan was released, but there is even more to discover!**

## Feature Overview

- **IMPROVED 145+ page manual** with your complete guide to flying the Black Square Caravan Professional, including systems guide, tutorials, operating limitations, performance tables, and electrical schematics
- **NEW Tablet Interface** for configuring options, payload settings, failure management, and real time visualizers for engines, electrical schematics, and environmental systems.
- **NEW 12 hot-swappable radios**, configurable via tablet interface. Incl. PMS & TDS
- **IMPROVED 100+ Random, scheduled, or performance triggered failures**, settable via the tablet, including engine damage, compatible with 3rd party UI's and instructor stations.
- **IMPROVED Fully simulated environmental control** 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.
- **Completely simulated electrical system**, with 80+ circuit breakers and failures.
- **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.
- **NEW Turbine engine failures**, such as compressor stall and surging, fuel control failure, fuel filter clogs, propeller governors, and fire detection system.
- **NEW FOD damage based on surface type.** Use the inertial separator 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 & Starship
- **NEW KLN-90B vintage GPS.** Download from https://github.com/falcon71/kln90b/releases
- **IMPROVED KNS-80 RNAV now supports autopilot coupling** with No-GPS configuration.
- **NEW Gyroscope physics simulation** for electric and pneumatic gyroscopes with precession, and partial failures, based on a coupled quadrature oscillator.
- **NEW Magnetic compass effects**, including fields from onboard circuits.
- **NEW Functional exterior elements (Interactive in MSFS2024) & control locks**: chocks, pitot covers, engine covers, rudder lock, and ground power cart. Pitot flags blow in the wind.
- **NEW Performance tables** reflect fine tuned aerodynamic and engine cruise performance.

- **NEW Fuel imbalance** and inadvertent crossfeeding based on terrain and acceleration**.**
- **NEW Voltage-based light dimming,** an immediately recognizable effect to nighttime pilots.
- **NEW Strobe light system** causes realistic distracting flashes in clouds.
- **Mathematically accurate VOR & ADF signal attenuation and noise degradation.**
- **Physics based instrument needles** bounce and respond to aerodynamic forces.
- Improper engine management will slowly **damage engines to failure**.
- 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 430 checklist items are provided for 42+ 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 Caravan Professional features a custom soundset created by Boris Audio Works, and 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

The Caravan Professional features a flight model with performance to match the real world aircraft based on real Caravan pilot feedback and in-flight data. 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 2020 & 2024, such as the new voxel CFD aerodynamics, CFD propeller, adverse yaw & stall parameters, and flexible tire physics. Engine damage produces a rough running engine and decreased performance.

## Paint Schemes

The Black Square Caravan Professional comes with twelve paint schemes across all variants. The Caravan Professional also comes with five interior upholstery packages. 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.

## Aircraft Specifications

| | |
|---|---|
| Length Overall | 41’7” (Gear) 42’4” (Floats) |
| Height | 15'6" (Gear) 17’9” (Floats) |
| Wheel Base | 13’4" (Gear) 15’5” (Floats) |
| Track Width | 11’8" (Gear) 10’8” (Floats) |
| Wingspan | 52'1” |
| Wing Area | 279.4 sqft. |
| Flight Load Factors | +3.8/-1.52 G’s (+2.4 G’s with Flaps Down) |
| Design Load Factor | 150% |
| Cabin W/L/H | 64” x 21’4" x 54" |
| Oil Capacity | 14 U.S. Quarts |
| Seating | 10-14 |
| Wing Loading | 31.3 lbs/sqft |
| Power Loading | 13.0 lbs/shp |
| Engine | 675 SHP (496 kW) Pratt & Whitney PT6A-114A |
| Propeller | 3-Blade McCauley, Constant Speed, Full-Feathering, Reversible, Aluminum, Hydraulically Actuated, 106 inch propeller. Feathered blade angle of 88°, Low pitch blade angle of 15.6°, and maximum reverse blade angle of -15°. |
| Approved Fuel Grades | JET A (ASTM-D1666)<br>JET A-1 (ASTM-D1666)<br>JET B (ASTM-D1666)<br>JP-1 (MIL-L-5616)<br>JP-4 (MIL-T-5624)<br>JP-5 (MIL-T-5624)<br>JP-8 (MIL-T-83133 A) |
| Fuel Capacity | Total Capacity: 335.6 U.S. Gallons<br>Total Capacity Each Tank: 167.8 U.S. Gallons<br>Total Usable: 332.0 U.S. Gallons |
| Electrical System | |
| Voltage: | 28 VDC |
| Battery: | 24V, 42 amp-hour, sealed lead acid battery |
| Starter-Generator: | 28V, 200 amp |
| Standby Alternator: | 28V, 75 amp, automatic operation when engaged |

## Aircraft Performance (Without Cargo Pod)

| | |
|---|---|
| Maximum Cruising Speed | 184 ktas |
| Normal Cruising Speed | 182 ktas |
| Economy Cruising Speed | 155 ktas |
| Takeoff Distance | 2,420 ft |
| Takeoff Ground Roll | 1,365 ft |
| Landing Distance | 1,795 ft |
| Landing Ground Roll | 950 ft |
| Normal Range | 907 nm |
| Maximum Range | 1,182 nm |
| Rate of Climb | 975 ft/min |
| Service Ceiling | 23,700 ft |
| Empty Weight | 4,071 lbs |
| Max Ramp Weight | 8,785 lbs |
| Max Takeoff Weight | 8,750 lbs |
| Max Landing Weight | 8,500 lbs |
| Useful Load | 4,714 lbs |
| Usable Fuel Weight | 2,224 lbs |
| Full Fuel Payload | 2,490 lbs |
| Maximum Operating Temp. | +53°C |
| Minimum Operating Temp. | -54°C |

## Aircraft Performance (Cargo Pod Installed)

| | |
|---|---|
| Maximum Cruising Speed | 174 ktas |
| Normal Cruising Speed | 172 ktas |
| Economy Cruising Speed | 149 ktas |
| Takeoff Distance | 2,500 ft |
| Takeoff Ground Roll | 1,405 ft |
| Landing Distance | 1,740 ft |
| Landing Ground Roll | 915 ft |
| Normal Range | 862 nm |
| Maximum Range | 1,081 nm |
| Rate of Climb | 925 ft/min |
| Service Ceiling | 22,800 ft |
| Empty Weight | 4,237 lbs |
| Max Ramp Weight | 8,785 lbs |
| Max Takeoff Weight | 8,750 lbs |
| Max Landing Weight | 8,500 lbs |
| Useful Load | 4,548 lbs |
| Usable Fuel Weight | 2,224 lbs |
| Full Fuel Payload | 2,324 lbs |
| Maximum Operating Temp. | +53°C |
| Minimum Operating Temp. | -54°C |

## Aircraft Performance (Cargomaster)

| | |
|---|---|
| Maximum Cruising Speed | 174 ktas |
| Normal Cruising Speed | 172 ktas |
| Economy Cruising Speed | 149 ktas |
| Takeoff Distance | 2,500 ft |
| Takeoff Ground Roll | 1,405 ft |
| Landing Distance | 1,740 ft |
| Landing Ground Roll | 915 ft |
| Normal Range | 862 nm |
| Maximum Range | 1,081 nm |
| Rate of Climb | 925 ft/min |
| Service Ceiling | 22,800 ft |
| Empty Weight | 3,925 lbs |
| Max Ramp Weight | 8,785 lbs |
| Max Takeoff Weight | 8,750 lbs |
| Max Landing Weight | 8,500 lbs |
| Useful Load | 4,860 lbs |
| Usable Fuel Weight | 2,224 lbs |
| Full Fuel Payload | 2,636 lbs |
| Maximum Operating Temp. | +53°C |
| Minimum Operating Temp. | -54°C |

## Aircraft Performance (Amphibian)

| | |
|---|---|
| Maximum Cruising Speed | 164 ktas |
| Normal Cruising Speed | 162 ktas |
| Economy Cruising Speed | 138 ktas |
| Takeoff Distance | 3,027 ft (Land) 4,082 ft (Water) |
| Takeoff Ground Roll | 1,810 ft (Land) 1,982 ft (Water) |
| Landing Distance | 1,426 ft (Land) 1,208 ft (Water) |
| Landing Ground Roll | 777 ft (Land) 598 ft (Water) |
| Normal Range | 732 nm |
| Maximum Range | 1,001 nm |
| Rate of Climb | 751 ft/min |
| Service Ceiling | 20,000 ft |
| Empty Weight | 5,379 lbs |
| Max Ramp Weight | 9,062 lbs |
| Max Takeoff Weight | 9,062 lbs |
| Max Landing Weight | 9,062 lbs |
| Useful Load | 3,683 lbs |
| Usable Fuel Weight | 2,224 lbs |
| Full Fuel Payload | 1,459 lbs |
| Maximum Operating Temp. | +53°C |
| Minimum Operating Temp. | -54°C |

## V-Speeds

| | | |
|---|---|---|
| Vr | 65 kts | (Rotation Speed) |
| Vs | 63 kts | (Clean Stalling Speed) |
| Vso | 50 kts | (Dirty Stalling Speed) |
| Vx | 72 kts | (Best Angle of Climb Speed) |
| Vy | 104 kts | (Best Rate of Climb Speed) |
| Va | 148 kts | (Maneuvering Speed) |
| Vg | 97 kts | (Best Glide Speed) |
| Vfo | 125 kts | (Maximum Flap Operating Speed) |
| Vne | 175 kts | (Do Not Exceed Speed) |

## Engine Limitations

| | |
|---|---|
| Maximum ITT: | 805°C (T/O) 765°C (Climb) 740°C (Cruise) 1090°C (Starting) |
| Maximum Torque: | 1,865 ft-lbs (T/O) 1,970 ft-lbs (Climb) 2,400 ft-lbs (Transient) |
| Maximum Gas Gen RPM: | 101.6% (Continuous) 102.6% (Transient) |
| Maximum Propeller RPM: | 1,900 (Continuous) 1,825 (Reverse) 2,090 (Transient) |
| Oil Pressure: | 85-105 PSI (Continuous) 40 PSI min. (Idle) |
| Oil Temperature: | 0-99°C (Continuous) -40-99°C (Idle) 104°C (Transient) |

- For every 10°C below -30°C ambient temperature, reduce maximum allowable Ng by 2.2%.
- Reverse thrust operation limited to durations of one minute.
- Normal oil pressure is 85-105 PSI above 72% Ng with oil temperature 60-70°C.
- Oil pressures below 85 PSI are undesirable, and should only be tolerated to complete a flight, preferably at reduced power settings.
- When ITT exceeds 765°C, time at this power setting should be limited to 5 minutes.

## Starter Limitations

Using Airplane Battery:

30 seconds ON - 60 seconds OFF
30 seconds ON - 60 seconds OFF
30 seconds ON - 30 **minutes** OFF

Using External Power:

20 seconds ON - 120 seconds OFF
20 seconds ON - 120 seconds OFF
20 seconds ON - 60 **minutes** OFF

# Instrumentation/Equipment List

## Main Panel

- Annunciator Panel
- True Airspeed Indicator
- Bendix/King KI 256 Vacuum Artificial Horizon
- Bendix/King KEA 130A Altimeter
- Bendix/King KI 229 Radio Magnetic Indicator (RMI)
- Bendix/King KI 525A Horizontal Situation Indicator (HSI)
- Vertical Speed Indicator
- Bendix/King KI 206 Localizer
- Mid-Continent Turn Coordinator
- Bendix/King KRA-10A Radar Altimeter
- Engine Instrumentation
- Duplicate Copilot Instrumentation

## Avionics

- Garmin GMA 340 Audio Panel
- Garmin GTN 750/650 (Com1/Com2)
- Garmin GNS 530/430 (Com1/Com2)
- Bendix/King KLN-90B
- Mid-Continent MD41-328 GPS Annunciator Control Unit
- Bendix/King KX-155B (Com1/Com2)
- Bendix/King KNS-80 RNAV Navigation System (incl. Nav3)
- Bendix/King KR 87 (ADF)
- Bendix/King KDI 572 (DME)
- Bendix/King KAP 140 Autopilot
- Bendix RDR1150XL Color Weather Radar
- Garmin GTX 327 Transponder

## Electrical/Miscellaneous

- 80+ Circuit Breakers
- Multi-Function Volt/Amp Meter
- Bendix/King KA 51B Remote Compass Synchroscope
- Propeller Amps Indicator
- Vacuum Indicator
- Oxygen Pressure Gauge
- Quartz Analog Chronometer
- Hobbs Timer

# 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.

**NOTE: THE FOLLOWING DOWNLOADS ARE OPTIONAL**, and not required to enjoy the base functionality of this Black Square aircraft; however, they are highly recommended for the most immersive experience possible.

## Installing the PMS GTN 750/650

**NOTE: No additional packages should be required from PMS to enable all WTT-Mode features in this aircraft.** WTT-Mode is included natively in this aircraft. Only the basic download described below is required, assuming you do not already have it installed.

1. Go to the following link, and click download for the **FREE GTN 750 Mod.**
   https://pms50.com/msfs/downloads/gtn750-basic/
2. Move the “pms50-instrument-gtn750” archive (zipped folder) from your browser’s download location (downloads folder by default) to your desktop, and extract (unzip) the archive by right clicking, and selecting “Extract All”.
3. Drag the resulting “pms50-instrument-gtn750” folder into your Microsoft Flight Simulator Community Folder.

   If you don’t know how to locate your MSFS Community Folder, you should be able to find it in one of the following locations, based on the service you used to purchase the simulator.

   **For the Windows Store install:**

   C:\Users\[YourUserName]\AppData\Local\Packages\Microsoft.FlightSimulator_8wekyb3d8bbwe\LocalCache\Packages\

**For the Steam install:**

C:\Users\[YourUserName]\AppData\Local\Packages\Microsoft.FlightDashboard_8wekyb3d8bbwe\LocalCache\Packages\

**Important: Windows 10 by default hides the "AppData" folder, so you will have to go to "View" in the menu of File Explorer, and select "Hidden items" so as to see it.**

**For the Custom install:**

If you used a custom location for your Flight Simulator installation, then proceed there.

For example, you may have set:
E:\Steam\steamapps\common\MicrosoftFlightSimulator\Community

## Installing The Working Title GNS 530/430

No additional downloads are required for the Working Title GNS 530/430 and all previous modifications should be removed from your community folder.  Some older aircraft may still require a "link" to the new GPS, which can be downloaded from the in-game marketplace for free.  This package is not required for the Black Square Caravan Professional, or any subsequently updated Black Square aircraft.

## TDS GTNxi 750/650 Integration

To switch between PMS and TDS products, toggle the PMS/TDS switch in the avionics selection section of the tablet interface's options page.  For more information on radio hot-swapping and selecting an avionics package, see the "Options Page" section of this manual.  If a new TDS installation is detected, the TDS will be automatically selected next time you load the aircraft for your convenience.  Your avionics selection, including your preferred GTN 750 product, will be saved for your next flight.

The TDS GTNxi is available from: **https://www.tdssim.com/tdsgtnxi**

LIMITATIONS:

MSFS native GPS units and native flight planners will not cross-fill from the GTNxi.  This could also be seen as an advantage, allowing simultaneous flight plan loading.

NOTE:  These are limitations of MSFS and not this aircraft, nor the TDS GTNxi.  If and when these issues are resolved, a coordinated effort from the developers of these products will be launched to remove these limitations as soon as possible.

## Installing The Falcon71 KLN-90B

1. Go to the following link, and click download for the **FREE KLN-90B Mod.**
   **https://github.com/falcon71/kln90b/releases**
2. Move the “falcon71-kln90b-vX.XX” archive (zipped folder) from your browser’s download location (downloads folder by default) to your desktop, and extract (unzip) the archive by right clicking, and selecting “Extract All”.
3. Drag the resulting “falcon71-kln90b” folder into your Microsoft Flight Simulator Community Folder.

   If you don’t know how to locate your MSFS Community Folder, follow the instructions in the “Installing the PMS GTN 750/650” section of this manual, above.

## 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 ‘Caravan Professional’ series 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.

## Regular News

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

We can assure you that none of your details will ever be sold or passed on to any third party and you can, of course, unsubscribe from this service at any time.

You can also keep up to date with Just Flight via Facebook and Twitter.

# 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

### Annunciator Panel

The Caravan's annunciator panel can be tested by two buttons adjacent and to the left of the panel, labeled "Fire Detect Test", and "Lamp Test". Press and hold the buttons to confirm all 24 colored annunciators illuminate in the panel. Also adjacent to the annunciator panel is the night dimming switch, which dims the annunciator panel. It also dims several other groups of annunciators within the main instrument panel.


Below the engine instrumentation and to the right of the altimeter is also an autopilot specific annunciator panel, which indicates active autopilot modes in a different format than on the KAP 140 autopilot itself, which is sometimes preferential for quick reference. This panel includes a red back-course indicator, and a red out-of-trim indicator, which illuminates when the aircraft's pitch is more than ten degrees away from the autopilot command pitch.

# True Airspeed Indicator

The Caravan's airspeed indicator displays both knots (outer scale), and miles per hour (inner scale), as well as reference speeds with colored arcs.  The red marking corresponds to the never-exceed speed.  The lower end of the green arc corresponds to the clean configuration stalling speed.  The upper end of the white arc corresponds to the maximum flap operating speed, and the lower end of the white arc corresponds to the full flap stalling speed.  The airspeed indicator also includes a true airspeed calculating ring, which can be positioned for pressure altitude and air temperature, much like an E6B flight computer, and produce a rough true airspeed indicator at the airspeed needle.


NOTE:  This is the first Black Square aircraft to implement an accurate calculation of calibrated airspeed (CAS).  In other aircraft, MSFS assumes the airspeed to be "ideal", suffering no effects from the airflow around the airframe, or the design of the pitot system.  For most aircraft, this effect is negligible, but for the Caravan, it can produce an apparent difference of up to 15 knots. For this reason, the airspeed indicator in the cockpit may not always match the airspeed displayed in the simulator's HUD. For more information, and an expanded discussion of CAS, see the "Why does the HUD airspeed not match the cockpit instrument?" question of the FAQ at the end of this manual.

## Bendix/King KI 256 Vacuum Artificial Horizon

A vacuum powered artificial horizon with illuminated decision height indicator, and adjustable attitude bars resides at the center of the panel.  Attitude bars can be adjusted with the small screw adjustment on the bottom right of the unit's face.  Note that while the KI256 is capable of displaying flight director command bars, the KAP 140 autopilot is not capable of driving them.


NOTE:  This attitude indicator is equipped with Black Square's highly accurate gyroscope dynamics simulation.  Users can experience the multitude of gyroscope dynamics and failures inherent to the operation of these instruments.  The partial or complete failure of gyroscopic instruments can surprise pilots and result in catastrophic loss of spatial awareness.  For more information on Black Square's gyroscope simulation, see the "Gyroscope Physics Simulation" section of this manual.

## Bendix/King KEA 130A Altimeter

The KEA 130A is a three pointer, precision, encoding altimeter, certified for flight up to 25,000 feet pressure altitude.  The Kholsman setting is adjusted via the knob in the bottom left corner of the unit.  Currently set barometric pressure is displayed in the Kholsman window on the right of the unit in inHg, and in the Kholsman window on the left of the unit in Millibars.

## Bendix/King KI 229 Radio Magnetic Indicator (RMI)

This RMI has an automatically rotating compass card that is driven via the aircraft's remote compass, and therefore, has no adjustment knob like an ADF.  The solid yellow needle of the RMI is permanently driven by the NAV1 VOR navigation source, the same as the HSI source. The hollow green needle of the RMI is permanently driven by the KR 87 ADF receiver.  Both needles will point directly to the tuned radio ground station whenever signal strength is sufficient.  Since there are no flags on this unit to indicate reception, it is necessary to properly identify the station via its morse code identifier before using the RMI indications as a source of navigation.  The needles will both point towards the 3 o'clock position when the unit is not receiving power, or the unit is not receiving signal from the remote compass.

## Bendix/King KI 525A Horizontal Situation Indicator (HSI)

The KI 525A HSI has an automatically controlled compass card, as opposed to most directional gyroscopic compass units, which can be automatically slaved to magnetic heading, or manually controlled via the remote compass controller.  The HSI has two knobs for controlling the heading bug for visual reference, and for autopilot heading lateral navigation mode, and a knob for adjusting the course indicated with the yellow needle in the center of the display.  The split yellow needle acts as a course deviation indicator, where the deviation scale depends on the navigation source, and operational mode, such as enroute GPS, or ILS antenna signal.  On either side of the unit are normally hidden, yellow, glideslope indicator needles, which come into view when the glideslope signal is valid.  Under the yellow course indicating needle, two windows with white indicators show the traditional to/from VOR indication when a VOR radio source is selected.  When no navigation source has a valid signal, a red “NAV” flag appears at the top of the display.  When no valid signal is received from the remote compass, a red “HDG” flag appears at the top of the display.  When the unit is not receiving power, both flags are visible.  The HSI in this aircraft can be controlled by either the NAV1 source, or the RNAV source, by selecting with the switch located above the localizer.

NOTE:  The autopilot will only use the KNS-80 as a navigation source when the no-GPS avionics configuration is selected from the tablet interface.  Press the navigation source button to illuminate its “RNAV” annunciator.  Use the toggle switch above the localizer to select “RNAV” as the HSI source.

## Vertical Speed Indicator

A vertical speed indicator displaying a maximum of +/- 4,000 feet per minute.  This instrument will display slipstreaming effects from the turbulent propeller wash passing over the static ports on the rear of the aircraft.

# Bendix/King KI 206 Localizer

The KI 206 Localizer acts as a secondary radionavigation source in this aircraft, being permanently driven by the NAV2 VOR radio source.  The KI 206 includes both lateral and vertical guidance needles, which can be driven from either a VOR/ILS receiver, or via the GNS 430W or GTN 650.  The unit incorporates both vertical “GS”, and horizontal “NAV” red flags to indicate when the unit has power, and when the respective navigation source is being received.  Two windows with white indicators show the traditional to/from VOR indication when a VOR radio source is selected.  This unit is not connected to the remote compass, and therefore, must be manually adjusted for the desired course with the omni-bearing-selector (OBS) knob on the unit’s face.

## Mid-Continent Turn Coordinator

A DC electric turn coordinator with indicator markings for a standard rate 2-minute turn, a traditional slip indicator, and a red power flag to indicate when the unit is not receiving power.

## Bendix/King KRA-10 Radar Altimeter

The KRA-10 Radar Altimeter displays the height of the belly-mounted radar transducer with respect to the terrain below the aircraft. The yellow indicating needle rests in a vertical "OFF" position when the unit is not receiving power, a valid signal, or when the indicated altitude is below 10 feet. An orange decision height bug can be positioned from 0 to 2,500 feet on the indicating scale with the adjustment knob. When passing the decision height in a descent, the integrated, yellow, decision height indicator will illuminate, as well as the connected indicator on the KI 256 attitude indicator. Be aware that the indicating scale is non-linear.

## Engine Instrumentation

A row of eight round-dial engine instruments resides at the top of the main instrument panel for monitoring the health of the powerplant. From left to right, the gauges are Propeller Torque (TRQ), Propeller RPM (RPM), Interstage Turbine Temperature (ITT), Gas Generator RPM (Ng), Oil Pressure (PSI), Oil Temperature (°C), Fuel Flow (FF), Left Fuel Tank Quantity (L QTY), and Right Fuel Tank Quantity (R QTY). Some of these instruments are passively driven from the accessory gearbox of the engine, while others are electrically driven; therefore, only some will remain functioning with a total loss of electrical power.


NOTE: This aircraft makes use of custom turbine engine dynamics code. Users should research and anticipate the following potentially novel turbine engine phenomenon:

Torque Bloom: While accelerating on the runway, increased ram air pressure increases combustion efficiency and fuel flow. Caution must be used while setting takeoff power, as torque may rapidly increase beyond the redline while accelerating.

Residual Heat: After shutdown, the engine retains substantial temperature, and cooling via “dry motoring” may be required before starting again.

Increased ITT with Inertial Separator and Bleed Air: Aircraft configuration can have a substantial impact on ITT, which may cause limit exceedances if not managed properly.

## Fuel Instrumentation & Imbalance

The fuel sender units in the Caravan are notoriously sensitive to lateral G-force, and how level the aircraft is resting on the ground. The fuel gauges may present inaccurate readings due to “sloshing” of fuel within the wing tanks; however, the gauges may also indicate a genuine fuel imbalance.

The simplistic fuel system of the Caravan allows fuel to crossfeed by gravity alone when the aircraft is not resting level, or is experiencing lateral acceleration during uncoordinated flight. Any time both fuel selector valves are open, fuel may crossfeed from the fullest/highest wing tank to the emptiest/lowest wing tank until an equilibrium is reached. In the event of severe imbalances, fuel may be lost overboard through the fuel vents if pressures are high enough to circumvent the anti-siphon feature.

Closing the fuel selector valves after shutdown, and waiting until engine start to open them, will prevent inadvertent crossfeeding of fuel. If fuel is allowed to crossfeed while on the ground, repositioning the aircraft to an oppositely sloped section of the airfield may be necessary to restore balance. In flight, closing a single fuel valve can restore balance by consuming fuel from the fullest tank. Given that this aircraft is also capable of random fuel leaks, fuel levels should be checked prior to takeoff, just as in the real aircraft, when any potential discrepancy exists.

## Duplicate Copilot Instrumentation

A duplicate six-pack of primary flight instrumentation is included on the co-pilot's side of the aircraft. Notably, the directional gyroscopic instrument is a traditional DG, and is not driven by the remote compass, and must be adjusted manually at startup, and continually for drift.

## Avionics

Black Square aircraft have reconfigurable radio panels that allow you to fly with many popular radio configurations from old-school no GPS panels, to modern installations with touchscreen GPS navigators.  Unlike previous Black Square aircraft, the radio configuration is selected via the options page of the tablet interface.  The radio selection will be automatically saved and reloaded at the start of a new flight.

**NOTE: For more information on radio hot-swapping and selecting an avionics package through the tablet interface, see the "Options Page" section of this manual.**

### Garmin GMA 340 Audio Panel

This audio controller is very common in light aircraft, and allows for the control of both receiving and transmitting audio sources on one panel.  In addition, this implementation also supports listening to multiple VHF communication sources at once, and transmitting on both Com1 and Com2 by pressing the "COM 1/2" button.  When you want to return to normal operation, press one of the "COM MIC" keys, and the integrated "COM 1/2" button indicator should extinguish.

# Garmin GTN 750/650 (Com1/Com2)

This modern touchscreen GPS is implemented by a 3rd party developer. For installation instructions, and instructions on its use, see the installation section of this manual, or the developer's website. **Both PMS GTN 750/650 and TDS GTNxi 750/650 products are supported.** The aircraft will automatically switch between the installed software with no required user action.



PMS50 GTN 750/650 TDS GTNxi 750/650

**NOTE: To switch between PMS and TDS products while the aircraft is loaded, toggle the PMS/TDS switch in the avionics selection section of the tablet interface's options page. For more information on radio hot-swapping and selecting an avionics package through the tablet interface, see the "Options Page" section of this manual.**

## Garmin GNS 530/430 (Com1/Com2)

This 2000's era full-color GPS is mostly or partially implemented by a 3rd party developer. For installation instructions, and instructions on its use, see the installation section of this manual, or the developer's website.


NOTE: To hear an audible radio station identifier, both the small adjustment knob on the GNS must be pressed, and the appropriate NAV receiver switch must be activated on the integrated audio control panel.

## Bendix/King KLN-90B

This 1990's era monochrome GPS with limited graphical mapping ability comprises a highly capable GPS unit with many features that are found in modern GPS units for pilots willing to learn the subtleties of the system. This GPS is implemented by a 3rd party developer. For installation instructions, and instructions on its use, see the installation section of this manual, or the developer's website.


NOTE: This GPS does not have integrated COM or NAV radios, and therefore must be used in conjunction with a KX-155 as COM/NAV1.

## Mid-Continent MD41-328 GPS Annunciator Control Unit

The GPS Annunciator Control Unit is included to enable the full functionality of the KLN-90B, but retains limited functionality with other GPS units. The NAV/GPS button may be used to control the HSI and autopilot course signal with any GPS unit. The GPS/APR button is used specifically for arming the KLN-90B's approach mode. The OBS/LEG button may be used to toggle OBS mode for any GPS that has this functionality, but is specifically designed to be used with the KLN-90B. The annunciator lights will depict the present modes of operation for any GPS installed.

## Bendix/King KX-155B (Com1/Com2)

This 1990's era Com/Nav receiver allows you to control audio and navigation source inputs from two independent communication and navigation antennas, the left side controlling the VHF Com radio, and the right controlling the VHF Nav radio. Frequency tuning increments can be toggled by pulling on the inner knob of the COM side (labeled "PULL 25K"). The small adjustment knob on the Com side of the unit controls receiver volume, and can be pulled to toggle between US and European frequency spacing. The smallest tunable increment in US mode is 25 kHz, and the smallest possible increment in European mode is 8.33 kHz. The COM display will show frequencies with three decimal places when in 8.33 kHz mode, and two decimal places in 25 kHz mode. When the inner frequency adjustment knob on the NAV side is pulled, the same frequency adjustment knob will tune the active NAV frequency, and the standby frequency will be flagged with dashes. Additionally, a small "T" symbol will be displayed between the active and standby COM frequencies whenever the radio is transmitting. The small adjustment knob on the Nav side of the unit controls Nav receiver identifier volume, and can be pulled for an audible identifier tone.

NOTE: To hear an audible radio station identifier, both the small, right adjustment knob on the KX155 must be pulled out, and the appropriate NAV receiver indicator light must be illuminated on the GMA 340 Audio panel.


## Bendix/King KNS-80 RNAV Navigation System

See the standalone section of this manual for instructions on using the KNS-80, below. All stored frequencies, radials, and offsets associated with this unit will be automatically saved and recalled at the beginning of a new flight.

NOTE: The autopilot in this aircraft is capable of receiving navigation input from the KNS-80, but will only do so when the no-GPS avionics configuration is selected from the tablet interface. When operating without a GPS, the navigation source selector panel's integrated annunciators will read "NAV/RNAV", instead of "NAV/GPS". For more details, see the "Flying an RNAV Course with the Autopilot" section of this manual.

## Bendix/King KR 87 ADF

The KR 87 ADF receiver allows for standby ADF frequencies to be selected with the dual concentric rotary knobs on the right of the unit. When tuning a frequency, you will be editing the standby frequency, which can be swapped into the active frequency by pressing the “FRQ <->” push button. The two push buttons to the right of the “FRQ <->” button are for controlling the integrated flight timer. The “FLT/ET” push button toggles between the flight duration timer, which is automatically started when power is applied, and the elapsed time timer, which is started, stopped, and reset with the “SET/RST” push button. The “ADF” push button toggles the receiver’s antenna mode between normal operation, and listening to the sense-only antenna (disabling the loop antenna), which makes receiving low signal strength audio-only transmissions easier. The “BFO” push button toggles the unit’s beat frequency oscillator, which is used to listen to low signal strength morse code identifiers. A secondary click the power knob will increment the standby frequency by 0.5 kHz, indicated with a dot to the left of the frequency.


## Bendix/King KDI 572R DME

This implementation of a KDI 572 behaves similarly to any other Distance Measuring Equipment (DME) receiver, displaying a nautical mile distance to the selected and tuned station, the current speed of the aircraft relative to the selected and tuned station, and a time-to-go until over the station. It should be noted that, like all other DME displays, this one is similarly dependent on being within the VOR service volume, and having good line-of-sight reception of the station. It should also be noted that these distances, speeds, and times, are based on slant-range to the station, not distance along the ground, as one would draw on a map. In order to receive DME information on the KDI 572, the station must be tuned in one of the two navigation radios, the station must be equipped with DME transmitting equipment, the station must have adequate signal strength, and the KDI 572 must have the appropriate navigation source selected via the selector knob mounted on its face.

Selecting “HLD” mode will hold the current DME frequency and information on the unit, while allowing the user to change the tuned NAV frequencies on the NAV1 or NAV2 radios. This can be useful for some specific instrument approaches. This unit’s state will be automatically saved and reloaded at the start of the next flight.

## Bendix/King KAP 140 Autopilot

The KAP 140 is a relatively simple autopilot, with standard modes of control. The unit has an autopilot master push button, and can be disabled via the yoke-mounted autopilot disconnect push buttons. The autopilot’s mode selections include (left to right along the row of push buttons), heading hold mode, lateral navigation mode, approach coupling mode, back course mode, and altitude hold mode. When the autopilot is disabled by any means except loss of power, the “AP” annunciator will flash for five seconds, and an audible tone will be heard.

The unit’s display consists of a right section with annunciators, and an altitude pre-selector, which can also be used to display the current barometric setting, and a left section with four annunciator locations for active and armed modes. On the left, active modes will appear in the top row, with lateral modes on the left, and vertical modes on the right. The bottom row will display armed modes for lateral and vertical control underneath their respective active modes. For instance, “ALT” will display in the upper row when an altitude has been captured, and the autopilot is holding that altitude. When a new altitude has been selected, and vertical speed mode has been activated to capture that altitude, “VS” will appear in the top row, and “ALT” in the bottom row to indicate that altitude holding is armed. On the right of the unit, the numerical display will show the currently selected altitude, adjusted with the dual concentric rotary encoder. When in altitude holding mode, this value can also be nudged by 100ft with the “UP” and “DN” buttons. Selecting a new altitude will not cause the aircraft to immediately attempt to capture that altitude. Pressing the “ALT” push button again, however, will activate vertical speed mode, which will automatically arm the altitude capture. The “ARM” push button has become unnecessary with updates to the KAP140 software over the years that incorporate automatically altitude arming. The vertical speed can then be adjusted with the “UP” and “DN” buttons.

NOTE: The KAP140 has its own dedicated electronic altimeter. This means that the aircraft will not climb or descend to match the altitude shown on the primary altimeter. The unit’s dedicated altimeter must be adjusted by pressing the “BARO” push button and selecting the desired barometric setting. Barometric pressure units can be toggled by holding the “BARO” push button for three seconds.

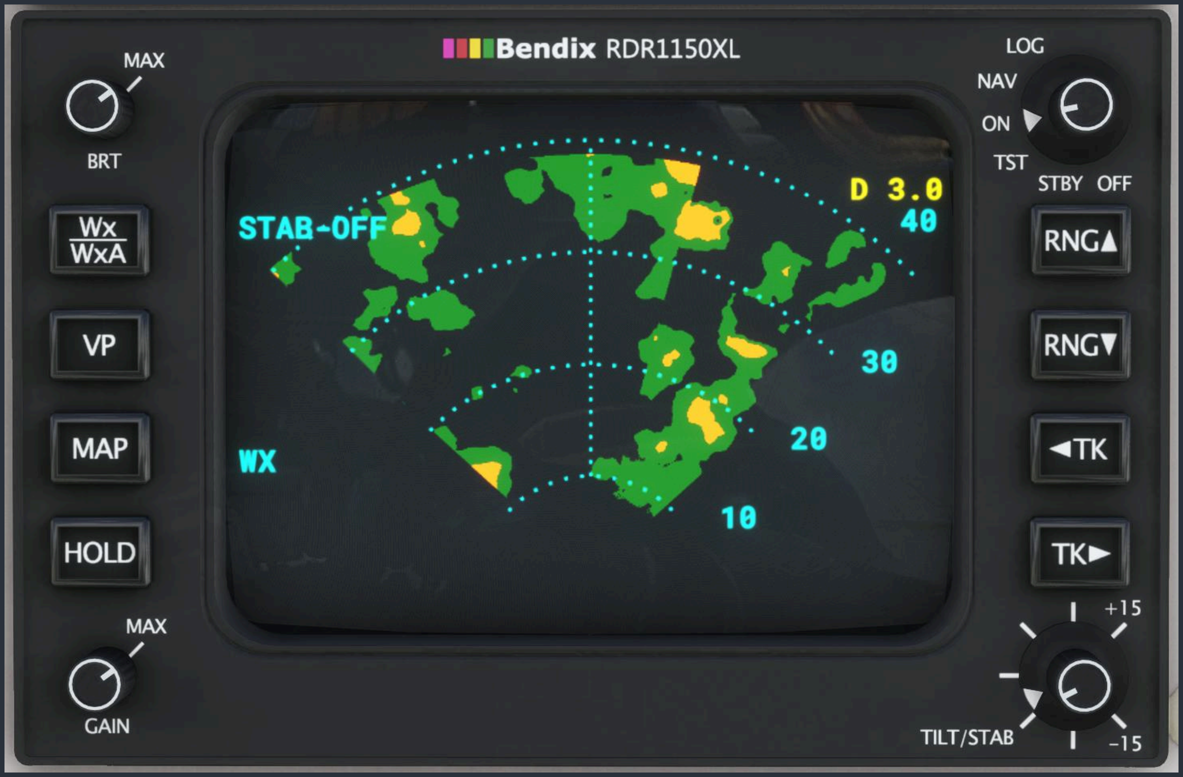
## Bendix RDR 1150XL Color Weather Radar

This implementation of the Bendix RDR 1150XL has six selectable modes via the mode select knob in the upper right-hand corner of the unit.  When cycled through the “OFF” mode, the unit will perform a self-test upon startup, and will annunciate if signal is not received from the aircraft’s external weather radar transceiver unit.

In “STBY” mode, the unit is in a safe standby mode, which does not energize the radar transmitter.  It is recommended that the unit be placed in standby mode whenever the aircraft is operating on the ground to avoid injuring ground personnel, or sensitive equipment on other nearby aircraft.  In this mode, the unit will annunciate “STAND BY” in yellow in the center of the radar arc.

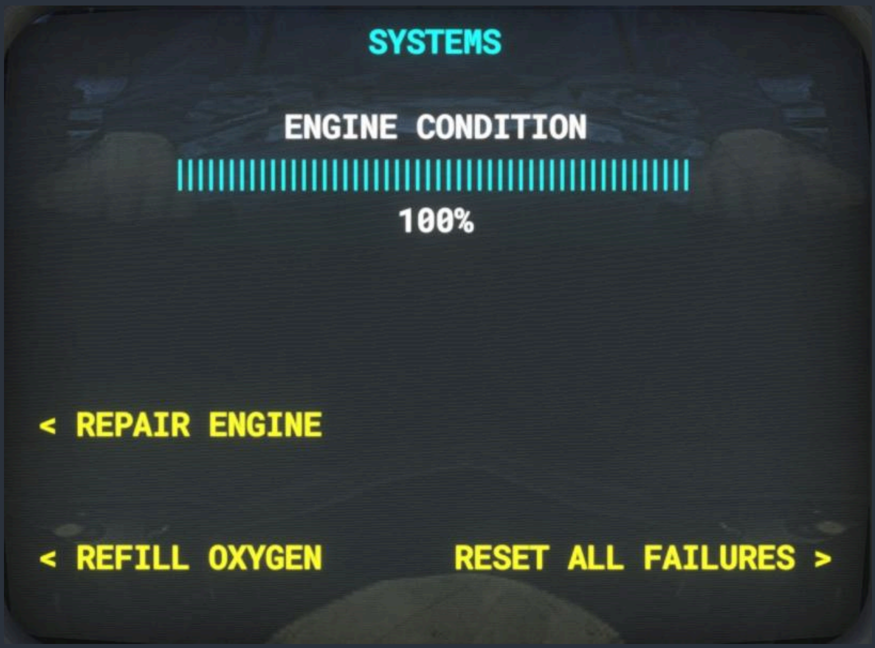
In “TST” mode, the unit will continuously display a sweeping test signal from the radar unit, which should subtend the full horizontal radar arc, and contain concentric arcs of magenta, red, yellow and green.  The “RT FAILURE” flag will also display in cyan.

The “ON” mode is the normal mode of operation for this unit.  In “ON” mode, the radar will display precipitation and severe turbulence in the above color spectrum, within the radar arc on the screen.  The range of the display can be adjusted with the “RNG ^”, and the “RNG v” push buttons.  Nautical mile distances are displayed adjacent to the range rings on the radar display.  By pressing the “VP” button, the unit can be toggled between horizontal and vertical profile modes, which are annunciated in the upper left-hand corner of the display.  The “<TK” and “TK>” buttons can be used to pan the radar transceiver to the right or left, and the “TILT” knob can be used to tilt the radar transceiver up or down.  The position of the radar transceiver is annunciated on the display in yellow, but there is no effect on the underlying weather radar simulation.  Lastly, “BRT”, and “GAIN” knobs on the left of the unit can be used to control the brightness and gain of the radar respectively.  “NAV” and “LOG” modes are not implemented yet in this unit.  This unit’s state will be saved automatically and reloaded.




This aircraft is equipped with an underlying software system that is capable of triggering a failure of almost any simulated aircraft system, either determined by the Mean Time Between Failure (MTBF) of each component, or at a scheduled time. Failures are configured via the tablet interface, discussed in the "Tablet Interface" section of this manual. The "NAV" and "LOG" pages of this weather radar interface have been replaced with quick access shortcuts for accessing the failure and engine condition options in this aircraft.

On the NAV page, you will be presented with a segmented bar graph indicating the current engine condition. Using the keys on the weather radar bezel indicated by the YELLOW text and accompanying arrows, you can reset engine conditions to 100% and restore all of their components to working order, refill the oxygen cylinder, or recharge the batteries.




On the LOG page, you will be presented with the current number of active failures. This can be useful if you wish to be alerted of new failures without having the tablet interface open, since the weather radar sits just within the forward view of the pilot. Pressing the corresponding button on the weather radar's bezel to reset all failures, will reset all the currently active failures.

## Garmin GTX 327 Transponder

The GTX 327 transponder supports the typical transponder modes of operation; off, standby, on, and altitude reporting mode. This transponder also has a VFR preset button, which will automatically set the transponder code to your region's VFR flight code (such as 1200 in the United States). The unit is also equipped with an ident button for responding to ident requests from air traffic control. Pressing the "FUNC" button will cycle through the unit's function modes, which are as follows:

1. Pressure Altitude (in flight levels)
2. Flight Timer (triggered by weight-on-wheels sensor)
3. Outside Air Temperature & Density Altitude
4. Count Up Timer
5. Count Down Timer

Timers can be started and stopped by pressing the "START/STOP" button, and the time can be cleared/reset with the "CLR" button.

# Electrical/Miscellaneous

## Circuit Breakers

The Caravan's circuit breaker panel is located on the electrical pedestal to the left of the pilot's seat. 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 may be monitored via the multi-function volt/amp meter 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. In the case of the Caravan Professional, two circuit breakers pertaining to the control of retractable landing gear on floats will be removed or added as appropriate. It should be noted that the left-hand column of circuit breakers in the Caravan are actually "bus feeders", which supply each row of equipment with power. In essence, pulling the first breaker of each row, such as "BUS 1 PWR" in the first row, is the same as pulling all the breakers in that row. Similarly, the first two rows of circuits are also connected to the standby alternator, which energizes when electrical loads on the main generator exceed a preset value, and the gas generator is operating above idle RPM.

## Multi-Function Volt/Amp Meter

A multi-function meter and associated rotary selector knob provides access to all the onboard electrical systems in the Caravan. The inner scale of the meter displays voltage, while the outer scale displays amperage. The selector knobs allows for monitoring of the current (amps) being drawn or produced (positive or negative amps) from the starter-generator ("GEN"), the standby alternator ("ALT"), and the aircraft battery ("BATT"). To test the ammeter, try switching to the "ALT" setting while in-flight, and moving the generator control switch to the "TRIP" position. Current draw on the starter-generator should fall to zero, and the standby alternator and battery should momentarily take over to share the load. The last position on the selector switch is "VOLT", which allows for the monitoring of the main bus voltage, which should mirror the aircraft battery voltage. This indication is important during engine starting to ensure the battery can supply sufficient voltage for an effective start.

# Bendix/King KA 51B Remote Compass Synchroscope

This aircraft contains a Bendix/King remote compass, and remote compass controller with integrated synchroscope.  The purpose of a remote compass is to supply several instruments, autopilots, or navigation systems with a reliable source of magnetic compass direction that is continuously correcting for gyroscopic drift.  This is accomplished by integrating a fluxgate magnetometer's sensing of magnetic direction with a larger gyroscope than could fit within the housing of a single panel-mounted instrument.  This remote compass erects to the correct magnetic heading when powered on, and will automatically correct for gyroscopic drift throughout the flight when the remote compass controller's mode switch is placed in the "SLAVE" position.  In this mode, the integrated synchroscope should display a white line, centered between the stationary + and - markings.


Should the position of the remote compass become unreliable, such as during flight through magnetic disturbances or over the earth's poles, the remote compass can be placed in a manual mode by placing the mode switch in the "FREE" position.  In this mode, the input of the magnetometer will be ignored, and the unit will behave like a normal directional gyroscope.  The position of the remote compass can be advanced in one direction or another by holding the remaining switch on the remote compass control in either the clockwise ("CW") direction, or the counter-clockwise ("CCW") direction.  In this mode, the synchroscope will show the set compass position's deviation from the detected magnetic heading.

## Propeller Amps Indicator

The propeller ammeter gauge indicates the flow of current to the propeller hub during deicing.


## Vacuum Indicator

The vacuum indicator shows the vacuum suction generated by the engine-driven vacuum pump on the engine's accessory gearbox.  The scale on the gauge has indicators for appropriate vacuum suctions at various pressure altitudes of operation.

## Oxygen Pressure Gauge

In the overhead panel of the Caravan, a recessed gauge indicates the oxygen pressure available in the onboard, refillable oxygen cylinder.  This cylinder is normally pressurized to 1,850 PSI when serviced on the ground.  Oxygen pressure will deplete as it is consumed by passengers and crew, when activated.  To activate the Caravan's built-in demand-type oxygen regulators for crew, place the oxygen supply lever in the overhead panel in the "ON" position.  Oxygen will be consumed by the crew only in accordance with the current pressure altitude of the aircraft, and the weights of the crew members.  The oxygen pressure is saved between flights, and can be refilled via the payload page of the tablet interface, or the "SYSTEMS" page on the weather radar display, or the payload page of the tablet interface.  When the cabin oxygen system is activated, the sound of pressurized gas flowing through pipes will be audible.


## Quartz Analog Chronometer

A precision (second counting) quartz chronometer for timing IFR approach legs or departure clearance void times.

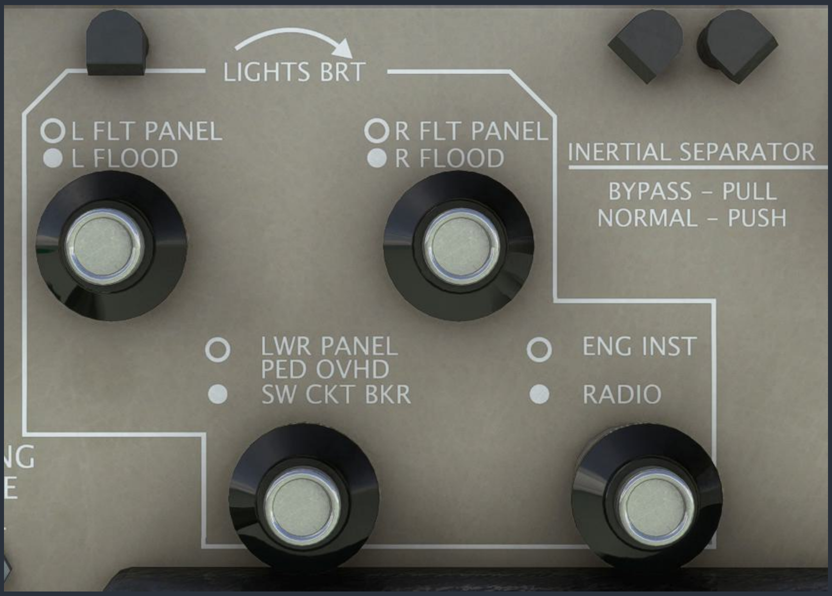
## Hobbs Timer

The included Hobbs timer in the aircraft runs from when the master switch is activated, to when it is shut off.  Indicated in tenths of an hour, this meter should be a reliable source of timing for your logbook recordings, or emergency leg timing in IMC, should you find yourself in a really unusual and dire situation.

# Lighting Controls

## Cockpit Lighting

Cockpit flood lighting is controlled by the dual concentric rheostats under the pilot's yoke. Three overhead flood lights (pilot, co-pilot, and pedestal area) are controlled via the outer concentric knobs in this area of the panel. These floodlights are very bright, and should only be used during pre/post flight operations, or during an emergency. An additional floodlight is provided to illuminate the circuit breaker panel to the left of the pilot's seat. This light is controlled via an inner concentric knob, colocated with the pedestal floodlight dimmer.




## Panel Lighting

Panel lighting is also controlled by the dual concentric rheostats under the pilot's yoke. The majority of panel lighting is provided through post lights affixed to the instrument panel, while some instruments have integrated lighting. The panel lighting is divided into the following zones: pilot's side panel, co-pilot's side panel, engine instruments, and radio backlighting. Care should be taken to always use the minimum amount of interior lighting necessary to clearly read the instruments in order to preserve crew night vision quality.

## Courtesy Lighting

Interior and exterior courtesy lights are provided to facilitate aircraft loading. The exterior lights are mounted behind the leading edges of each wing to illuminate the pilot and copilot boarding doors. The interior courtesy lights are mounted along the center aisle of the cabin and above the aft loading doors. The “CABIN LIGHTS” toggle switch on the lower-left main instrument panel activates these lights, regardless of main bus power. These lights are powered via the hot battery bus, so they have the potential to drain the aircraft of power if left illuminated for multiple hours.

## Individual Reading Lights

There are a total of fourteen individual reading lights above the passenger seats, and over the aft baggage area. Unlike the courtesy lights, these lights require the aircraft’s main bus to be powered. The lights are activated by pressing their associated toggling push button. Ensure that cabin lighting is turned off during all flight and ground operations, as light bleeds from the cabin into the cockpit area, diminishing the quality of crew night vision. Keep in mind that incandescent, direct current (DC), cabin lighting presents a significant drain on the aircraft battery during operation.

## Map Lights

Small map reading lights on each yoke are aimed at the floor of the cabin, and can be illuminated by adjusting the rheostat on the right horn of each yoke.



## Voltage-Based Light Dimming

Black Square's aircraft implement 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.  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, or the  “SYSTEMS” screen on the Weather Radar.

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, 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.

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 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.

Without the need for any aircraft power, the cabin temperature can be partially equalized with the outside air temperature by opening any of the cabin doors, 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 the use of the air conditioning system in “VENTILATE” mode. Ventilate mode does not engage the air conditioning compressor, but instead, only the three ventilation fans. The rate of temperature equalization, active heating, or active cooling can be increased by placing the air conditioning switch in either the “COOL” or “VENTILATE” position, and positioning the “AC FAN” switches in their “HIGH” positions. Be aware that these ventilation systems increase the load required from the current power source substantially, and therefore should be used predominantly while under power, or when external power is supplied to the distribution bus.

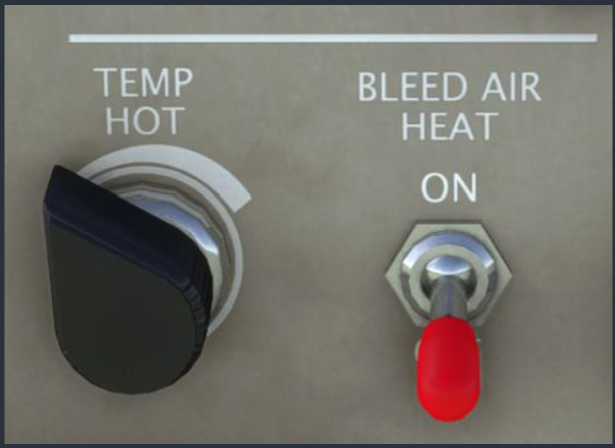
## Cabin Temperature Monitoring

A temperature monitoring system is available in this aircraft to monitor cabin temperature, and alert the pilot to when cabin temperatures have become unacceptably hot or cold. The digital LCD temperature display on the right side of the panel, above the co-pilot standby instrumentation, will display temperatures from -99° to 999° Celsius, or Fahrenheit, toggleable with the small blue push button. Backlighting for this instrument is dimmed via the “RADIO” light dimmer, along with the other avionics backlighting. In addition to this LCD display, two small LED’s are located outboard of the prop-amps gauge to indicate when cabin temperatures are unacceptably hot or cold within the pilot’s primary field of view, and call their 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.


## Cabin Environmental Controls

The primary environmental controls are located below the center of the main instrument panel behind the throttle quadrant. As discussed above, placing the air conditioning control switch in ventilate mode will begin equalizing the cabin temperature with the outside air temperature, so long as the cabin air intake vents are opened with the “VENT AIR” knobs on the overhead panel. These valves admit air into the cabin through the two screened intakes at the top of the wing strut fairings. The fresh cabin air is sourced from the inlets on the wings to avoid possible carbon monoxide contamination from the engine’s exhaust. The cabin temperature can also be equalized with ram air from the pilot and copilot’s side ram air doors, which are extended by pulling on the “VENT PULL” knobs on either side of the instrument panel.

Cabin heating is provided by engine compressor bleed air. To increase the cabin temperature, the red “BLEED AIR HEAT” toggle switch must be placed in the “ON” position. This will provide hot bleed air from the running engine to the air mixing valve so long as the gas generator RPM is above 30%, and the red firewall shutoff handle on the pedestal is pushed in. The temperature control knob is used to set a target temperature for both the heating and cooling systems. The knob can rotate approximately 180° to select temperature targets from 50°F (10°C), to 100°F (38°C). The target temperature is displayed on the cabin visualizer page of the tablet interface.



Three pull handles to the right of the other climate controls actuate valves, which control the direction of heating air.  The first, marked "CABIN HEAT MIXING AIR" is used to select whether lower temperature bleed air from the P2.5 compressor stage, or yet cooler cabin return air, is mixed with the hotter P3 air from the engine before passing through a cooling muffler and into the cabin.


When the handle is pushed into the "FLT-PUSH" position, only cabin return air is mixed with the P3 bleed air, effectively cooling the bleed air before it is regulated to the desired vent temperature.  When the handle is pulled out to the "GND-PULL" position, P2.5 bleed air is mixed with the P3 bleed air instead, resulting in hotter vent temperatures.  This position should only be used when trying to heat the cabin on the ground in very cold ambient temperatures. Pulling the handle out to the "GND-PULL" position in flight will isolate the hot P3 bleed air with no cabin return air or P2.5 bleed air, because the P2.5 high pressure valve is fully closed above approximately 92% gas generator RPM to provide maximum engine power.

Failing to use the "FLT-PUSH" position during flight may result in a vent over-temperature, and subsequent cabin heating failure.  The P2.5 bleed valves and their function are discussed further in the "P2.5 Bleed Air Valves" section of this manual.  If the incoming bleed air from the engine is too hot to be regulated down to the desired cabin temperature, the cabin temperature target display on the cabin visualizer page of the tablet interface will display in red, which should be the operator's cue to push in the cabin heat mixing air handle.

The middle of the three handles is used to select whether the heating air should be routed to the vents in the cockpit area, or the vents in the aft side walls of the passenger cabin.  Leaving the handle halfway deployed will result in equal airflow between the forward and aft cabins.  The rightmost knob controls the defroster diverter louvers in the cockpit heating air distribution ducts. When this handle is pulled outwards, and the middle handle discussed above is pushed fully forwards, any heating air produced from the engine bleed air will be directed upwards at the inside of the aircraft's windshield, rather than outwards towards the crew members.


Placing the air conditioning mode switch in the “COOL” position will engage the air conditioning compressor clutch and begin to cool the cabin to the target air temperature so long as the engine’s gas generator RPM is above approximately 55%.  Sometimes it is necessary to place the condition lever into the high idle position to activate the air conditioning system on the ground.  The rate of cooling can also be increased by positioning the “AC FAN” switches in their “HIGH” positions.  The air conditioning system can be defeated by the hot bleed air entering the cabin, assuming the bleed air mixture is hotter than the desired cabin temperature.  This may happen if the cabin heat mixing air handle is pulled out into the “GND-PULL” position, at which time the in temperature target display on the cabin visualizer page of the tablet interface will display in red.

## Air Conditioning Temperature Effects

When the air conditioning compressor clutch is engaged, the load is increased on the engine's accessory gearbox.  The load is proportional to the differential between the outside air temperature and the desired cabin temperature.  This increased load on the engine can cause internal temperatures to increase.  The temperature increase is proportional to the airflow through the engine nacelle, which is influenced by the aircraft's speed, and propeller RPM.  Particularly while operating on the ground, the operator should keep an eye on engine temperatures.  During low airspeed climbs or while operating at low altitudes, the additional cooling air required by the engine may send interstage turbine temperatures and oil temperatures into a dangerous regime if not properly managed.  This may require a reduction of power during climbs to observe ITT limits.


Ambient cooling air is passed over the air conditioning condenser coils in the engine compartment through a pair of louvered grills on the pilot's side of the engine cowling.

## Oxygen Duration Table (Hours)

This aircraft is equipped with an **upgraded 115 cubic foot** composite oxygen cylinder.

| # of Occupants | 10,000 ft | 15,000 ft | 20,000 ft | 25,000 ft | 30,000 ft |
|---|---|---|---|---|---|
| 1 | 38.4 | 25.6 | 19.2 | 15.4 | 12.8 |
| 2 | 19.2 | 12.8 | 9.6 | 7.7 | 6.4 |
| 3 | 12.6 | 8.4 | 6.3 | 5.0 | 4.2 |
| 4 | 9.6 | 6.4 | 4.8 | 3.8 | 3.2 |
| 5 | 7.8 | 5.2 | 3.9 | 3.1 | 2.6 |
| 6 | 6.6 | 4.4 | 3.3 | 2.6 | 2.2 |
| 7 | 5.4 | 3.6 | 2.7 | 2.2 | 1.8 |
| 8 | 4.3 | 2.9 | 2.2 | 1.7 | 1.4 |
| 9 | 3.9 | 2.6 | 1.9 | 1.6 | 1.3 |
| 10 | 3.4 | 2.3 | 1.7 | 1.4 | 1.1 |
| 11 | 3.1 | 2.1 | 1.6 | 1.3 | 1.0 |
| 12 | 3.0 | 2.0 | 1.5 | 1.2 | 1.0 |
| 13 | 2.7 | 1.8 | 1.3 | 1.1 | 0.9 |
| 14 | 2.6 | 1.7 | 1.2 | 1.0 | 0.9 |

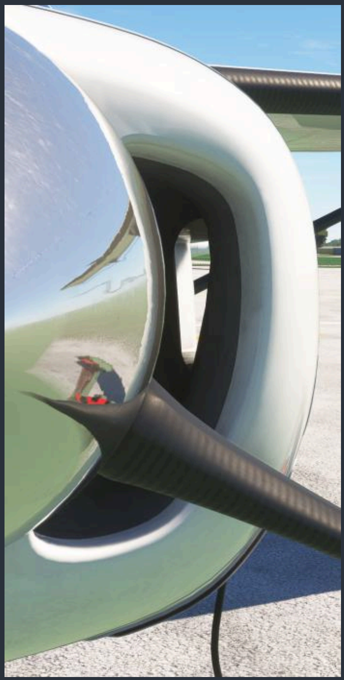
Approximate duration of useful consciousness following a cabin depressurization event:

35,000 ft MSL - less than 1 minute
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

# Turboprop Engine Operation

## Inertial Separator

Most turboprop engines possess a method of separating particulate from engine induction air by method of 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 deflector, or simply "bypass") is activated, the airflow must take a sharp turn, which ejects particulate through a vent at the side of the engine.  Inertial separators have the disadvantage of reducing free airflow to the engine, thus reducing maximum torque, or torque available at for a given ITT for a given set of conditions.  This aircraft 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 separator in this aircraft is activated manually by rotating and pulling a large, black control handle away from the instrument panel.  The inertial separator should be used whenever operating on unimproved or marginal surfaces, and whenever entering visible moisture.  Unlike other aircraft, the manual actuation of this inertial separator can be accomplished in a few seconds, so it is not necessary to anticipate sky conditions several miles away from the aircraft.

Proper functioning of the inertial separator door can be confirmed from the exterior of the aircraft.  When the control handle is pulled out in the "bypass" position, a clear path can be observed from the induction air inlet, through the engine nacelle, and out the bypass duct, emerging forward of the pilot's boarding door.

## Turbine Engine Ignition

This turboprop engine is equipped with a continuous ignition system that can be energized with the “IGNITION” switch on the electrical control panel.  In the “ON” position, the igniters arc continuously.  This position should be used during extreme weather conditions to prevent engine flameout, such as heavy precipitation.  In the “NORM” position the igniters will only be energized when the starter switch is in the on position.

## 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 power lever having minimal or zero control over the engine’s fuel flow.  This failure can occur during any phase of flight.  In the case of the Caravan Professional, this failure may not necessitate an engine shutdown, as the fuel control manual override lever can be used to restore throttle control.  Should this occur, follow the loss of engine power checklist, and advance the manual override lever slowly out of its detent. Operators should take extreme caution when applying power changes through the manual override control, as the mechanical control system of the primary fuel control unit is not present when operating through the backup control.

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 activated 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.

## Propeller Governor

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 free turbine engine aircraft, the propeller blade pitch system is usually configured to drive the blades into their fully feathered position automatically when oil pressure is lost.  For this reason, a decrease in indicated oil pressure is expected while exercising propeller pitch on the ground.  To ensure that these systems are functioning properly, a governor test button is provided for use during the runup procedure.  Holding the red “OVERSPEED GOVERNOR PUSH TO TEST” button, located above the electrical control panel, will offset the overspeed propeller governor to a lower RPM, limiting the propeller to around 1,750 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.

## Residual Heat & Dry Motoring

After shutdown, engine temperatures (measured as ITT) may remain sufficiently hot as to require dry motoring of the engine to reduce temperatures to safe levels before attempting a start.  This limitation may present itself during quick turnarounds in high ambient temperatures with little wind to provide cooling.  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 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.

## 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 battery cart.  The cart is capable of supplying many times the capacity of the aircraft's onboard batteries, 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.



In this aircraft, the external power is not connected directly to the aircraft's main electrical distribution bus when the connector is fitted into the receptacle on the outside of the aircraft. The guarded "External Power" switch on the electrical panel must also be placed in either the "STARTER" position to apply power to only the aircraft's starter motor, or the "BUS" position to apply power to the entire aircraft via the main distribution bus.

# Engine Power Settings (Without Cargo Pod)

All figures at max. gross weight.  Do not exceed 765°C ITT during climb, or 740°C during cruise.
*Applicable only at gross weight of 8,300 lbs or less.

## Take-Off Power - Standard Day (ISA) No Wind

| Press. Alt. (ft) | Torque (FT-LBS) | Prop RPM | Fuel Flow (PPH) | T/O Ground Roll (ft) | 50ft Obstacle T/O Dist. (ft) | Rate of Climb (ft/min) |
|---|---|---|---|---|---|---|
| SL | 1,865 | 1,900 | 465 | 1,365 | 2,420 | 975 |
| 2,000 | 1,865 | 1,900 | 445 | 1,537 | 2,725 | 940 |
| 4,000 | 1,865 | 1,900 | 430 | 1,750 | 3,080 | 925 |
| 6,000 | 1,865 | 1,900 | 427 | 2,000 | 3,500 | 895 |
| 8,000 | 1,780 | 1,900 | 425 | 2,295 | 4,000 | 805 |

## Maximum Cruise Power - Standard Day (ISA)

| Pressure Alt. (ft) | Torque (FT-LBS) | Prop RPM | Fuel Flow (PPH) | True Airspeed | Range (nm) |
|---|---|---|---|---|---|
| 4,000 | 1,865 | 1,900 | 426 | 181 | 850 |
| 8,000 | 1,750 | 1,900 | 389 | 182 | 910 |
| 12,000 | 1,585 | 1,900 | 362 | 181 | 955 |
| 16,000 | 1,350 | 1,900 | 310 | 174 | 1,046 |
| 22,000* | 1,110 | 1,900 | 257 | 165 | 1,162 |

## Normal Cruise Power - Standard Day (ISA)

| Pressure Alt. (ft) | Torque (FT-LBS) | Prop RPM | Fuel Flow (PPH) | True Airspeed | Range (nm) |
|---|---|---|---|---|---|
| 4,000 | 1,600 | 1,750 | 365 | 164 | 887 |
| 8,000 | 1,500 | 1,750 | 334 | 164 | 945 |
| 12,000 | 1,400 | 1,750 | 308 | 164 | 1,011 |
| 16,000 | 1,335 | 1,750 | 284 | 163 | 1,076 |
| 22,000* | 1,175 | 1,750 | 256 | 162 | 1,170 |

## Long Range Cruise Power - Standard Day (ISA)

| Pressure Alt. (ft) | Torque (FT-LBS) | Prop RPM | Fuel Flow (PPH) | True Airspeed | Range (nm) |
|---|---|---|---|---|---|
| 4,000 | 1,445 | 1,600 | 327 | 151 | 924 |
| 8,000 | 1,355 | 1,600 | 298 | 150 | 992 |
| 12,000 | 1,330 | 1,600 | 281 | 152 | 1,049 |
| 16,000 | 1,295 | 1,600 | 268 | 154 | 1,104 |
| 22,000* | 1,250 | 1,600 | 255 | 158 | 1,182 |

## Climb Performance 115 KTS - Standard Day (ISA)

| Target Alt. (ft) | Torque (FT-LBS) | Prop RPM | Fuel Flow (PPH) | Time to Climb (min) | Fuel to Climb (gal) | Dist. to Climb (nm) |
|---|---|---|---|---|---|---|
| 4,000 | 1,865 | 1,900 | 465 | 4 | 5 | 9 |
| 8,000 | 1,780 | 1,900 | 413 | 9 | 10 | 18 |
| 12,000 | 1,600 | 1,900 | 408 | 15 | 15 | 32 |
| 16,000 | 1,550 | 1,900 | 400 | 24 | 25 | 48 |
| 20,000 | 1,350 | 1,900 | 360 | 33 | 30 | 65 |
| 24,000* | 1,060 | 1,900 | 332 | 52 | 43 | 107 |

## Descent Performance 140 KTS -800 FPM - Standard Day (ISA)

| Target Alt. (ft) | Fuel Flow (PPH) | Time to Descend (min) | Fuel to Descend (gal) | Dist. to Descend (nm) |
|---|---|---|---|---|
| 24,000 | 232 | 30 | 17 | 91 |
| 20,000 | 242 | 25 | 15 | 75 |
| 16,000 | 255 | 20 | 13 | 59 |
| 12,000 | 256 | 15 | 8 | 43 |
| 8,000 | 264 | 10 | 6 | 28 |
| 4,000 | 276 | 5 | 3 | 14 |

# Engine Power Settings (Cargo Pod & Cargomaster)

All figures at max. gross weight.  Do not exceed 765°C ITT during climb, or 740°C during cruise. Shaded areas denote operation at max. ITT.  *Applicable only at weights of 8,300 lbs or less.

## Take-Off Power - Standard Day (ISA) No Wind

| Press. Alt. (ft) | Torque (FT-LBS) | Prop RPM | Fuel Flow (PPH) | T/O Ground Roll (ft) | 50ft Obstacle T/O Dist. (ft) | Rate of Climb (ft/min) |
|---|---|---|---|---|---|---|
| SL | 1,865 | 1,900 | 465 | 1,405 | 2,500 | 915 |
| 2,000 | 1,865 | 1,900 | 445 | 1,582 | 2,815 | 882 |
| 4,000 | 1,865 | 1,900 | 430 | 1,800 | 3,182 | 868 |
| 6,000 | 1,865 | 1,900 | 427 | 2,060 | 3,616 | 840 |
| 8,000 | 1,780 | 1,900 | 425 | 2,362 | 4,132 | 755 |

## Maximum Cruise Power - Standard Day (ISA)

| Pressure Alt. (ft) | Torque (FT-LBS) | Prop RPM | Fuel Flow (PPH) | True Airspeed | Range (nm) |
|---|---|---|---|---|---|
| 4,000 | 1,865 | 1,900 | 426 | 172 | 808 |
| 8,000 | 1,750 | 1,900 | 389 | 172 | 861 |
| 12,000 | 1,585 | 1,900 | 362 | 169 | 892 |
| 16,000 | 1,350 | 1,900 | 310 | 161 | 967 |
| 22,000* | 1,110 | 1,900 | 257 | 151 | 1,063 |

## Normal Cruise Power - Standard Day (ISA)

| Pressure Alt. (ft) | Torque (FT-LBS) | Prop RPM | Fuel Flow (PPH) | True Airspeed | Range (nm) |
|---|---|---|---|---|---|
| 4,000 | 1,600 | 1,750 | 365 | 156 | 843 |
| 8,000 | 1,500 | 1,750 | 334 | 155 | 894 |
| 12,000 | 1,400 | 1,750 | 308 | 153 | 944 |
| 16,000 | 1,335 | 1,750 | 284 | 151 | 994 |
| 22,000* | 1,175 | 1,750 | 256 | 148 | 1,071 |

## Long Range Cruise Power - Standard Day (ISA)

| Pressure Alt. (ft) | Torque (FT-LBS) | Prop RPM | Fuel Flow (PPH) | True Airspeed | Range (nm) |
|---|---|---|---|---|---|
| 4,000 | 1,445 | 1,600 | 327 | 143 | 878 |
| 8,000 | 1,355 | 1,600 | 298 | 142 | 937 |
| 12,000 | 1,330 | 1,600 | 281 | 142 | 980 |
| 16,000 | 1,295 | 1,600 | 268 | 142 | 1,021 |
| 22,000* | 1,250 | 1,600 | 255 | 144 | 1,081 |

## Climb Performance 115 KTS - Standard Day (ISA)

| Target Alt. (ft) | Torque (FT-LBS) | Prop RPM | Fuel Flow (PPH) | Time to Climb (min) | Fuel to Climb (gal) | Dist. to Climb (nm) |
|---|---|---|---|---|---|---|
| 4,000 | 1,865 | 1,900 | 465 | 5 | 5 | 9 |
| 8,000 | 1,780 | 1,900 | 413 | 10 | 10 | 20 |
| 12,000 | 1,600 | 1,900 | 408 | 17 | 17 | 35 |
| 16,000 | 1,550 | 1,900 | 400 | 25 | 26 | 45 |
| 20,000 | 1,350 | 1,900 | 360 | 37 | 35 | 72 |
| 24,000* | 1,060 | 1,900 | 332 | 68 | 54 | 125 |

## Descent Performance 140 KTS -800 FPM - Standard Day (ISA)

| Target Alt. (ft) | Fuel Flow (PPH) | Time to Descend (min) | Fuel to Descend (gal) | Dist. to Descend (nm) |
|---|---|---|---|---|
| 24,000 | 264 | 30 | 20 | 91 |
| 20,000 | 271 | 25 | 17 | 75 |
| 16,000 | 282 | 20 | 14 | 59 |
| 12,000 | 288 | 15 | 11 | 43 |
| 8,000 | 292 | 10 | 7 | 28 |
| 4,000 | 300 | 5 | 4 | 14 |

# Engine Power Settings (Amphibian)

All figures at max. gross weight. Do not exceed 765°C ITT during climb, or 740°C during cruise. Shaded areas denote operation at max. ITT. *Applicable only at weights of 7,800 lbs or less.

## Take-Off Power - Standard Day (ISA) No Wind (Land/Water)

| Press. Alt. (ft) | Torque (FT-LBS) | Prop RPM | Fuel Flow (PPH) | T/O Ground Roll (ft) | 50ft Obstacle T/O Dist. (ft) | Rate of Climb (ft/min) |
|---|---|---|---|---|---|---|
| SL | 1,865 | 1,900 | 465 | 1,810 / 1,982 | 3,027 / 4,082 | 751 |
| 2,000 | 1,865 | 1,900 | 445 | 2,038 / 2,232 | 3,408 / 4,596 | 724 |
| 4,000 | 1,865 | 1,900 | 430 | 2,319 / 2,539 | 3,853 / 5,196 | 712 |
| 6,000 | 1,865 | 1,900 | 427 | 2,654 / 2,906 | 4,378 / 5,904 | 689 |
| 8,000 | 1,780 | 1,900 | 425 | 3,043 / 3,332 | 5,003 / 6,747 | 620 |

## Maximum Cruise Power - Standard Day (ISA)

| Pressure Alt. (ft) | Torque (FT-LBS) | Prop RPM | Fuel Flow (PPH) | True Airspeed | Range (nm) |
|---|---|---|---|---|---|
| 4,000 | 1,865 | 1,900 | 426 | 164 | 770 |
| 8,000 | 1,750 | 1,900 | 389 | 164 | 821 |
| 12,000 | 1,585 | 1,900 | 362 | 161 | 851 |
| 16,000 | 1,350 | 1,900 | 310 | 154 | 922 |
| 20,000* | 1,270 | 1,900 | 292 | 150 | 983 |

## Normal Cruise Power - Standard Day (ISA)

| Pressure Alt. (ft) | Torque (FT-LBS) | Prop RPM | Fuel Flow (PPH) | True Airspeed | Range (nm) |
|---|---|---|---|---|---|
| 4,000 | 1,600 | 1,750 | 365 | 149 | 804 |
| 8,000 | 1,500 | 1,750 | 334 | 148 | 852 |
| 12,000 | 1,400 | 1,750 | 308 | 146 | 900 |
| 16,000 | 1,335 | 1,750 | 284 | 144 | 948 |
| 20,000* | 1,185 | 1,750 | 265 | 142 | 996 |

## Long Range Cruise Power - Standard Day (ISA)

| Pressure Alt. (ft) | Torque (FT-LBS) | Prop RPM | Fuel Flow (PPH) | True Airspeed | Range (nm) |
|---|---|---|---|---|---|
| 4,000 | 1,445 | 1,600 | 327 | 136 | 837 |
| 8,000 | 1,355 | 1,600 | 298 | 135 | 893 |
| 12,000 | 1,330 | 1,600 | 281 | 135 | 934 |
| 16,000 | 1,295 | 1,600 | 268 | 135 | 974 |
| 20,000* | 1,280 | 1,600 | 262 | 136 | 1,001 |

## Climb Performance 115 KTS - Standard Day (ISA)

| Target Alt. (ft) | Torque (FT-LBS) | Prop RPM | Fuel Flow (PPH) | Time to Climb (min) | Fuel to Climb (gal) | Dist. to Climb (nm) |
|---|---|---|---|---|---|---|
| 4,000 | 1,865 | 1,900 | 465 | 5 | 6 | 8 |
| 8,000 | 1,780 | 1,900 | 413 | 9 | 10 | 17 |
| 12,000 | 1,600 | 1,900 | 408 | 15 | 16 | 29 |
| 16,000 | 1,550 | 1,900 | 400 | 23 | 23 | 45 |
| 20,000* | 1,350 | 1,900 | 360 | 36 | 33 | 72 |

## Descent Performance 140 KTS -800 FPM - Standard Day (ISA)

| Target Alt. (ft) | Fuel Flow (PPH) | Time to Descend (min) | Fuel to Descend (gal) | Dist. to Descend (nm) |
|---|---|---|---|---|
| 20,000 | 285 | 25 | 20 | 75 |
| 16,000 | 300 | 20 | 16 | 59 |
| 12,000 | 305 | 15 | 13 | 43 |
| 8,000 | 311 | 10 | 8 | 28 |
| 4,000 | 325 | 5 | 5 | 14 |

# 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 veins, 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.

## Pneumatic Gyroscopes

Pneumatic gyroscopes are powered by either positive (“Instrument Air”) or negative (“Vacuum Suction”) pressure differential in aircraft.  The earliest aircraft attitude gyroscopes were powered by venturi suction generators on the exterior of the aircraft, as this did not require the aircraft to have an electrical system to operate.  Later, vacuum pumps, or sometimes positive pressure pumps, were added to the engine’s accessory gearbox to reduce drag on the exterior of the aircraft, and also to supply air to the instruments before takeoff.  With a pneumatic instrument air system, the dynamics of an air pump compound the dynamics of the gyroscope itself.

The speed of a pneumatic gyroscope is controlled by the air pressure (positive or negative) available to it from the source (usually a pump in modern aircraft).  The pressure the pump can generate is directly proportional to engine shaft RPM.  At lower engine RPM, the performance of a gyroscope may noticeably degrade over time.  For this reason, some aircraft operators recommend a higher engine idle RPM before takeoff into instrument conditions.  This ensures the attitude indicating gyroscopes are spinning as quickly as possible before takeoff.  Notable to nighttime and instrument flying, an engine failure means an eventual gyroscope failure.  Once the engine is no longer running, the gyroscope performance will begin to degrade for several minutes until it provides no useful information.  Some pneumatic attitude indicators are equipped with an “OFF” or “ATT” flag to indicate when gyroscope speed is no longer suitable for use, but many do not.

When a pneumatic pump fails, it is possible for it to experience a complete failure, or a partial failure.  A partial failure may cause a slow degradation of gyroscope performance to a level that still provides usable attitude information, but with significant procession and warbling effects.  A complete vacuum failure rarely results in a completely stopped gyroscope and stationary attitude display, however.  During a complete failure, there is often a rotating shaft or blade debris in the pneumatic pump housing, and minimal venturi suction effects on a vacuum pump exhaust pipe.  These effects may cause the gyroscope to continue tumbling indefinitely while in flight, only coming to a stop when on the ground.  This can be distracting during instrument flight, so some pilots prefer to cover up the erroneous information on the attitude display to avoid spatial disorientation.

## 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.

# Tips on Operation within MSFS

## Turboprop Engine Simulation

The aircraft makes use of Black Square's new gas generator and engine temperature simulation, which offers a vast improvement over the default behavior. Along with the new beta range implementation, these systems produce one of the most realistic turboprop simulations in MSFS. Expect realistic hot starts based on numerous environmental factors, accurate ITT and oil temperature behavior that becomes limiting at high altitude, and precise beta operations while taxiing. The gas generator RPM is also influenced by many factors, and follows a more realistic speed curve at different throttle settings.

## Engine Limits and Failures

When you operate an engine beyond its limits, damage to the aircraft 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% of its initialized value, the CHIP DETECT annunciator light will illuminate. 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 this aircraft does not possess an annunciator pertaining to starter motor overheat, so failure may arise unannounced.

## 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 new 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 annunciator panel for those 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.

## 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 should keep in mind that the battery has no internal resistance; however, battery charging rate is correctly simulated in this aircraft, 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.

## Third Party Navigation and GPS Systems

There now exist a number of freeware and payware products to enhance or add advanced navigation systems to MSFS. For example, the TDS GTNxi 750/650, the PMS50 GTN 750/650, and the Working Title GNS 530/430. Several of these advanced GPS units implement their own autopilot and flight plan managers out of necessity, with the Working Title GNS being the latest to do so. They may also require the use of their own special variables to be compatible with an aircraft’s radionavigation equipment. Accommodating all these different products is not trivial. Black Square’s hot-swappable avionics system, and failure system to a lesser extent, have compounded the difficulty. Be aware that swapping a GPS unit is also swapping the autopilot, and that all these software options may not behave exactly the same, as they were developed by entirely different teams with different priorities.

## 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 are always able to be cleared by deicing equipment, thankfully.

This aircraft is equipped with propeller deicing, pitot heat, stall warning heat, windshield heat, deicing boots, windshield defrosters, and an inertial separator. Electrical anti-icing for the propellers, pitot-static probes, stall warning heat, and windshield heat, work continuously, and will slowly remove ice from these areas of the aircraft. Window defrosting is provided by the cabin heating system, and requires the following conditions to be met: the cabin air distributor pull handle must be pushed in towards the “FWD CABIN” position, the “DEFROST” cabin air pull handle must be pulled away from the instrument panel, and the environmental control system must be operating with bleed air available. For more information on cabin temperature and environmental controls, see the “Environmental Control Panel” section of this manual.

Lastly, the aircraft is also equipped with deicing boots that use regulated bleed air to inflate, thereby shedding ice from the leading edges of the aircraft.  The three-position airframe deicing switch can be used to automatically inflate all three deicing boot zones in sequence, or manually inflate all zones at once.  In the momentary “AUTO” position, first the boots on the tail surfaces will inflate, followed by the inboard wings and landing gear struts, and lastly the outboard wings and wing struts.


Similarly to the deicing boots, the propeller deicing three-position switch activates a 90-second timer when placed in the “AUTO” position; however, the timer system can be bypassed to manually heat the electric propeller deicing boots by placing the switch in the “MANUAL” position.  If using the manual position, the operator must manually cycle the switch to the “OFF” approximately every 90 seconds to prevent ice buildup beyond the base of the propeller.

The windshield heat switch functions in a similar manner.  When in the “AUTO” position, a temperature sensing system cycles power to the windshield deicing elements to prevent ice buildup.  If the sensing circuitry fails, placing the switch in the “MANUAL” position will apply continuous voltage to the elements, but the heated windshield could become damaged if the elements overheat due to improper use of the manual switch setting.

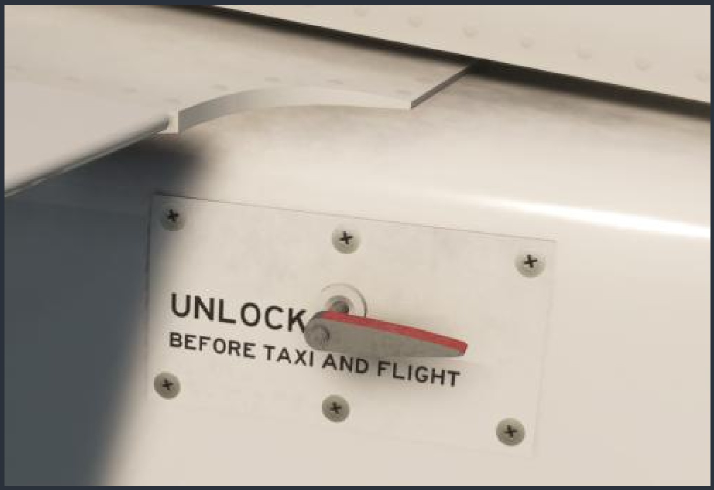
## Foreign Object Debris Damage

This aircraft simulates damage caused to turbine engines by the 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 separator whenever operating on unimproved surfaces, including all ground operations, and whenever ice is present.

## Control Locks

Functioning control locks are provided for the pilot's yoke.  The control lock can be removed by clicking on it.  The control lock is stowed beside the pilot's seat, leaning against the electrical console.


This aircraft is also equipped with an integral rudder lock, which is engaged via a lever on the exterior of the aircraft, or the toggle switch on the payload page of the tablet interface.  As a safety feature, the rudder lock will disengage if the yoke is pulled fully aft.



## Engine & Pitot Covers

Unlike some other Black Square aircraft, it is essential to remove the engine intake cover and pitot covers before starting the aircraft, as they will not be removed automatically.  Engine covers left deployed 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 during the start sequence.  The engine intake cover has an attached flag, visible from the pilot's seated position from over the glareshield to help avoid catastrophic starts.  Engine intake and pitot covers "REMOVE BEFORE FLIGHT" flags can also act as wind indicators.


## 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.

## Headphone Isolation

Simulated active noise cancelling headphones can be toggled by clicking on the pilot's headphone jacks. When the headphone cables are visible, the headphone sound isolation is active. The amount of noise cancellation can be adjusted by scrolling the mouse wheel while hovering over the headphone jack clickspot. The headphone isolation only affects engine and wind noise, allowing you to enjoy subtle sounds and hear interaction feedback without overpowering engine sounds.


## Magnetic Compass Effects

This aircraft is equipped with Black Square's new magnetic compass simulation, which filters inputs from the simulation's magnetosphere environment and combines it with the influence of onboard magnetic fields. This means that the magnetic compass will respond more realistically to aircraft movement, and take a realistic amount of time to settle on a new heading.

Complex aircraft have many high power electrical loads onboard that can produce their own magnetic fields, which disturb the compass and produce false readings. The "magnetic compass is erratic when propeller heat is on" placards in the cockpit now have meaning. The largest electrical loads on the aircraft will now cause a deflection in the indicated magnetic heading corresponding to their magnitude, location in the aircraft, and the direction of the field generated relative to the compass' location.

# 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 or cabin side wall, beside 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

Your selections on the options page will be saved and restored next time you load the aircraft.

### 1. Primary Avionics Selection

The primary avionics choice will occupy the role of the COM1 and NAV1 radios.  This selection could limit the available choices for secondary and tertiary avionics selections.  When a GPS is selected as the primary avionics choice, it will always be the unit driving the pilot's HSI and autopilot.  This selection will be saved and recalled at the start of your next flight.

### 2. Secondary Avionics Selection

The secondary avionics choice will occupy the role of the COM2 and NAV2 radios.  This selection could limit the available choices for tertiary avionics selections.  When a GPS is selected as the secondary avionics choice, it will only drive the pilot's HSI and autopilot if no GPS is selected as the primary avionics selection, and the capability exists for the secondary choice.  For example, a secondary PMS50 GTN 650 or TDS GTNxi 650 will drive the autopilot and pilot's HSI if the KX155 is selected as the primary radio.

NOTE: This NAV2 control of the autopilot is not currently possible with the WT GNS 530 installed as NAV2 in this aircraft, but may be at some point in the future, and is possible with other avionics combinations in other Black Square aircraft.

This selection will be saved and recalled at the start of your next flight.

### 3. PMS50 GTN / TDS GTNxi Switch

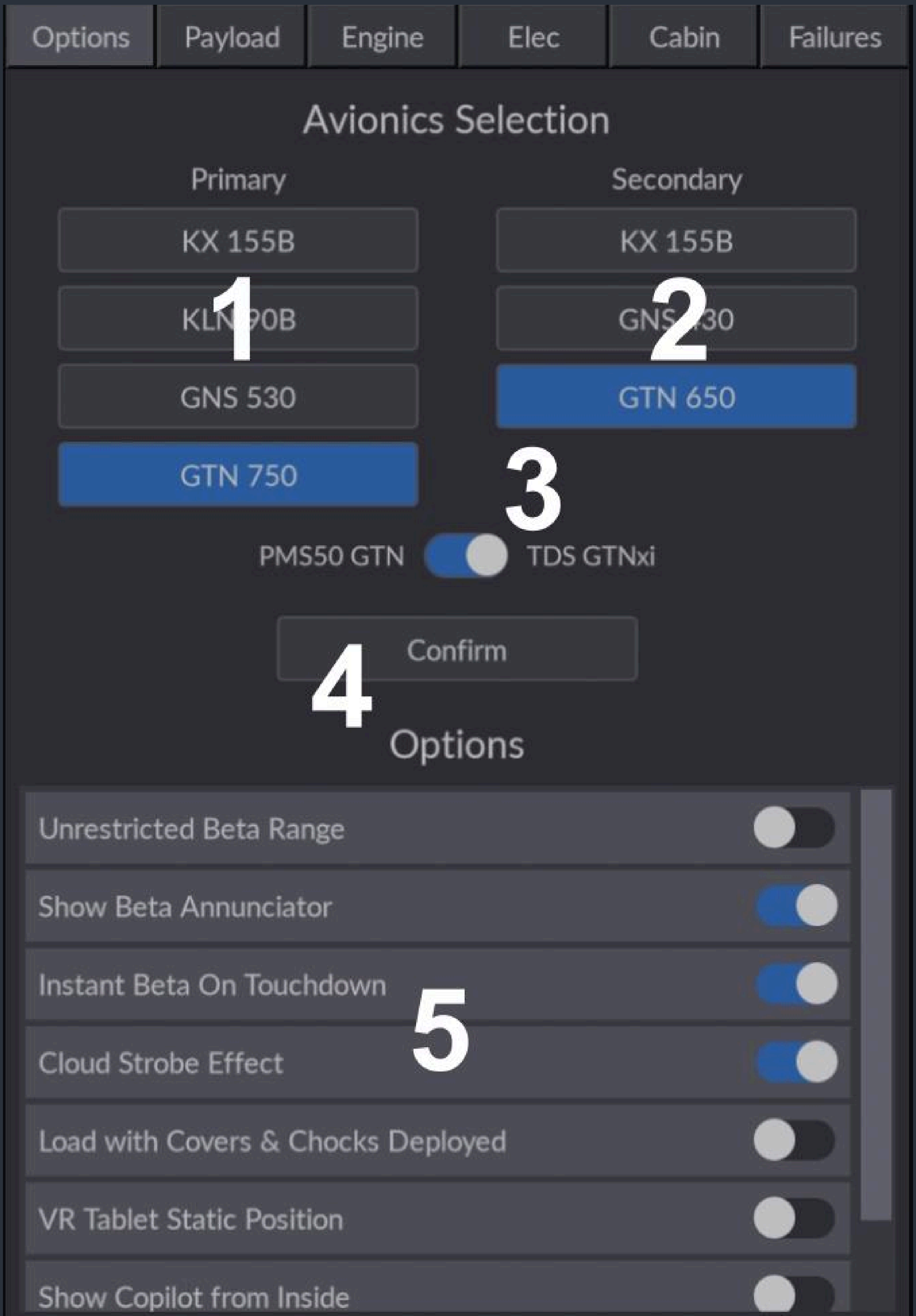
To switch between the PMS50 and TDS offerings of GTN GPS units, toggle this switch.  This selection will be saved and recalled at the start of your next flight.

### 4. Confirm Avionics Selection

Your avionics selection will only take effect once you have pressed the confirm button.  Once pressed, the button will display a series of messages while the avionics are reconfigured.  This takes a few seconds, and should not be interrupted due to the complexity of new avionics software.  The autopilot will be disengaged when this change takes effect.  Once the change is complete, the confirm button will remain grayed out until you make a change to your avionics selection with the buttons above.

### 5. Options List

The scrolling options list contains all configuration options for the aircraft.  Your selections will be saved and recalled at the start of your next flight.


Options
Payload
Engine
Elec
Cabin
Failures
Avionics Selection
Primary
Secondary
KX 155B
KX 155B
1
2
GNS 530
GTN 650
GTN 750
3
PMS50 GTN
TDS GTNxi
Confirm
4
Options
Unrestricted Beta Range
Show Beta Annunciator
Instant Beta On Touchdown
5
Cloud Strobe Effect
Load with Covers & Chocks Deployed
VR Tablet Static Position
Show Copilot from Inside

## 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 limits.

### **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. All cabin doors and baggage compartment doors can also be opened from the inside of the aircraft without the tablet interface. If a door fails to open, its operation is being impeded by the aircraft's condition, such as airflow around the aircraft, or the cabin pressurization. The oxygen cylinder can also be refilled via the weather radar display.

### **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 can also be toggled by clicking on the stowed wheel chocks 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
Engine
Elec
Cabin
Failures
gal/lbs
L/kg
Empty Weight: 4,237 lbs
Max. T/O Weight: 8,750 lbs
Useful Load: 4,513 lbs
Fuel on Board:
174 gal (1,174 lbs)
Endurance: 2.7 hrs
Range: 829 nm
Pilot Door
Copilot Door
Passenger Door
Refill Oxygen
170 lbs
Pilot
170 lbs
Copilot
170 lbs
Pax 1
340 lbs
Pax 2
170 lbs
Pax 3
340 lbs
Pax 4
Empty
Pax 5
Empty
Pax 6
Empty
Pax 7
Empty
Pax 8
Empty
Aft Baggage
Left
Main
167.8 gal
84 gal
566 lbs
Right
Main
167.8 gal
Exterior Elements
Wheel Chocks
Engine Covers
External Power
Nose
FWD
Limit
COG
AFT
Limit
Tail
1
2
3
4
5
6

## 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

This aircraft has an electric fuel boost pump and an engine driven pump, 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 torqometer, 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

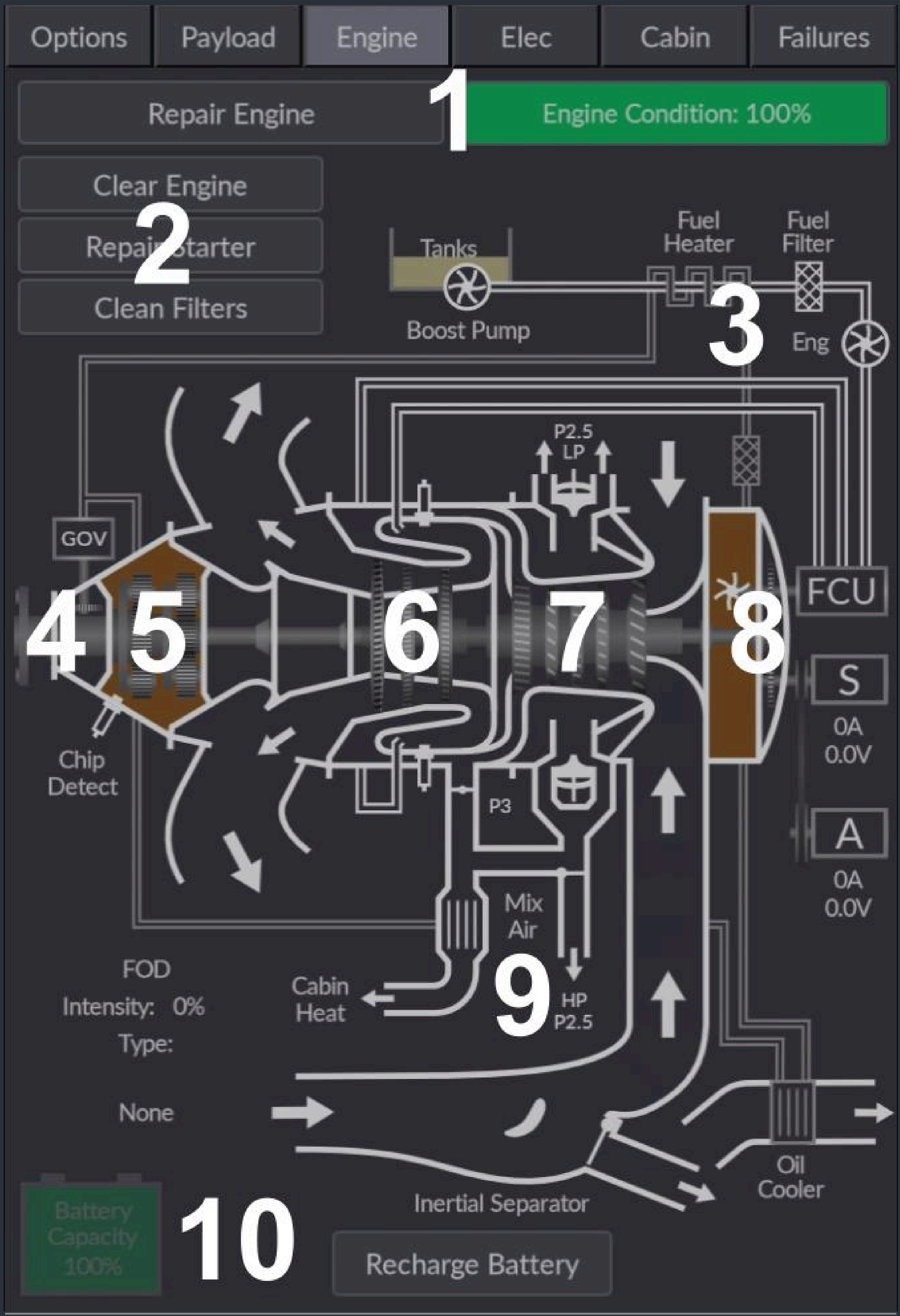
Control of the engine's intake and bleed air relies on a series of valves and louvers. Ambient air enters the induction system through the air inlet under the engine, at the bottom of the visualizer. This air is always at the same temperature and pressure as the air surrounding the aircraft.

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

When ambient pressure and temperature ram air reaches the gas generator, it is pressurized before entering the combustion chamber. This air is metered by the bleed air controller, before passing through the cooling muffler, and sent into the cabin air ducts. Also pictured here is the cabin heat mixing air valve, which either admits P2.5 bleed air into the cabin heating duct with the hotter P3 bleed air, or dumps the P2.5 bleed air overboard whenever the P2.5 bleed valve is open during engine operation at gas generator speeds below ~89%.

## **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
Engine
Elec
Cabin
Failures
Repair Engine
1
Engine Condition: 100%
Clear Engine
2
Repair Starter
Clean Filters
Tanks
Boost Pump
Fuel Heater
Fuel Filter
3
Eng
P2.5 LP
GOV
FCU
4
5
6
7
8
S
0A
0.0V
A
0A
0.0V
Chip Detect
P3
Mix Air
FOD
Intensity: 0%
Type:
None
Cabin Heat
9
HP P2.5
Oil Cooler
Inertial Separator
Battery Capacity 100%
10
Recharge Battery

## 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 selected tank into the fuel control unit (FCU). As the fuel lines are pressurized, a slug of fuel will travel from the tanks to the 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 run automatically, whenever the engine is at low power output, or manually, usually when the aircraft encounters severe turbulence or precipitation. See the “Turbine Engine Ignition” section of this manual for more information

### 3. 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 level 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.

### 4. Intake Air

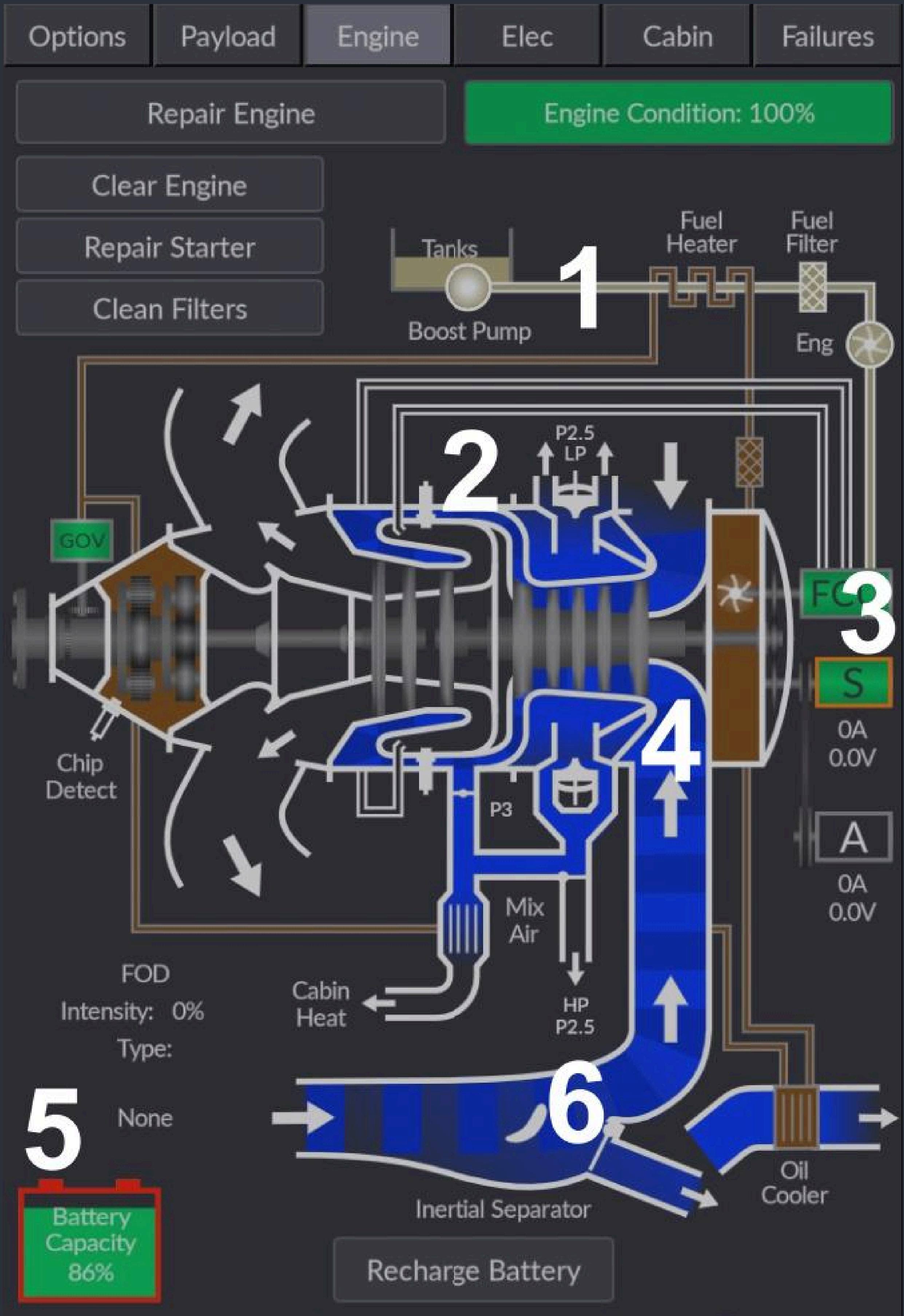
The gasses in the intake manifold are color-coded not for temperature, but pressure. Fully saturated, bright blue indicates sea level pressure. Darker blues indicate higher pressures, and greens and yellows indicate lower than sea level pressures. Seen here, the intake air is at the same pressure as 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.

### **5.** Battery Temperature

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.

### **6.** 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 Separator” section of this manual.


Options
Payload
Engine
Elec
Cabin
Failures
Repair Engine
Engine Condition: 100%
Clear Engine
Repair Starter
Clean Filters
Tanks
Boost Pump
1
Fuel Heater
Fuel Filter
Eng
2
P2.5 LP
GOV
3
S
0A
0.0V
A
0A
0.0V
4
Chip Detect
P3
Mix Air
FOD
Intensity: 0%
Type:
None
Cabin Heat
HP P2.5
5
6
Oil Cooler
Inertial Separator
Battery Capacity 86%
Recharge Battery

## 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 three 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 low pressure and high pressure P2.5 bleed valves help maintain the correct engine operating RPM, and are 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.  The oil cooler door is also now shown in the open position.

## 6. Chip Detector

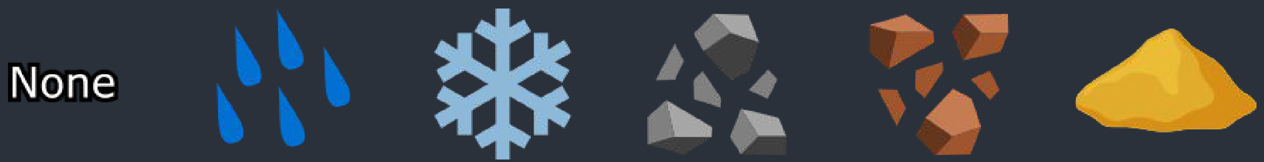
The chip detector is a magnetic pair of electrodes at the bottom of the planetary reduction gearbox oil sump.  This is the most likely location in the engine for metallic particles to collect due to wear.  The magnet attracts the particulate, and the electrodes allow for a complete circuit to be created 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 warning light will illuminate on the instrument panel.  A chip detect warning is usually indicative of an incipient engine failure, and power should be reduced immediately.

## 7. Standby Alternator

This aircraft incorporates a belt-driven standby alternator, the depiction of which here is similar to that of the main generator, described in the “Fuel Control Unit & Starter Motor” section, above.  Since the standby alternator is not also a starter motor, it will always display the letter “A”, for alternator, so as not to be confused with “S” for starter.

## 8. Foreign Object Debris (FOD)

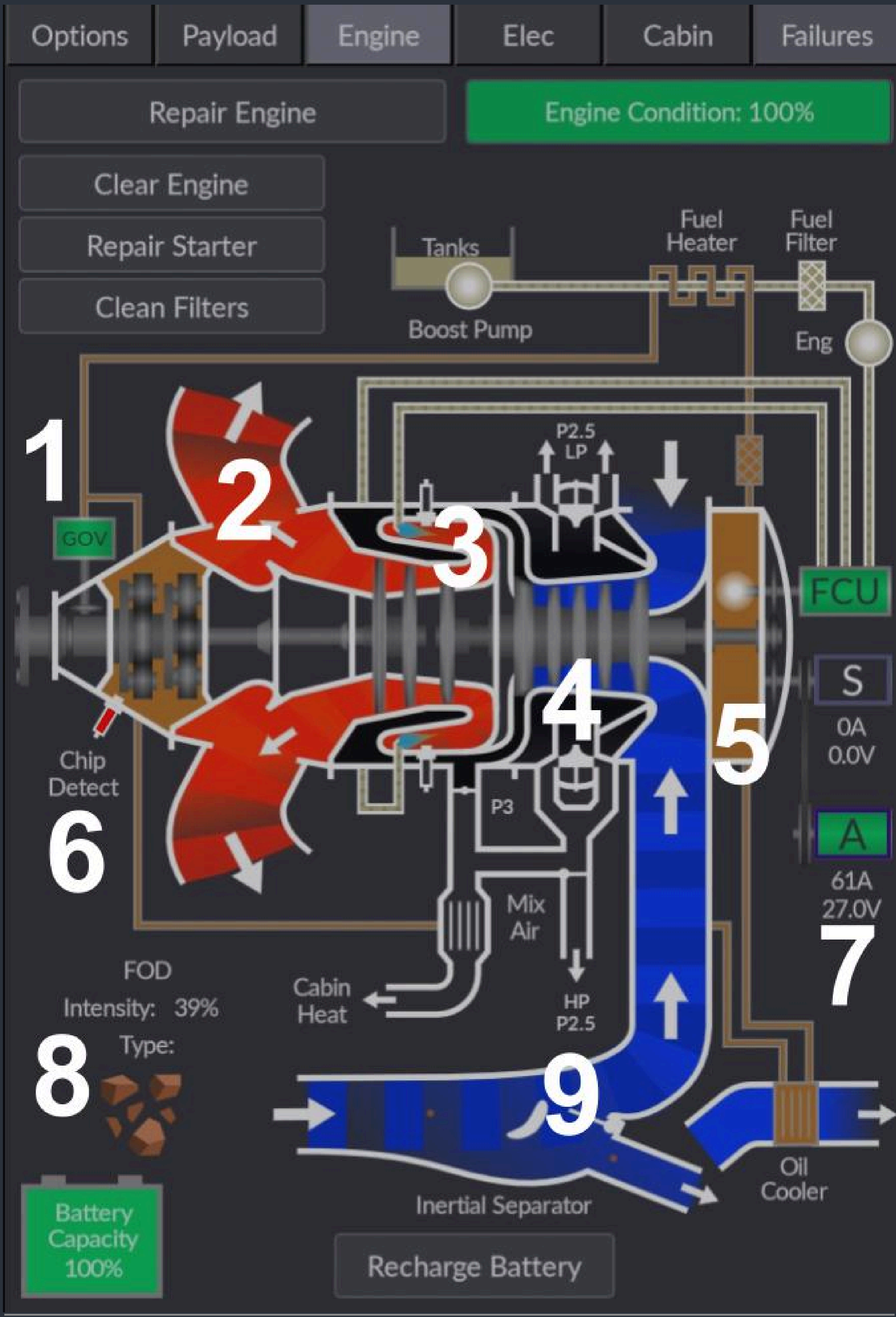
It is possible to encounter Foreign Object Debris (FOD) whenever operating on the ground, particularly on unimproved or worn surfaces.  FOD can also enter the engine in flight in the form of ice, heavy precipitation, or birds.  An icon representing the current type of FOD being encountered will appear 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
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Engine Condition: 100%
Clear Engine
Repair Starter
Clean Filters
Tanks
Boost Pump
Fuel Heater
Fuel Filter
Eng
1
2
3
GOV
P2.5 LP
FCU
S
0A
0.0V
4
5
Chip Detect
6
P3
A
61A
27.0V
Mix Air
7
FOD
Intensity: 39%
Type:
Cabin Heat
HP P2.5
8
9
Oil Cooler
Inertial Separator
Battery Capacity 100%
Recharge Battery

## Live Schematic Page

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. Voltmeter

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.

### 2. Active & Inactive Equipment

When a circuit component, such as a starter motor, is inactive, it will be grayed out.

### 3. 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 conductive metal to which many wires attach, though they can also be purely conceptual, and used to aid your 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 generator control switch sends a trigger voltage to the generator controller to energize the generator field windings, thus supplying output voltage to the main distribution bus through the generator controller.

### 4. 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.

## 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. Standby Alternator & Controllers

Several pieces of equipment in this aircraft have intelligent controllers that monitor their status, or control their output, such as the standby alternator or starter-generator.  These controllers are depicted as green rectangles, which are illuminated when they are receiving power.  For example, in this aircraft, no power can be used from the standby alternator unless the standby alternator controller is also receiving power and the alternator is activated by logic power from the standby alternator switch.

## 7. Circuit Breakers

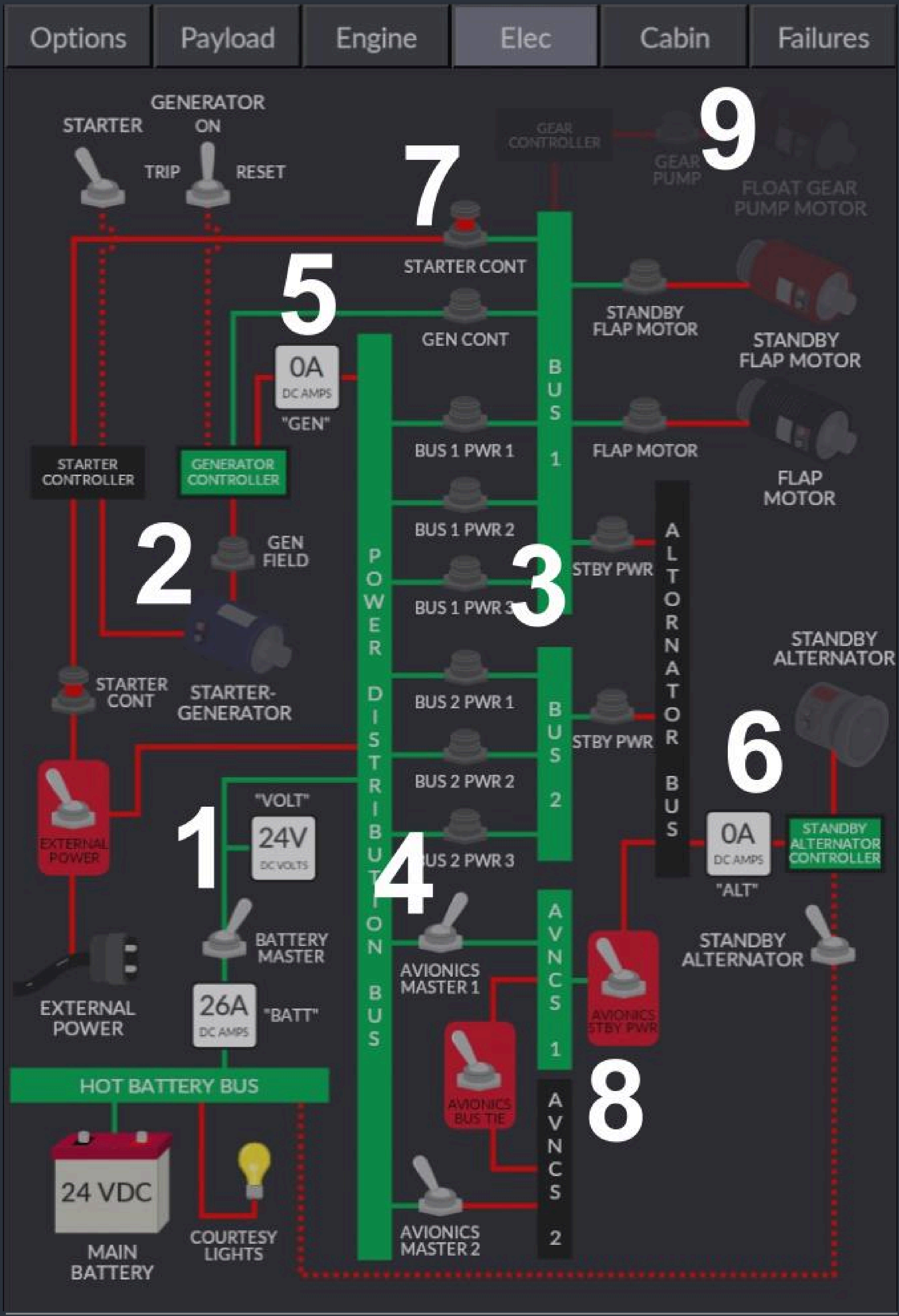
Circuit breakers will show their red collar when the breaker has been tripped by excessive current.  The breaker can be reset manually by clicking on the tripped breaker in the cockpit.  If the breaker has tripped due to a failure, it will trip again soon, assuming the circuit is still under load and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

## 8. Amphibious Gear Control

This aircraft is equipped with the electromechanical systems for landing gear control on amphibious floats.  When this package is not installed on the exterior of the aircraft, these systems will appear grayed out on the live schematic page.

## 9. Emergency Avionics Power

In this aircraft, two guarded switches allow for power to be routed through the two normally independent avionics buses in the event of a power distribution failure.  The avionics standby power switch is used to feed the number 1 avionics electrical bus directly from the standby alternator while bypassing all other electrical distribution.  The avionics bus tie switch can be used to directly connect the number 1 and number 2 avionics electrical buses, to bypass one of the bus feeder circuit breakers.



Options
Payload
Engine
Elec
Cabin
Failures
STARTER
GENERATOR ON
TRIP
RESET
GEAR CONTROLLER
GEAR PUMP
FLOAT GEAR PUMP MOTOR
9
7
STARTER CONT
5
GEN CONT
STANDBY FLAP MOTOR
STANDBY FLAP MOTOR
0A
DC AMPS
"GEN"
BUS 1
BUS 1 PWR 1
FLAP MOTOR
FLAP MOTOR
STARTER CONTROLLER
GENERATOR CONTROLLER
BUS 1 PWR 2
GEN FIELD
2
POWER DISTRIBUTION BUS
BUS 1 PWR 3
3
STBY PWR
ALTORNATOR BUS
STANDBY ALTERNATOR
STARTER CONT
STARTER-GENERATOR
BUS 2 PWR 1
BUS 2
STBY PWR
6
BUS 2 PWR 2
"VOLT"
24V
DC VOLTS
1
EXTERNAL POWER
4
BUS 2 PWR 3
0A
DC AMPS
"ALT"
STANDBY ALTERNATOR CONTROLLER
BATTERY MASTER
AVNCS 1
AVIONICS MASTER 1
AVIONICS STBY PWR
STANDBY ALTERNATOR
EXTERNAL POWER
26A
DC AMPS
"BATT"
AVIONICS BUS TIE
HOT BATTERY BUS
8
AVNCS 2
24 VDC
MAIN BATTERY
COURTESY LIGHTS
AVIONICS MASTER 2

# Cabin Climate Visualizer Page

Although the Caravan Professional is a simple aircraft in many respects, it also has a large cabin with many passengers to keep comfortable. The climate control system has several manual controls that must be correctly configured to effectively heat or cool the cabin.

## Heating Cabin

When the desired cabin temperature is warmer than the outside ambient air, heating is provided by the P2.5 or 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. Engine Bleed Air Supply

The heating system in this aircraft derives hot air primarily from the P3 bleed valve on the engine. Cooler air can also be sourced from the P2.5 bleed air valve and mixed with the P3 bleed air instead of cabin return air to raise the temperature of the heating air before it enters the cabin. Here, we see two valves for the P3 and P2.5 bleed air sources, which are controlled via the red “BLEED AIR HEAT” switch on the instrument panel.

### 2. Cabin Heat Mixing Valve

The cabin heat mixing valve is controlled via a pull handle on the instrument panel, and selects whether P2.5 bleed air, or cabin return air is mixed with the P3 bleed air before entering the cooling muffler, and then the cabin. P2.5 bleed air that is not mixed with the P3 bleed air is exhausted overboard.

### 3. Firewall Shutoff Valve

A red pull handle on the lower pedestal controls a valve capable of isolating the cabin from engine bleed air in the event of an emergency. This valve is located downstream of the other bleed air valves discussed above, at the aft of the engine compartment.

### 4. 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.

## **5.** Air Vents & Air Flow Selector Valves

Cabin heating air can be directed forward through the cockpit vents, or aft, through the cabin side wall vents by pulling the middle of the three heating air control pull handles on the instrument panel. Air that is directed towards the cockpit can be further diverted towards the windshield through the defroster ducts. For more information on the environmental control systems, see the “Environmental Simulation & Controls” section of this manual.

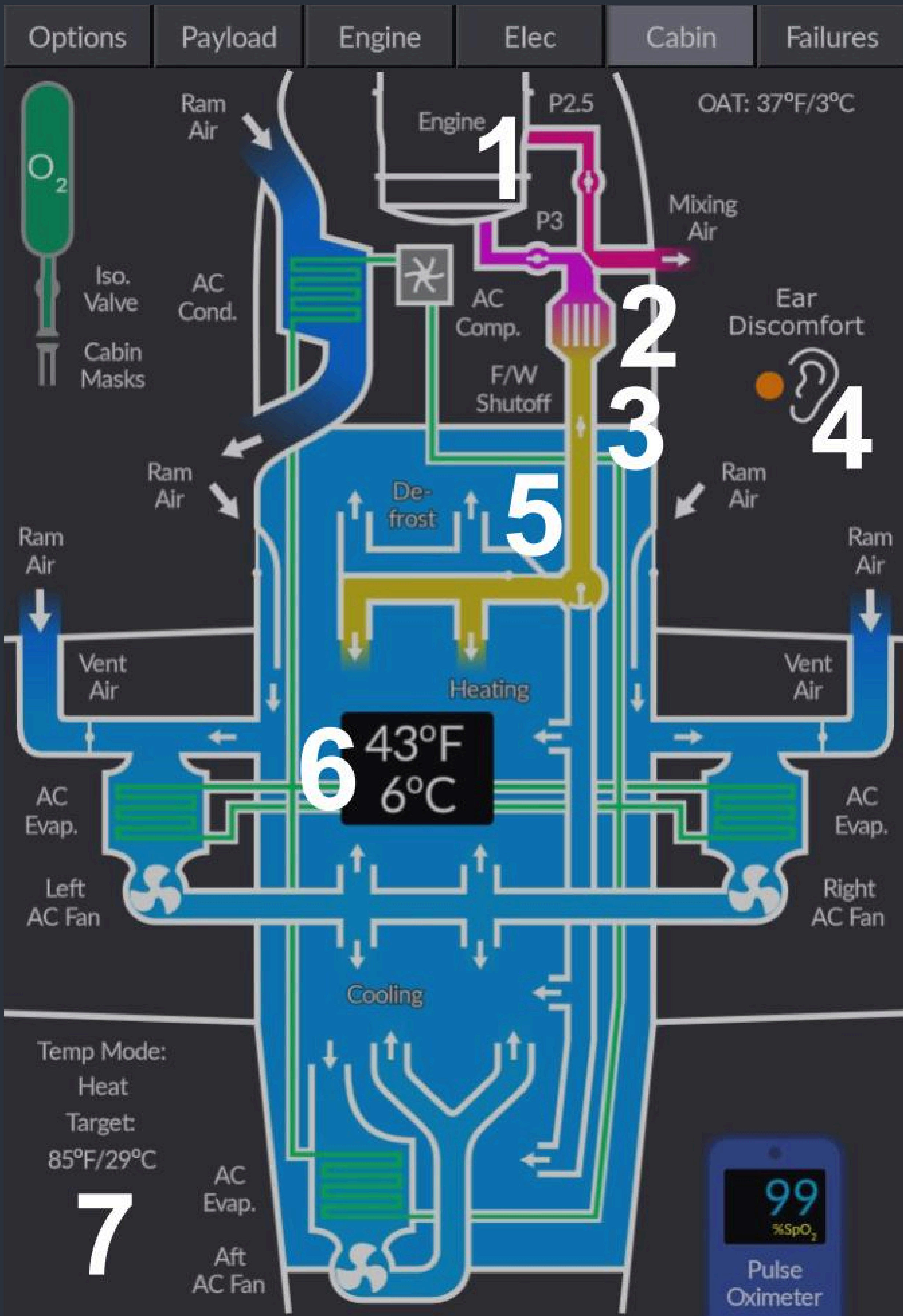
## **6.** Main Cabin Volume & Vents

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.

## **7.** Climate Control Modes & Target

The operating mode of the climate control system is implied by the position of the “BLEED AIR HEAT” and air conditioning and ventilation switches. This mode is annunciated, along with the temperature controller’s target cabin temperature. For instance, if the air conditioning switch is placed in the “COOL” position, but the “BLEED AIR HEAT” switch is also in the “ON” position, the displayed climate control system mode will be “heat”, as the heating air has the potential to overpower the air conditioner.

The target temperature will display the numeric set point of the “TEMP HOT” rotary selector knob, when the active climate control system is receiving power. 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 adjust the cabin heat mixing air pull handle while attempting to heat the cabin. When attempting to cool the cabin, this either indicates that the ambient temperature is too hot to adequately cool the cabin, or that the air conditioner is being defeated by the hot bleed air. Here, the heating target temperature can be seen in degrees Fahrenheit and Celsius.


Options
Payload
Engine
Elec
Cabin
Failures
Ram Air
Engine
P2.5
OAT: 37°F/3°C
1
P3
Mixing Air
$O_2$
Iso. Valve
AC Cond.
AC Comp.
2
Ear Discomfort
Cabin Masks
F/W Shutoff
3
4
Ram Air
5
Ram Air
De-frost
Ram Air
Ram Air
Vent Air
Heating
Vent Air
6
43°F
6°C
AC Evap.
AC Evap.
Left AC Fan
Right AC Fan
Cooling
Temp Mode:
Heat
Target:
85°F/29°C
7
AC Evap.
Aft AC Fan
99
%$SpO_2$
Pulse Oximeter

## 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. 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 below 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.  The second valve controls the flow of oxygen to the cabin oxygen mask outlets in the ceiling, here also seen in the open position.

### 2. Air Conditioning Condenser Ram Air

The vapor cycle cooling system requires cool ram air from the exterior of the aircraft to function, which is passed over the air conditioning condenser.  This air is admitted to the engine cowling through a louvered grill on the pilot’s side of the engine cowling, and then exhausted through a similar louvered grill directly aft of the inlet.

### 3. Air Conditioning Compressor & Condenser

The air conditioning system (also known as the vapor cycle cooling system), is driven by a clutched compressor on the accessory gearbox of the engine.  The clutch will only engage when the gas generator RPM of the engine 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 refrigerant pipes pass through a condenser on the pilot’s side of the engine cowling, which requires cooler ambient air to operate.  For more information on the air conditioning operation, see the “Environmental Simulation & Controls” section of this manual.

### 4. Ram Air Cockpit Vents

Two pull handles, marked “VENT PULL ON”, on either side of the main instrument panel can be used to deploy two small doors on the exterior of the aircraft, just forward and below the windshields.  These vents admit ambient temperature ram air into the cabin.

### 5. Cabin Air Inlet Valves

Each wing strut fairing has a grilled air inlet, which can be used to admit ambient temperature air into the cabin by rotating the “VENT AIR” knobs on the overhead panel.  When attempting to actively heat or cool the aircraft, these valves should be in the closed position to prevent conditioned air from escaping through the wing intakes, and to prevent unconditioned air from being forced into the cabin during flight.

## 6. Ventilation Fans & Air Conditioning Evaporators

Just downstream of the cabin vent air control valves and at the aft of the cabin are the air conditioning evaporators coils, and air conditioning ventilation fans. When the air conditioning compressor is operating, chilled refrigerant will be passed through the evaporator coils. The fans will run any time the air conditioning switch is positioned either in the “VENTILATE” or “COOL” position. The ventilation fan speed can be increased with the three “AC FANS” switches, which will affect the overall rate of heating or cooling.

## 7. Pulse Oximeter

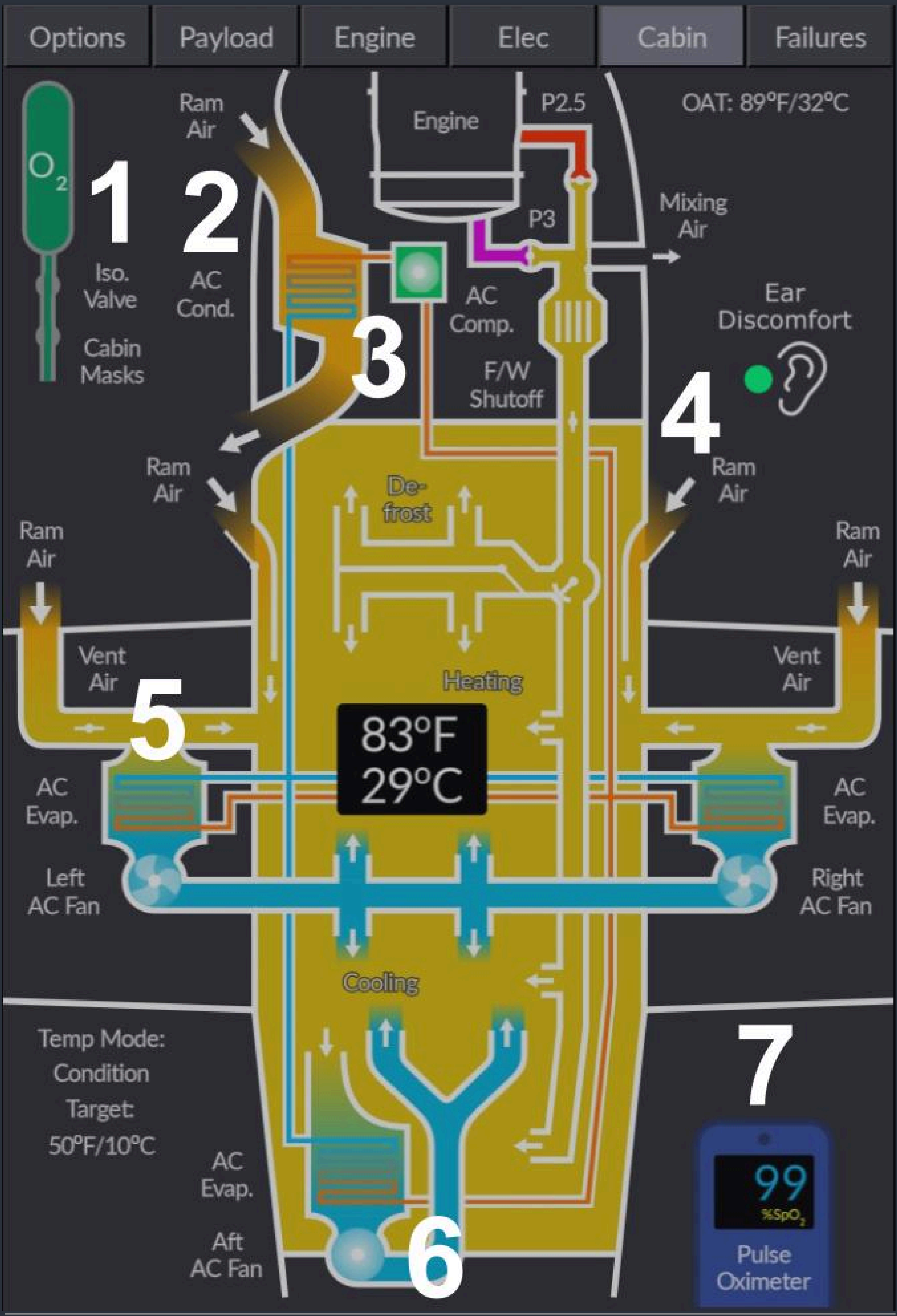
Loss of conscientiousness and impaired cognitive functioning in low oxygen environments does not happen instantaneously. Except in the case of the most severe decompression events, oxygen must leave the blood supply in order for hypoxia to take effect. This process can take over an hour at lower cruising 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, descend immediately to a lower altitude, or open the oxygen valve to use supplemental oxygen.

Generally speaking, 98% oxygen saturation ($SpO_2$) 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 $SpO_2$ of roughly 90-92% for exposure under 60 minutes.

An $SpO_2$ below 90% results in cognitive impairment, possibly detrimental to flight safety.

An $SpO_2$ below 80% can lead to incapacitation after exposure of just a few minutes.



Options
Payload
Engine
Elec
Cabin
Failures
Ram Air
Engine
P2.5
OAT: 89°F/32°C
O2
1
2
Iso. Valve
AC Cond.
AC Comp.
P3
Mixing Air
Cabin Masks
3
F/W Shutoff
Ear Discomfort
4
Ram Air
Ram Air
De-frost
Ram Air
Ram Air
Vent Air
Vent Air
5
Heating
83°F
29°C
AC Evap.
AC Evap.
Left AC Fan
Right AC Fan
Cooling
Temp Mode:
Condition
Target:
50°F/10°C
7
AC Evap.
Aft AC Fan
6
99
%SpO2
Pulse Oximeter

## 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

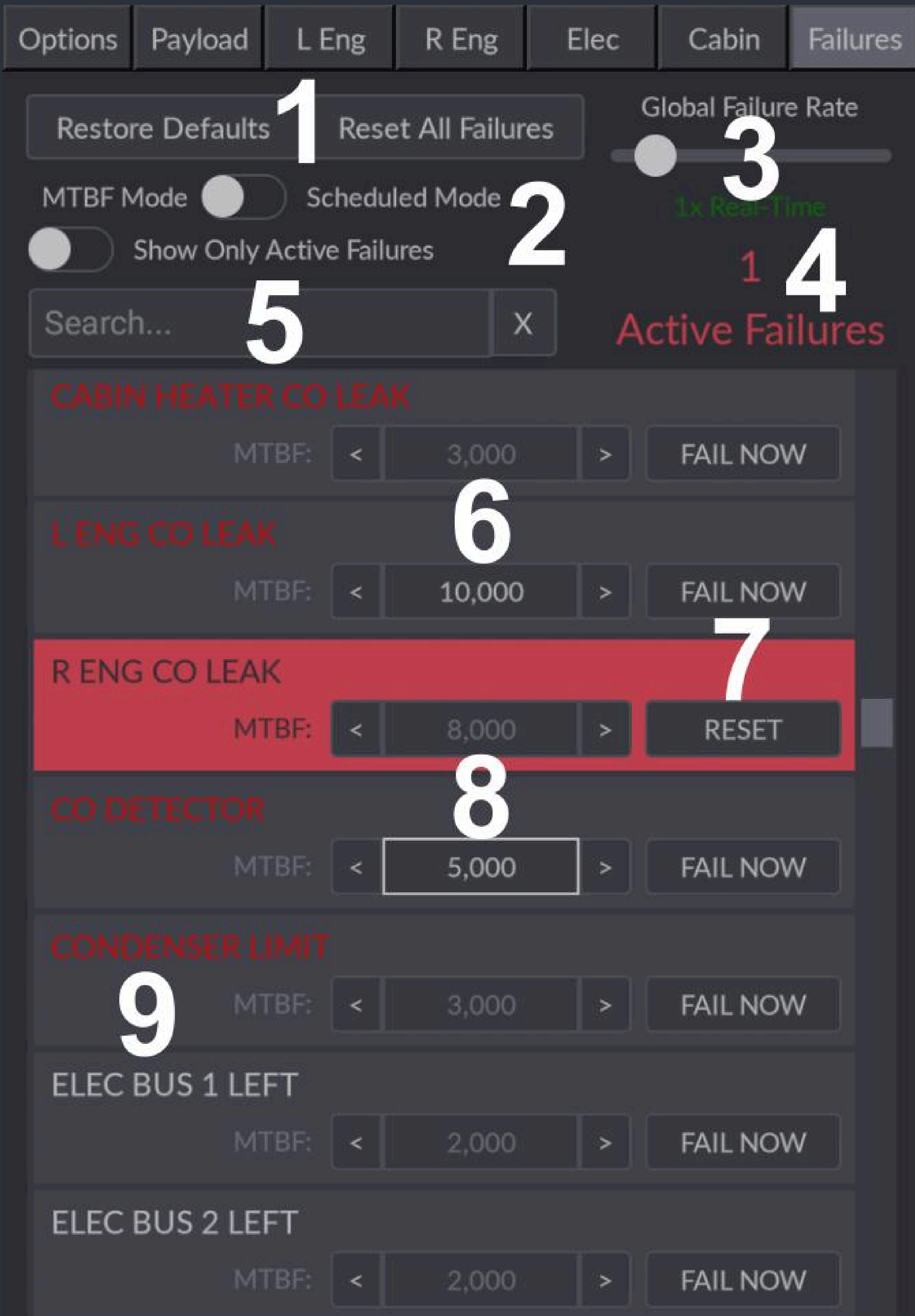
After being triggered by any means, individual failures can be reset by pressing the "RESET" button. Failures can also be triggered manually in this mode by pressing the "FAIL NOW" button.

## 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
CABIN HEATER CO LEAK
MTBF:
3,000
FAIL NOW
6
L ENG CO LEAK
MTBF:
10,000
FAIL NOW
7
R ENG CO LEAK
MTBF:
8,000
RESET
8
CO DETECTOR
MTBF:
5,000
FAIL NOW
CONDENSER LIMIT
9
MTBF:
3,000
FAIL NOW
ELEC BUS 1 LEFT
MTBF:
2,000
FAIL NOW
ELEC BUS 2 LEFT
MTBF:
2,000
FAIL NOW

## 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

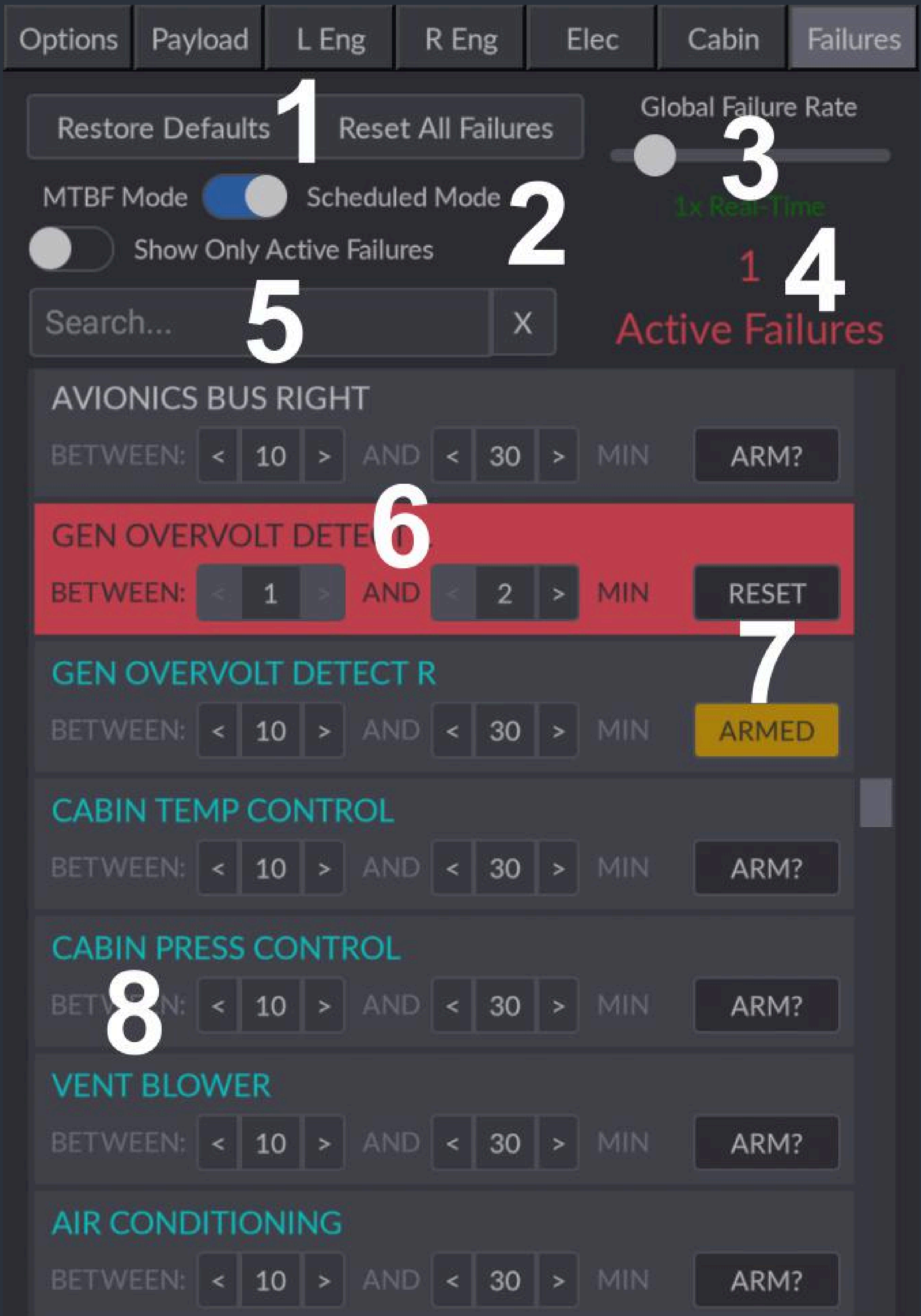
The time window in which a specific failure will occur can be adjusted with the arrow buttons beside the “after” and “before” times.  These times are expressed in minutes.  The minimum time after which a failure will occur is one minute, and the maximum time before which a failure will occur is ninety 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
1x Real-Time
MTBF Mode
Scheduled Mode
Show Only Active Failures
1
Active Failures
Search...
X
AVIONICS BUS RIGHT
BETWEEN: < 10 > AND < 30 > MIN
ARM?
GEN OVERVOLT DETECT L
BETWEEN: < 1 > AND < 2 > MIN
RESET
GEN OVERVOLT DETECT R
BETWEEN: < 10 > AND < 30 > MIN
ARMED
CABIN TEMP CONTROL
BETWEEN: < 10 > AND < 30 > MIN
ARM?
CABIN PRESS CONTROL
BETWEEN: < 10 > AND < 30 > MIN
ARM?
VENT BLOWER
BETWEEN: < 10 > AND < 30 > MIN
ARM?
AIR CONDITIONING
BETWEEN: < 10 > AND < 30 > MIN
ARM?
1
2
3
4
5
6
7
8

# 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

ENGINE FAILURE
ENGINE FIRE
MAIN GENERATOR
STANDBY ALTERNATOR
PROPELLER GOVERNOR
FUEL CONTROLLER
ENGINE SURGE
PRIMARY INJECTORS
SECONDARY INJECTORS
LP BLEED
HP BLEED
FUEL FILTER
ENG DRIVEN FUEL PUMP
MAIN FLAP MOTOR
STBY FLAP MOTOR
VACUUM PUMP
PARTIAL VACUUM
PITOT BLOCKAGE
STATIC BLOCKAGE
L BRAKE
R BRAKE
OXYGEN LEAK
OXYGEN ISOLATION VALVE
L FUEL LEAK
R FUEL LEAK
DEICE BOOT INTEG
BLEED OVERTEMP
DOOR LATCH
MANUAL GEAR EXTENSION
WATER RUDDER CABLE

# Electrical Bus Failures

ELEC BUS 1-1
STBY POWER 1
ELEC BUS 2-1
STBY POWER 2
ELEC BUS 1-2
ELEC BUS 2-2
ELEC BUS 1-3
ELEC BUS 2-3

# Breaker Protected Failures

IGNITION
STARTER CONTROLLER
GEN CONTROLLER
GEN FIELD
AUX FUEL PUMP
ANNUNCIATOR PANEL
FIRE DETECTOR
AP ANNUNCIATOR PANEL
REMOTE COMPASS GYRO
L TURN COORDINATOR
R TURN COORDINATOR
ITT GAUGE
OIL TEMP GAUGE
FUEL FLOW GAUGE
L FUEL QUANTITY
R FUEL QUANTITY
OVERSPEED TEST
BLEED AIR VALVE
L PITOT HEAT
R PITOT HEAT
WSHLD ANTI-ICE
WSHLD ANTI-ICE CONTROL
DE-ICE BOOTS
PROP ANTI-ICE
PROP ANTI-ICE CONTROL
FUEL CONTROL HEATER
L LANDING LIGHT
R LANDING LIGHT
STROBE LIGHT
BEACON LIGHT
TAXI LIGHT
NAV LIGHTS
MAP LIGHTS
INSTRUMENT LIGHTS
RADIO LIGHTING
CABIN LIGHTS
WING ICE LIGHT
L VENT BLOWER
R VENT BLOWER
AFT VENT BLOWER
STALL WARNING
AIR CONDITIONING
BLIND ALT ENCODER
STBY HORIZON
ALT ENCODER
ELEC TRIM
COMM 1
NAV 1
XPNDR
GLIDESLOPE 1
ADF
HSI
GYRO MAG SLAVING
AUDIO PANEL
AP ACTUATORS
AP CONTROLLER
COMM 2
NAV 2
GLIDESLOPE 2
DME
RNAV
RADAR ALT
AVIONICS FAN
AUDIO AMPLIFIER
FUEL SELECTOR WARN
WX RADAR CONTROLLER
WX RADAR ANTENNA
AMPHIB GEAR CONTROL
AMPHIB GEAR PUMP

# Miscellaneous Systems

## Audible Warning Tones

This version of the Caravan 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 beeping tone will sound five times quickly when the aircraft is within 1,000 ft of the selected altitude displayed on the KAP140 Autopilot.
- Autopilot Disconnect Tone: Whenever the autopilot is disconnected via the autopilot master push button, the control yoke mounted disconnect buttons, or automatically disconnects when overpowered, a soft warning chime will sound.
- Stall Warning Horn: When the aircraft is within approximately 5-10 knots of stalling speed, a constant tone warning horn will sound.
- Overspeed Horn: When the aircraft exceeds the VNE (red line) airspeed on the airspeed indicator, a repeating beeping tone warning will sound until the speed of the aircraft is reduced to below VNE.
- Engine Fire Siren: When a fire is detected in the engine, a loud siren will sound to alert the pilot to take immediate action. This tone cannot be canceled or silenced except by extinguishing the engine fire, or pulling the fire detector circuit breaker. Through completing the engine fire checklists, the pilot will close the fuel shutoff valve and disable the aircraft's power sources. This will cease the warning sound. The fire warning siren can be tested by pressing the red fire detector test button adjacent to the annunciator panel. This warning siren will be accompanied by the RED "ENGINE FIRE" annunciator.
- Fuel Selector Off Tone: Added to later model Caravans as the result of early accidents, a warning tone is incorporated to alert the pilot of when the engine has been disconnected from all potential fuel supplies, either by the overhead fuel selectors, or by the firewall valve pull handle on the lower pedestal. The warning system is also activated anytime either fuel selector is off during engine starting, or when only one fuel tank is feeding, and that fuel tank's quantity is less than approximately 25 US gallons.

  This warning tone can be disabled by pulling the fuel selector warning circuit breaker at the bottom of the circuit breaker panel, but the annunciator will continue to indicate normally. The system can be completely disabled by pulling both the fuel selector warning circuit breaker, and the starter controller circuit breaker. The tone can be tested by pressing the annunciator test button when Avionics Bus #1 is receiving power. This warning tone will be accompanied by a red "FUEL SELECT OFF" annunciator.

## Amphibious Gear Advisory System

The amphibian package includes a gear advisory system to remind the operator of the correct gear configuration for the surface type below the aircraft. When the aircraft descends below 400ft AGL, a laser system assesses the surface type under the aircraft. If the gear is correctly positioned for the surface type, the system will announce once either, “gear is up for water landing”, or “gear is down for runway landing”. If the surface type is not correct, the system will announce, “check gear” continuously, until the correct gear position is selected, or the gear advisory push button is pressed. When climbing through 1,500ft AGL, If the landing gear is not retracted after takeoff, the system will announce, “check gear position” until the gear is raised, or the gear advisory push button is pressed.

## VOR & ADF Signal Degradation

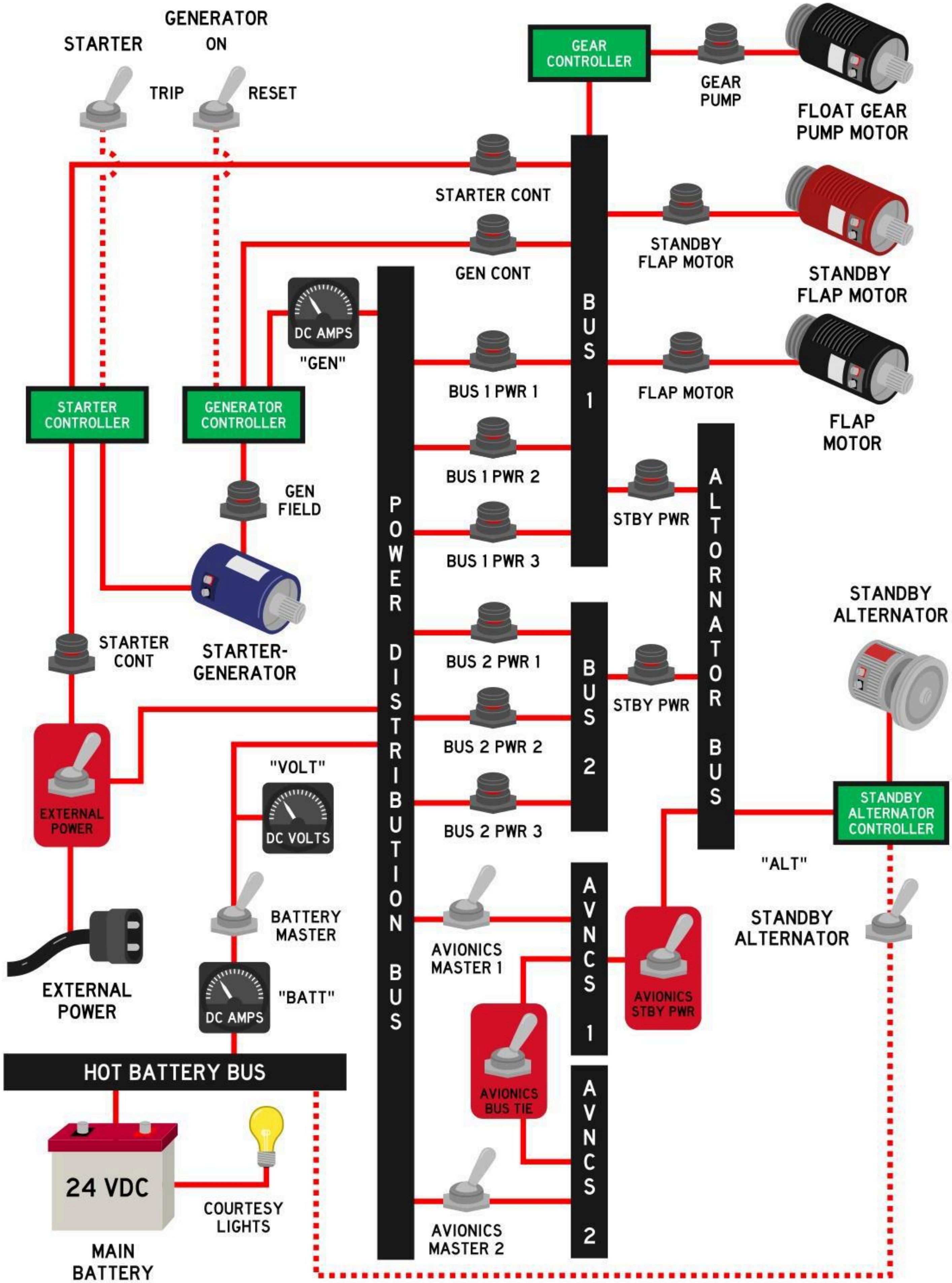
Unlike in the real world, navigation receivers in Microsoft Flight Simulator produce only ideal readings. Signal strength is not affected by distance, altitude, terrain, or atmospheric conditions. When a station is out of range, the signal is abruptly switched off. This is unrealistic, and does not give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

# Overview Electrical Schematic

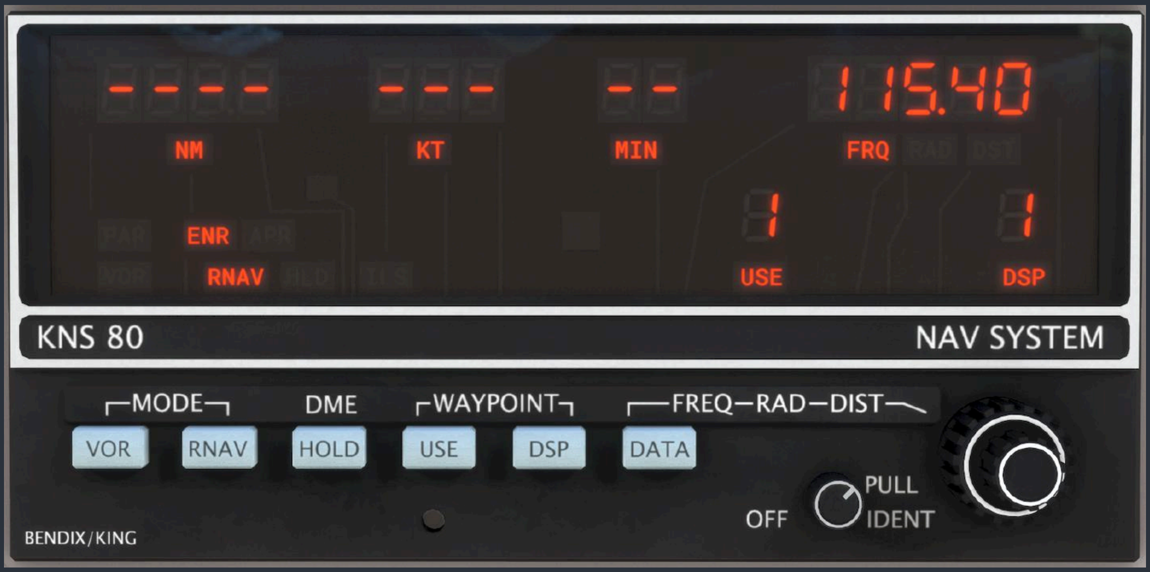
The Caravan Professional’s electrical system is relatively simple for an aircraft of its size, but contains a few safety features to mitigate the risk posed by an electrical distribution failure.

**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.**



STARTER
GENERATOR
ON
TRIP
RESET
GEAR CONTROLLER
GEAR PUMP
FLOAT GEAR PUMP MOTOR
STARTER CONT
STANDBY FLAP MOTOR
STANDBY FLAP MOTOR
GEN CONT
DC AMPS
"GEN"
BUS 1
BUS 1 PWR 1
FLAP MOTOR
FLAP MOTOR
STARTER CONTROLLER
GENERATOR CONTROLLER
BUS 1 PWR 2
GEN FIELD
STBY PWR
ALTORNATOR BUS
POWER DISTRIBUTION BUS
BUS 1 PWR 3
STANDBY ALTERNATOR
STARTER CONT
STARTER-GENERATOR
BUS 2 PWR 1
BUS 2
STBY PWR
BUS 2 PWR 2
"VOLT"
EXTERNAL POWER
DC VOLTS
BUS 2 PWR 3
STANDBY ALTERNATOR CONTROLLER
"ALT"
BATTERY MASTER
AVIONICS MASTER 1
AVNCS 1
STANDBY ALTERNATOR
EXTERNAL POWER
DC AMPS
"BATT"
AVIONICS STBY PWR
AVIONICS BUS TIE
HOT BATTERY BUS
AVNCS 2
24 VDC
COURTESY LIGHTS
AVIONICS MASTER 2
MAIN BATTERY

# Using the KNS-80 RNAV Navigation System




## The Concept

When most pilots hear the acronym "RNAV", they probably think of the modern RNAV, or GPS approach type, or precision enroute navigation for airliners; however, long before this type of navigation, there was the onboard RNAV computer. This 1980's era digital computer allowed pilots to fly complex routes with precision away from traditional ground-based radionavigation sources, such as VOR's and NDB's, and fly much shorter routes as a result. As the technology improved, even an early form of RNAV approaches became possible. Before GPS, the onboard RNAV computer allowed for GPS-like flying in a sophisticated package of digital electronics, marketed towards small to mid-size general aviation aircraft.

## How it Works

To understand how the RNAV computer works, consider the utility of being able to place a ground-based VOR antenna anywhere you like along your route. If your destination airport does not have a radionavigation source on the field, you could simply place one there, and fly directly to or from it. You could also place an antenna 10 miles out from a runway to set up for a non-precision approach. You could even place an antenna on the threshold of a runway, set your HSI course to the runway heading, and fly right down to the runway with lateral guidance; in fact, this is how an ILS receiver works. The KNS-80 Navigation System allows the user to "move" a virtual VOR antenna anywhere they like within the service volume (area of reliable reception) of an existing VOR antenna.

## "Moving" a VOR

To "move" a VOR antenna to somewhere useful, we must know how far from the tuned VOR station we would like to move it, and in what direction. These quantities are defined by a nautical mile distance, and a radial upon which we would like to move the antenna. For example, to place a virtual VOR 10 miles to the Southwest of an existing station, we would need to enter the station's frequency, a displacement radial of 225°, and a displacement distance of 10.0 nm. Once we have entered this data into the RNAV computer, the resulting reading from this new virtual VOR station will be indicated on our HSI in the same manner as any other VOR, assuming the HSI source selector switch is set to "RNAV", and not "NAV1". This means that you can rotate the course select adjustment knob to any position you like, to fly to/from from the new virtual station on any radial or bearing, so long as you stay within the service volume of the tuned VOR station.

## Data Entry

Now that you understand the basics of RNAV navigation, let's learn how to enter the data from above into the KNS-80. On the right side of the unit, you will find the "DATA" push button, and the adjacent data entry knob. Between the two exists a marking, reading, "FREQ-RAD-DST", to remind you of the order in which data should be entered, frequency first, then radial, and finally distance. At any given time, either "FRQ", "RAD", or "DST" is shown on the LCD screen to indicate which type of data is being entered. Press the "DATA" push button to cycle through the data entry process, and use the data entry knob to tune a frequency, enter a radial, and finally a distance.

## Data Storage Bins

Below the data entry area on the screen, there are two numbers shown, 1-4, in either the "USE" or the "DSP" (Display) positions. The KNS-80 can hold up to four different combinations of frequency, radial, and distance data at one time. This can be greatly useful while planning a flight on the ground. The data channel being edited is indicated by the "DSP" number, and the data being used by the computer and subsequently displayed on the HSI is indicated by the "USE" number. To cycle through the two numbers, press the "USE" or "DSP" push buttons to the left of the "DATA" push button. Whenever the two numbers are different, indicating that one data channel is being edited, but another is being displayed on the navigation equipment, the "USE" numeral will flash continuously.

## Distance Measuring Equipment

On the top left-hand side of the LCD display is a traditional Distance Measuring Equipment (DME) display, with a nautical mile distance to the virtual VOR station, a current speed of the aircraft relative to the station, and a time-to-go until over the station. It should be noted that, like all other DME displays, this one is similarly dependent on being within the VOR service volume, and having good line-of-sight reception of the station. It should also be noted that these distances, speeds, and times, are based on slant-range to the station, not distance along the ground, as one would draw on a map. For most procedures, it was determined that this fact did not make such a large difference as to be detrimental to the procedure, but pilots should still be aware of the distinction. Pressing the "HOLD" push button will place the unit in DME hold mode, which will hold the current DME frequency and information on the unit's display while allowing the user to change the tuned NAV frequency. This can be useful for some specific instrument approaches. This feature cannot be used in RNAV modes of operation.

### Modes of Operation

Lastly, in the bottom left-hand corner of the LCD display, the KNS-80's many modes are annunciated. The KNS-80's modes fall into two categories; VOR and RNAV, and are activated by the "VOR" and "RNAV" push buttons. Further subcategories of modes are activated by pressing the appropriate push button multiple times. The VOR modes allow for the driving of an HSI with traditional VOR and ILS (including glideslope) data from the unit's third VHF navigation receiver. The VOR mode allows for behavior identical to a standard VOR receiver, with 10° of full-scale deflection to either side of the HSI's course deviation indicator (CDI). Pressing the VOR button again will enter PAR mode, which puts the CDI in a "PARallel" mode of operation, and linearizes the course deviation to +/- 5 nm full-scale deflection. This can be useful for tracking airways more accurately. Pressing the RNAV push button will enter the RNAV modes, where the CDI deflection is based on the displaced virtual VOR shown in the "USE" numeral. There are two RNAV modes, "RNAV/ENR" (Enroute), which drives the CDI with linear deflections of +/- 5 nm full-scale, and "RNAV/APR" (Approach), which drives the CDI with linear deflections of +/- 1.25 nm full-scale. Finally, when an ILS frequency is tuned in the currently USEd RNAV data, "ILS" will annunciate on the screen.

**Modes in Summary:**

**VOR:** Angular course deviation, 10° full-scale deflection, just like a third NAV radio.
**VOR/PAR:** Linear course deviation, 5 nm full-scale deflection, useful for existing airways.

**RNAV/ENR:** Linear course deviation, 5 nm full-scale deflection, displaced VOR waypoints.
**RNAV/APR:** Linear course deviation, 1.25 nm full-scale deflection, displaced VOR waypoints.

### Other Possible Uses

Another possible use for the RNAV Navigation System is simply determining your distance away from an arbitrary point within a VOR service volume. This can be useful for many applications, such as ensuring that you remain clear of controlled airspace, or a temporary flight restriction (TFR). It could also be used for maintaining a certain distance away from a coastline, or flying circles around a target on the ground. A further possible use for the RNAV Computer is enhanced VOR "Fencing", such as for avoiding special use airspace, military operations areas, international airspace borders, or Air Defense Identification Zones (ADIZ), or descent planning, or radionavigation switchover points. Finally, one of the most useful applications of the RNAV System is in establishing holding patterns. Before GPS, holding pattern entry and flight could be even more confusing than it already is today. With an RNAV computer, a holding point entry waypoint can be placed anywhere, and flown around like there is a purpose-placed ground-based transmitter at the entry point.

## Flying an RNAV Course with the Autopilot

The autopilot will only use the KNS-80 as a navigation source when the no-GPS avionics configuration is selected from the tablet interface. Press the navigation source button to illuminate its "RNAV" annunciator. Use the toggle switch below the localizer to select "RNAV" as the HSI source. Then, select the desired course with the HSI's course select knob.

## Recommended Skills

1. Direct Route Navigation
2. Parallel Flight along Airways
3. Location & Distance from Waypoints
4. Enhanced Geo-Fencing
5. Maintaining Distance from Ground Points
6. Holding Pattern Entries
7. Fly a Rectangular Course

## Direct Flight to Airport Tutorial

Lastly, as a first illustration of the power within the RNAV navigator, follow these steps to fly from any location within the chosen VOR service volume directly to an airport of your choosing without the need for any colocated navigational aid.

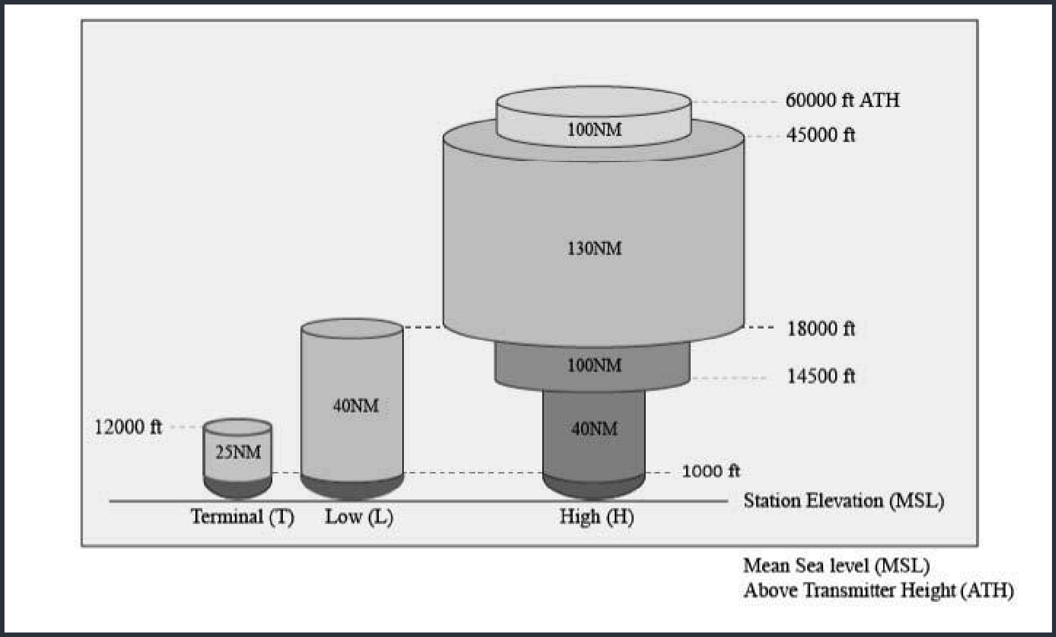
1. Locate the nearest VOR station to your desired destination, and its frequency, radial, and distance from the destination airport. While other station frequencies, radials, and distances can be found on approach, arrival, and departure charts, the easiest place to start is often with a mobile app or website that lists nearby stations along with other airport information. Examples include: ForeFlight, Garmin Pilot, FltPlan Go, SkyVector.com, and Airnav.com. These radials and distances can also be calculated during preflight planning by hand with a plotter, or with most flight planning software applications. In this case, we will use SkyVector.com to search for a destination airport, in this case, Beverly Airport in the US state of Massachusetts.

Nearby Navigation Aids

| ID | Name | Freq | Radial / Range | | ID | Name | Freq | Bearing / Range | |
|---|---|---|---|---|---|---|---|---|---|
| **LWM** | LAWRENCE | 112.50 | 154° | 12.3 | **OW** | STOGE | 397 | 198° | 29.4 |
| **BOS** | BOSTON | 112.70 | 029° | 14.0 | **MJ** | FITZY | 209 | 302° | 31.9 |
| **NZW** | SOUTH WEYMOUTH | 133.40 | 017° | 26.1 | **ESG** | ROLLINS | 260 | 005° | 38.4 |
| **MHT** | MANCHESTER | 114.40 | 145° | 26.3 | **CO** | EPSOM | 216 | 323° | 39.9 |

In the fourth block of data, we are presented with four nearby VOR stations (on the left), all providing good coverage to Beverly Airport. To assess whether or not a VOR provides good service to your destination, reference the following chart for VOR service volumes published by the Federal Aviation Administration. For the vast majority of VOR stations, reception will be acceptable within 40 nm of the station while in-flight, and is usually the only volume worth considering for low altitude general aviation flights.

For this example, we will choose the nearest VOR at Lawrence Airport, (LWM). This VOR has a frequency of 112.50 Mhz, a radial to Beverly Airport of 154°, and a distance of 12.3 nm. These are all three pieces of data that we need to fly directly to Beverly.




2. Enter the three pieces of data we located above into the KNS-80 RNAV computer. Once the KNS-80 is powered on, all your data entered during previous flights will be loaded from memory, and the active "display", and "use" data channels will be set to 1, and 1. First, we will use the dual concentric rotary knobs on the right of the unit to enter the frequency 112.5 Mhz into data channel 1, just as we would with any other navigation radio.

3. Once our desired frequency has been set we will use the “DATA” push button to page through the three required pieces of data in this data channel in the order “FREQ-RAD-DST”.  Press the “DATA” button once, and then enter the radial 154.0, again with the dual concentric rotary knobs.  Should your desired radial include a decimal component, the inner rotary knob can be pulled and rotated for decimal entry.


4. When our desired radial is set, press the “DATA” push button once again to enter our desired distance offset of 12.3 nm.  Again, should your desired distance include a decimal component, the inner rotary knob can be pulled and rotated for decimal entry.

5. Data entry is now complete; however, before we can begin following the CDI to the airport, we need to choose an RNAV mode of operation, probably RNAV/ENR for enroute operation, unless we need increased precision for some reason. Press the "RNAV" push button until "ENR" and "RNAV" are annunciated above the button. In RNAV modes of operation, our CDI will guide us to the displaced VOR waypoint at Beverly Airport that we just created, and all displayed DME information will be relative to that new waypoint.

   NOTE: VOR modes of operation WILL NOT provide CDI or DME information relative to the active waypoint. They are for operation as a conventional navigation radio with reference to existing VOR stations, in either angular or linear course deviation mode.


6. Lastly, make sure the HSI SOURCE switch in your aircraft is set to RNAV; otherwise, we will not see the RNAV information displayed on the HSI.


7. To fly directly to the displaced VOR waypoint at our destination airport, simply rotate the omni-bearing selector (OBS) or course (CRS) knob on your HSI, as you would to fly to a VOR, and follow the CDI needle with a TO indication. Countdown the distance and time remaining until arriving at your destination with the DME information provided on the KNS-80. When you have arrived, the TO/FROM indication will reverse, and DME distance will approach zero, just like with a conventional VOR receiver. Even at distances of 40 nm, this system is usually precise enough to place your route of flight inside the airport perimeter fence at your destination.

# Normal Checklists

*Amphibious Model Only

## Before Starting Engine

| | |
|---|---|
| Preflight Inspection | Complete |
| Passenger Cabin Doors | Unlocked |
| Cabin Doors | Latched |
| Parking Brake | Set |
| Control Lock | Removed |
| Seats & Seatbelts | Secure |
| Switches | Off |
| *Landing Gear | Up Water/Down Land |
| Ignition Switch | Norm |
| Circuit Breakers | All In |
| Fuel Selectors | Both On |
| Oxygen Pressure | 1850 psi |
| Ventilation & A/C | Off |
| Bleed Air Heat | Off |
| Cabin Mixing Air | FLT-PUSH |
| Emergency Power Lever | Normal |
| Power Lever | Idle |
| Propeller Lever | Full Forward |
| Fuel Condition Lever | Cutoff |
| Fuel Cutoff | Pushed In |
| Firewall Valve | Pushed In |
| Battery Switch | On |
| Annunciators | Test |
| Fire Detector/Warning | Test |
| Flap Lever | Up |
| No Smoking/Seatbelt Lights | As Required |

## Engine Start (Battery)

| | |
|---|---|
| Beacon Light | On |
| Avionics Switch 1 | On |
| Bus Volts | 24V Min. |
| Emergency Power Annun | Extinguished |
| Propeller Area | Clear |
| Fuel Boost Pump | On |
| Fuel Press Low Annun | Extinguished |
| Fuel Flow | None |
| Starter Switch | Start |
| Oil Pressure | Rising |
| Ng RPM Stable | Greater than 12% |
| Fuel Condition Lever | Low Idle |
| Fuel Flow | 90 to 140 lb/hr |
| ITT | 1090 max. 2s |
| Ng RPM | Greater than 52% |
| Starter Switch | Off |
| Starter Engaged Annun | Extinguished |
| Engine Instruments | Check |
| Generator Switch | Reset |
| Generator Load | Positive |
| Battery Charging Current | Negative |
| Gen Off Annun | Extinguished |
| Fuel Boost Pump | Norm |
| Fuel Boost Pump Annun | Extinguished |
| Weather Radar | Off/Standby |
| Avionics Switch 2 | On |
| Nav Lights | As Required |
| Suction | Check |
| Remote Compass | Slaved & Aligned |
| Ventilation & Defrost | As Required |
| Radios | Check |

## Engine Start (External Power)

| | |
|---|---|
| Beacon Light | On |
| Avionics Switch 1 | On |
| Battery Volts | 20V Min. |
| External Power | Bus |
| Bus Volts | 24-28.5V |
| Emergency Power Annun | Extinguished |
| Propeller Area | Clear |
| Fuel Boost Pump | On |
| Fuel Press Low Annun | Extinguished |
| Fuel Flow | None |
| Starter Switch | Start |
| Oil Pressure | Rising |
| Ng RPM Stable | Greater than 12% |
| Fuel Condition Lever | Low Idle |
| Fuel Flow | 90 to 140 lb/hr |
| ITT | 1090 max. 2s |
| Ng RPM | Greater than 52% |
| Starter Switch | Off |
| Starter Engaged Annun | Extinguished |
| Engine Instruments | Check |
| Generator Switch | Reset |
| Generator Load | Positive |
| Gen Off Annun | Extinguished |
| External Power | Off |
| Battery Charging Current | Negative |
| Fuel Boost Pump | Norm |
| Fuel Boost Pump Annun | Extinguished |
| Weather Radar | Off/Standby |
| Avionics Switch 2 | On |
| Nav Lights | As Required |
| Suction | Check |
| Remote Compass | Slaved & Aligned |
| Ventilation & Defrost | As Required |
| Radios | Check |

## Taxi

| | |
|---|---|
| Flight Instruments | Set & Check |
| Cabin Lights | Off |
| Cockpit Lighting | Dim for Taxi |
| Taxi/Recog Light | As Required |
| Inertial Separator | As Required |
| Parking Brake | Release |
| Brakes | Test |
| Remote Compass | Aligned |
| *Water Rudder | Down Water/Up Land |

## Before Takeoff (Runup)

| | |
|---|---|
| Parking Brake | Set |
| Seats & Seatbelts | Secure |
| Flight Controls | Free & Correct |
| Standby Alternator | On |
| Standby Alternator | Check Zero Amps |
| Generator Load | Load to 30-60 Amps |
| Generator Switch | Trip |
| Standby Alternator Load | Positive |
| Generator Switch | Reset |
| Fuel Boost Pump | Norm |
| Fuel Selectors | Both On |
| Fuel Quantity | Check |
| Fuel Cutoff | Push In |
| Trims | Set for T/O |
| Flaps | 10 (Norm) 20 (Short Field) |
| Power Lever | 400 ft-lbs |
| Suction | Check |
| Bus Volts | 24V Min. |
| Inertial Separator | On |
| ITT | Check Increase |
| Inertial Separator | Off |
| Engine Instruments | Check |
| Power Lever | 1800 RPM |
| Overspeed Governor | Press & Hold |
| Propeller RPM | Check (1750 +/-60 RPM) |
| Power Lever | Idle |
| Pitot Heat | On |
| Generator Load | Increase |
| Pitot Heat | Off |
| Windshield Anti-Ice | On |
| Generator Load | Increase |
| Windshield Anti-Ice | Off |
| Propeller De-Ice | On |
| Propeller Amps | 20-24 Amps |
| Propeller De-Ice | Off |
| Airframe De-Ice | On |
| Airframe De-Ice Annun | Observe Cycle |
| Airframe De-Ice | Off |
| Pitot Heat | On if OAT less than 4c |
| Ice Protection | As Required |
| Heading Bug | 30 Degrees Left |
| Autopilot Heading Mode | Engage |
| Yoke Movement | Observe |
| Heading Bug | 30 Degrees Right |
| Yoke Movement | Observe |
| Autopilot Disconnect | Test |
| Autopilot | Set for Climb |
| Battery Charging Current | Less than 10A |
| Weather Radar | As Required |
| Strobe Lights | As Required |
| Annunciators | Test & Consider |
| Flight Instruments | Set & Check |
| Storm Windows | Closed |
| Cabin Mixing Air | FLT-PUSH |
| Fuel Condition Lever | High Idle |
| Parking Brake | Release |

## Takeoff

| | |
|---|---|
| Transponder | ALT Mode |
| Landing Lights | On |
| Inertial Separator | As Required |
| *Water Rudder | Up |
| Power Lever | Set for T/O (See POH) |
| Annunciators | Check |
| Engine Instruments | Green |
| Brakes | Release |
| ITT | 805 max |
| *Landing Gear Up | No Rwy Remaining |
| Flaps | Retract at 95kts |

## Max Performance Climb

| | |
|---|---|
| Propeller Lever | 1900 RPM |
| Power Lever | 1865 ft-lbs |
| ITT | Less than 765 |
| Air Conditioning / Heat | As Required |

## Enroute Climb

| | |
|---|---|
| Pitot Heat | On if OAT less than 4c |
| Ice Protection | As Required |
| Propeller Lever | 1600-1900 RPM |
| Power Lever | 1865 ft-lbs |
| ITT | Less than 740 |
| Air Conditioning / Heat | As Required |

## Cruise

| | |
|---|---|
| Landing & Taxi Lights | Off |
| Pitot Heat | On if OAT less than 4c |
| Ice Protection | As Required |
| No Smoking/Seatbelt Lights | As Required |
| Oxygen | As Required |
| Inertial Separator | As Required |
| Propeller Lever | 1600-1900 RPM |
| Power Lever | Set for Cruise (See POH) |

## Descent

| | |
|---|---|
| Pitot Heat | On if OAT less than 4c |
| Ice Protection | As Required |
| No Smoking/Seatbelt Lights | On |
| Propeller Lever | 1600-1900 RPM |
| Power Lever | Reduce |

## Before Landing

| | |
|---|---|
| Seats & Seatbelts | Secure |
| Fuel Selectors | Both On |
| Oxygen | Off |
| Landing Lights | On |
| Inertial Separator | As Required |
| Condition Lever | High Idle |
| Propeller Lever | Full Forward |

| | |
|---|---|
| Flaps | As Required |
| *Landing Gear | Up Water/Down Land |
| *Water Rudder | Up |
| Autopilot | Disconnect |

## Landing

| | |
|---|---|
| Flaps | Full |
| Power Lever | Beta after Landing |
| Brake | As Required |
| Power Lever | Idle before 25kts |

## Balked Landing

| | |
|---|---|
| Power Lever | Set for T/O (See POH) |
| Flaps | 20 Degrees |
| Airspeed | 80kts min. |
| *Landing Gear Up | No Rwy Remain |
| Flaps | Retract when Safe |

## After Landing

| | |
|---|---|
| *Water Rudder | Down Water/Up Land |
| Flaps | Up |
| Pitot Heat | Off |
| Ice Protection | Off |
| Strobe Lights | Off |
| Taxi/Recog Light | On |
| Landing Lights | Off |
| Condition Lever | Low Idle |
| Weather Radar | Off/Standby |
| Inertial Separator | As Required |

## Shutdown & Securing

| | |
|---|---|
| Parking Brake | Set |
| Avionics | Off |
| Standby Alternator | Off |
| Fuel Boost Pump | Off |
| Heat & A/C | Off |
| Power Lever | Idle for 1 min |
| Propeller Lever | Feather |
| Condition Lever | Cutoff |
| Exterior Lights | Off |
| Battery Switch | Off |
| Fuel Selectors | Both Off |
| Oxygen | Off |
| Inertial Separator | Off |

## Instrument Markings & Colors

### Propeller Torque:

0-1970 ft-lbs (GREEN)
1865 ft-lbs (RED)
1970 ft-lbs (RED)

### Propeller RPM:

1600-1900 RPM (GREEN)
1900 RPM (RED)

### Interstage Turbine Temperature (ITT):

100-740 °C (GREEN)
765-805 °C (YELLOW)
805 °C (RED)
1090 °C (RED)

### Gas Generator RPM (Ng):

520-102% (GREEN)
102% (RED)

### Oil Pressure:

40-85 psi (YELLOW)
85-105 psi (GREEN)
105 psi (RED)

### Oil Temperature:

-40-40 °C (YELLOW)
40-104 °C (GREEN)
104 °C (RED)

### Fuel Flow:

0 PPH (MINIMUM)
500 PPH (MAXIMUM)

### Fuel Quantity:

0 lbs / 0 gal (MINIMUM)
1100 lbs / 160 gal (MAXIMUM)

### Oxygen Pressure:

0-500 psi (YELLOW)
1550-1850 psi (GREEN)
1950-2000 psi (RED)

### Vacuum Suction:

4.5-5.5 inHg to 15,000 ft (GREEN)
4.0-5.5 inHg to 20,000 ft (GREEN)
3.5-4.0 inHg to 25,000 ft (GREEN)
3.0-3.5 inHg to 30,000 ft (GREEN)

### Propeller Ammeter:

20-24 amps (GREEN)

### Airspeed Indicator:

SEE V-SPEEDS

# Abnormal & Emergency Checklists

## Engine Fire (Ground)

| | |
|---|---|
| Condition Lever | Cutoff |
| Ignition Switch | Norm |
| Fuel Cutoff | Pull Out |
| Fuel Selectors | Both Off |
| Starter Switch | Motor |
| Observe | If fire continues... |
| Battery Switch | Off |

## Engine Failure (Takeoff)

| | |
|---|---|
| Power Lever | Idle |
| Braking | Maximum |
| Flaps | Retract |
| Condition Lever | Cutoff |
| Fuel Cutoff | Pull Out |
| Fuel Selectors | Both Off |
| Battery Switch | Off |

## Engine Failure (In Flight)

| | |
|---|---|
| Airspeed | 95 kts |
| Fuel Cutoff | Push In |
| Fuel Selectors | Both On |
| Fuel Boost Pump | On |
| Ignition Switch | Norm |
| Engine Power | If Not Restored... |
| Flaps | Retract |
| Propeller Lever | Feather |
| Airspeed | 97 kts |
| Air Conditioning | Off |
| Nonessential Equipment | Off |
| Favorable Landing Site | Select |

## Engine Fire (In Flight)

| | |
|---|---|
| Power Lever | Idle |
| Propeller Lever | Feather |
| Condition Lever | Cutoff |
| Fuel Cutoff | Pull Out |
| Firewall Valve | Pull Out |
| Cockpit Vents | Push Off |
| Ventilation Fans | Maximum |
| Overhead Fans | Maximum |
| Flaps | 20 Degrees |
| Favorable Landing Site | Select |

## Starter Does Not Disengage

| | |
|---|---|
| Battery Switch | Off |
| External Power | Off |
| Condition Lever | Cutoff |

## Hot or Hung Start

| | |
|---|---|
| Condition Lever | Cutoff |
| Starter Switch | Motor |
| Starter Switch | Off when ITT > 400 |

## Engine Clearing

| | |
|---|---|
| Propeller Lever | Feather |
| Condition Lever | Cutoff |
| Power Lever | Idle |
| Starter Switch | Motor |
| Starter Switch | Off after 30s |

## Engine Surges

| | |
|---|---|
| Power Lever | Reduce |
| Observe | If Surging is Severe… |
| Power Lever | Idle |
| Land | As Soon as Practical |

## CHIP DETECTOR Illuminated

| | |
|---|---|
| Possible Engine Failure | Anticipate |
| Power Lever | Reduce |
| Land | As Soon as Practical |

## Fuel Control Unit Failure

| | |
|---|---|
| Power Lever | Idle |
| Emergency Power Lever | As Required |
| Ng RPM | Greater than 65% |

## Fuel Imbalance

| | |
|---|---|
| Coordinated Flight | Maintain |
| If Fuel Imbalance… | Greater than 200lbs |
| Fuel Selector | Emptiest Off |
| Fuel Flow | Monitor |
| When Fuel Balance… | Restored |
| Fuel Selectors | Both On |

## Prop Governor Failure

| | |
|---|---|
| Power Lever | Reduce |
| Oil Pressure | Check |
| Exercise Propeller | If No Control… |
| Airspeed | Reduce |
| Power Lever | To Maintain RPM |
| Land | As Soon as Practical |

## Battery Overheat (AMBER Annun.)

| | |
|---|---|
| Battery Switch | Off |
| Battery Charging Current | If Charging... |
| Generator Switch | Trip |
| Standby Alternator | Off |
| Bus Circuit Breakers | Pull Off (6) |
| Avionics | Off |
| Standby Alternator | On |
| Standby Avionics Power | On |
| Standby Bus Tie | On |
| Standby Alternator Load | Monitor |

## Battery Hot (RED Annun.)

| | |
|---|---|
| Battery Switch | Off |
| Generator Switch | Trip |
| Standby Alternator | Off |
| Bus Circuit Breakers | Pull Off (6) |
| Avionics | Off |
| Standby Alternator | On |
| Standby Avionics Power | On |
| Standby Bus Tie | On |
| Standby Alternator Load | Monitor |

## Generator Failure

| | |
|---|---|
| Bus Volts | If less than 25V... |
| Circuit Breakers | Check In |
| Generator Load | If Zero... |
| Generator Circuit Breakers | Check In |
| Generator Switch | Reset |
| Generator Load | If Zero... |
| Generator Load | Reduce |
| Avionics 2 | Off |
| Air Conditioning / Heat | Off |
| Ice Protection | Off |
| Exterior Lights | Off |
| Generator Circuit Breakers | Pull Off |
| Standby Alternator | On |
| Standby Alternator Load | Monitor |

## Electrical Fire

| | |
|---|---|
| Battery Switch | Off |
| Generator Switch | Trip |
| Standby Alternator | Off |
| Cockpit Vents | Push Off |
| Air Conditioning / Heat | Off |
| Oxygen | On & Use |
| Avionics | Off |
| Bus Circuit Breakers | Pull Off (8) |
| Restore Essential Power | Bus by bus |
| Restore Essential Power | Circuit by Circuit |

## Severe Icing Encounter

| | |
|---|---|
| Ignition Switch | On |
| Inertial Separator | On |
| Ice Protection | All On |
| Ice Inspection Light | On |
| Ice Build-Up | Monitor |
| Propeller Lever | 1900 RPM |
| Bleed Air Heat | On |
| Temperature Control | Maximum |
| Defrost & Mixing Air | Full On |

## Air Start with Starter (Preferred)

| | |
|---|---|
| Generator Load | Reduce |
| Standby Alternator | Off |
| Avionics | Off |
| Ignition Switch | Norm |
| Air Conditioning / Heat | Off |
| Emergency Power Lever | Normal |
| Power Lever | Idle |
| Propeller Lever | Minimum RPM |
| Condition Lever | Cutoff |
| Fuel Cutoff | Push In |
| Fuel Selectors | Both On |
| Battery Switch | On |
| Fuel Boost Pump | On |
| Aux Fuel Pump Annun | Illuminated |
| Fuel Press Low Annun | Extinguished |
| Altitude | Less than 20,000 ft |
| Starter Switch | Start |
| Ignition Annun | Illuminated |
| Oil Pressure | Rising |
| Ng RPM Rising | Greater than 12% |
| Condition Lever | Low Idle |
| ITT | 1090 max. 2s |
| Ng RPM | Greater than 52% |
| Starter Switch | Off |
| Ignition Switch | As Required |
| Fuel Boost Pump | Norm |
| Condition Lever | High Idle |

## Air Start Windmilling

| | |
|---|---|
| Generator Switch | Trip |
| Standby Alternator | Off |
| Avionics | Off |
| Air Conditioning / Heat | Off |
| Emergency Power Lever | Normal |
| Power Lever | Idle |
| Propeller Lever | Minimum RPM |
| Condition Lever | Cutoff |
| Fuel Cutoff | Push In |
| Fuel Selectors | Both On |
| Battery Switch | On |
| Fuel Boost Pump | On |
| Aux Fuel Pump Annun | Illuminated |
| Fuel Press Low Annun | Extinguished |
| Ignition Switch | On |

| | |
|---|---|
| Airspeed | Greater than 100 kias |
| Altitude | Less than 20,000 ft |
| Ng | Non-Zero |
| Condition Lever | Low Idle |
| ITT | 1090 max. 2s |
| Ng RPM | Greater than 52% |
| Ignition Switch | As Required |
| Fuel Boost Pump | Norm |
| Condition Lever | High Idle |
| Generator Switch | Reset |

# Flap Failure

| | |
|---|---|
| Flap Circuit Breakers | Check In |
| Standby Flap Mode | Standby |
| Standby Flap Motor | As Desired |

# *Landing Gear Manual Extension

| | |
|---|---|
| Amphib Gear Motor | Pull Off |
| Landing Gear | Handle Down |
| Manual Gear Select | Gear Down |
| Pump Handle | 20+ Pumps |
| Gear Indicators | Four Green |

# *Landing Gear Up after Manual Extension

| | |
|---|---|
| Manual Gear Select | Gear Up |
| Amphib Gear Motor | Push On |
| Landing Gear | Handle Up |
| Gear Indicators | Four Blue |

# Remote Compass Misalignment

| | |
|---|---|
| Gyro Slave Circuit Breaker | Pull & Reset |
| Remote Compass Alignment | If Misaligned... |
| Remote Compass | Free Mode |
| Compass Position | Slew to Mag. Heading |

# Autopilot Failure or Trim Runaway

| | |
|---|---|
| Autopilot | Disconnect |
| Autopilot Circuit Breakers | Pull Off |

# Cabin Door Open

| | |
|---|---|
| Airspeed | Reduce |
| Increased Drag | Anticipate |
| Land | As Soon as Practical |

# Emergency Descent

| | |
|---|---|
| Seats & Seatbelts | Secure |
| Power Lever | Idle |
| Propeller Lever | Full Forward |
| Flaps | 10 Degrees |
| Airspeed | 175 kts |

# Maximum Glide

| | |
|---|---|
| Flaps | Retract |
| Propeller Lever | Feather |
| Airspeed | 97 kts |
| Air Conditioning | Off |
| Nonessential Equipment | Off |

# 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, featuring the KNS-80 Navigation System, and the RDR 1150XL, additional resources are available online for the real world counterparts of these units. In particular the **"KNS-80 Pilot's Guide"**, available on Bendix/King's website, and the **"Weather Radar Pilot Training DVD"** on Bendix/King's YouTube channel. Additionally, the **"KLN-90B Pilot's Guide"** is also available on Bendix/King's website.

# 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 Control Lock | L:bksq_ControlLocks | Boolean |
| Rudder Lock | L:bksq_RudderLock | 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 |
| Cargo Pod Doors | L:bksq_CargoPodDoors | Boolean |
| Pilot’s Window | L:bksq_StormWindow | Boolean |
| Copilot’s Door Override | L:var_DoorLockOverride | Boolean |
| Pilot’s Sun Visor Position | L:var_Visor_L | 0 - 100 |
| Copilot’s Sun Visor Position | L:var_Visor_R | 0 - 100 |
| Pilot’s Left Armrest | L:var_ArmrestLL | 0 - 100 |
| Pilot’s Right Armrest | L:var_ArmrestLR | 0 - 100 |
| Copilot’s Left Armrest | L:var_ArmrestRL | 0 - 100 |
| Copilot’s Right Armrest | L:var_ArmrestRR | 0 - 100 |

## Primary Control Variables

| Description | Variable | Range |
|---|---|---|
| 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 |
| Emergency Power Control Lever | L:var_emergencyPowerLeverPosition | 0 - 100 |
| Inertial Separator Pull Handle | L:XMLVAR_InterSep | Boolean |
| External Power Switch Cover | L:var_ExternalPowerCover | Boolean |
| External Power Switch | L:var_ExternalPowerSwitch | 1=Starter, 2=Bus |
| Generator Switch | L:var_GeneratorSwitch | 1=Reset, 2=Trip |
| Fuel Boost Pump Switch | L:var_FuelPumpSwitch | 1=Norm, 2=On |
| Standby Alternator Switch | L:var_StandbyAlternatorSwitch | Boolean |
| Standby Avionics Power Switch Cover | L:var_StandbyAvionicsPowerCover | Boolean |
| Avionics Bus Tie Switch Cover | L:var_AvionicsBusTieCover | Boolean |
| Standby Avionics Power Switch | L:var_StandbyAvionicsPowerSwitch | Boolean |
| Avionics Bus Tie Switch | L:var_AvionicsBusTieSwitch | Boolean |
| Pitot Heat Switch | L:var_PitotHeat_L | Boolean |
| Stall Warning Heat Switch | L:var_PitotHeat_R | Boolean |
| Windshield Deicing Switch | L:var_WindshieldDeiceSwitch | 0=Auto, 2=Man |
| Propeller Heat Switch | L:var_PropDeiceSwitch | 0=Auto, 2=Man |
| Airframe Deicing Boots Switch | L:var_AirframeDeiceSwitch | 0=Auto, 2=Man |
| Friction Lock | L:var_FrictionLockKnob | 0 - 100 |
| Fuel Cutoff Pull Handle | L:var_FuelCutoffHandle | 0 - 100 |
| Firewall Cutoff Pull Handle | L:var_FirewallCutoffHandle | 0 - 100 |
| Prop Governor Overspeed Test Button | L:var_PropOverspeedTestButton | Boolean |
| Fire Detector Test Button | L:var_FireTest | Boolean |
| Annunciator Panel Test Button | L:var_AnnunciatorLightTestButton | Boolean |

| | | |
|---|---|---|
| Annunciator Dimming Switch | L:var_AnnunciatorDim | Boolean |
| Electrical Multimeter Mode | L:var_meterMode | 0-3 |
| Alternate Static Air Pull Handle | L:XMLVAR_Cabin_Air_8_Position | 0 - 100 |
| Standby Flap Actuator Switch Cover | L:var_StandbyFlapMovementCover | Boolean |
| Standby Flap Mode Switch Cover | L:var_StandbyFlapModeCover | Boolean |
| Standby Flap Actuator Switch | L:var_StandbyFlapMovementSwitch | Boolean |
| Standby Flap Mode Switch | L:Flap_Stby_Mode_Switch | Boolean |
| Water Rudder Handle | L:var_WaterRudderHandle | 0 - 100 |
| Amphibious Gear Pump Selector | L:var_AmphibianManualGearSelector | 0 - 100 |
| Amphibious Gear Pump Handle | L:var_ManualGearHandle | Boolean |
| Amphibious Gear Warning Cancel | L:var_GearAdvisoryLatching | 2=Cancel |

## Lighting Control Events & Variables

| **Description** | **Variable** | **Range** |
|---|---|---|
| Wing/Ice Light | B:LIGHTING_WING_1_Toggle<br>(K:TOGGLE_WING_LIGHTS) | |
| Taxi Light | B:LIGHTING_TAXI_1_Toggle<br>(K:TOGGLE_TAXI_LIGHTS) | |
| Left Landing Light | B:LIGHTING_LANDING_1_Toggle<br>(1 K:LANDING_LIGHTS_SET) | |
| Right Landing Light | B:LIGHTING_LANDING_2_Toggle<br>(2 K:LANDING_LIGHTS_SET) | |
| Strobe Lights | B:LIGHTING_STROBE_1_Toggle<br>(K:STROBES_TOGGLE) | |
| Navigation Lights | B:LIGHTING_NAVIGATION_1_Toggle<br>(K:TOGGLE_NAV_LIGHTS) | |
| Beacon Light | B:LIGHTING_BEACON_1_Toggle<br>(K:TOGGLE_BEACON_LIGHTS) | |
| No Smoking Sign | L:var_NoSmokingSign | Boolean |
| Seat Belt Sign | L:var_SeatbeltSign | Boolean |
| Cabin Overhead Lights | L:var_CabinLights | Boolean |

| | | |
|---|---|---|
| Pilot's Panel Lights | L:var_PanelLightKnob_L | 0 - 100 |
| Copilot's Panel Lights | L:var_PanelLightKnob_R | 0 - 100 |
| Engine Instrument Lights | L:var_EngineInstrumentLightsKnob | 0 - 100 |
| Pilot's Panel Flood Light | L:var_FloodLightKnob_L | 0 - 100 |
| Copilot's Panel Flood Light | L:var_FloodLightKnob_R | 0 - 100 |
| Pedestal Flood Light | L:var_PedestalLightKnob | 0 - 100 |
| Circuit Breaker Panel Lights | L:var_CircuitBreakerLightKnob | 0 - 100 |
| Radio/Avionics Lighting Dimmer | L:var_RadioLightsKnob | 0 - 100 |

## Environmental Control Variables

| **Description** | **Variable** | **Range** |
|---|---|---|
| Oxygen Flow Valve | L:var_OxygenOn | Boolean |
| Pilot Ram Air Door | L:XMLVAR_Cabin_Air_1_Position | 0 - 100 |
| Copilot Ram Air Door | L:XMLVAR_Cabin_Air_2_Position | 0 - 100 |
| Bleed Air Cabin Heat Mixing Valve | L:XMLVAR_Cabin_Air_3_Position | 0 - 100 |
| Fore-Aft Cabin Diverter Valve | L:XMLVAR_Cabin_Air_4_Position | 0 - 100 |
| Defroster Valve | L:XMLVAR_Cabin_Air_5_Position | 0 - 100 |
| Left Wing Cabin Air Inlet | L:var_OverheadFan_L | 0 - 100 |
| Right Wing Cabin Air Inlet | L:var_OverheadFan_R | 0 - 100 |
| Cabin Temperature Target Knob | L:var_CabinTemperatureKnob | 50 - 100 |
| Bleed Air Heat Switch | L:var_BleedAirSwitch | Boolean |
| Ventilation Mode Switch | L:var_AirconMode | 0=AC, 2=Ventilate |
| Left A/C Fan Speed Switch | L:var_AirConditioningFan_L | Boolean |
| Aft A/C Fan Speed Switch | L:var_AirConditioningFan_Aft | Boolean |
| Right A/C Fan Speed Switch | L:var_AirConditioningFan_R | Boolean |

## Instrument Variables

| Description | Variable | Range |
| --- | --- | --- |
| RNAV Drives HSI | L:var_rnavDrivesHsi | Boolean |
| Gyro Slaving Mode | L:var_GyroSlaveModeSwitch | Boolean |
| Dme Mode | L:var_dmeMode | 0 - 4 |
| True Airspeed Calculator | L:var_trueAirspeedRing | 0 - 100 |

## Primary Control Events Events

| Description | Event |
| --- | --- |
| Condition Lever | B:FUEL_1_Condition_Lever_High_Idle<br>B:FUEL_1_Condition_Lever_Low_Idle<br>B:FUEL_1_Condition_Lever_Cut_Off |
| Battery Master Switch | K:BATTERY1_SET |
| Avionics Bus 1 Master Switch | B:ELECTRICAL_Avionics_Bus_1_Toggle |
| Avionics Bus 2 Master Switch | B:ELECTRICAL_Avionics_Bus_2_Toggle |
| Ignition Switch | B:ENGINE_Ignition_1_Set |
| Starter Switch | B:ENGINE_Starter_Ignition_1_Set |

## Instrument Events

| Description | Variable |
| --- | --- |
| Autopilot Master | H:KAP140_Push_AP (K:AP_MASTER) |
| Autopilot Heading Mode | H:KAP140_Push_HDG (K:AP_PANEL_HEADING_HOLD) |
| Autopilot NAV Mode | H:KAP140_Push_NAV (K:AP_NAV1_HOLD) |
| Autopilot Approach Mode | H:KAP140_Push_APR (K:AP_APR_HOLD) |
| Autopilot Backcourse Mode | H:KAP140_Push_REV (K:AP_BC_HOLD) |
| Autopilot Altitude Hold Mode | H:KAP140_Push_ALT (K:AP_ALT_HOLD) |
| Autopilot UP Button | H:AUTOPILOT_Push_VerticalSpeed_UP_1 |

| | |
|---|---|
| Autopilot DOWN Button | H:AUTOPILOT_Push_VerticalSpeed_DOWN_1 |
| Autopilot ARM Button | H:KAP140_Push_ARM |
| Autopilot BARO Adjust Button | H:KAP140_Push_BARO |
| Autopilot Outer Knob | H:KAP140_Knob_Outer_INC / H:KAP140_Knob_Outer_DEC |
| Autopilot Inner Knob | H:KAP140_Knob_Inner_INC / H:KAP140_Knob_Inner_DEC |
| Power Lever Go-Around Mode | K:AUTO_THROTTLE_TO_GA |
| Autopilot & Flight Director Disengage | K:AUTOPILOT_DISENGAGE_TOGGLE |
| Transponder Ident | K:XPNDR_IDENT_ON |
| VLOC/GPS (when using GNS 530) | K:TOGGLE_GPS_DRIVES_NAV1 (H:AS530_CDI_Push) |
| Toggle COM1 Receive | K:COM1_RECEIVE_SELECT |
| Toggle COM2 Receive | K:COM2_RECEIVE_SELECT |
| Toggle COM3 Receive | K:COM3_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 |
| Toggle RNAV Receive | K:RADIO_VOR3_IDENT_TOGGLE |
| Altimeter Baro Increase | K:KOHLSMAN_INC |
| Altimeter Baro Decrease | K:KOHLSMAN_DEC |
| Decision Height Increase | K:INCREASE_DECISION_HEIGHT |
| Decision Height Decrease | K:DECREASE_DECISION_HEIGHT |

## Avionics Variables & Events

Not all variable and event names are listed here for multiple instances of avionics. For instance, to control a GTN 650, just replace “GTN750” with “GTN650”, or “H:AS530_1_MENU_Push” with “H:AS430_1_MENU_Push”. For communications radios, change the index to the corresponding radio, such as “K:COM1_VOLUME_INC” to “K:COM2_VOLUME_INC”. For Black Square aircraft with multiple GNS 530 units installed, increment the index, as well, such as “H:AS530_1_DRCT_Push” to “H:AS530_2_DRCT_Push”.

### PMS50 GTN

| **Description** | **Variable or Event** |
|---|---|
| Volume Knob Set | L:GTN750_Vol |
| Volume Knob Increase | H:GTN750_VolInc |
| Volume Knob Decrease | H:GTN750_VolDec |
| Home Button | H:GTN750_HomePush |
| Direct-To Button | H:GTN750_DirectToPush |
| Inner Knob Increase | H:GTN750_KnobSmallInc |
| Inner Knob Decrease | H:GTN750_KnobSmallDec |
| Knob Push | H:GTN750_KnobPush |
| Outer Knob Increase | H:GTN750_KnobLargeInc |
| Outer Knob Decrease | H:GTN750_KnobLargeDec |

### TDS GTNxi

| **Description** | **Variable or Event** |
|---|---|
| Volume Knob Increase | L:TDSGTNXI750U1_LKnobInc |
| Volume Knob Decrease | L:TDSGTNXI750U1_LKnobDec |
| Home Button | L:TDSGTNXI750U1_HomeKey |
| Direct-To Button | L:TDSGTNXI750U1_DTOKey |
| Inner Knob Increase | L:TDSGTNXI750U1_RKnobInnerInc |
| Inner Knob Decrease | L:TDSGTNXI750U1_RKnobInnerDec |

| | |
|---|---|
| Knob Push | L:TDSGTNXI750U1_RKnobCRSR |
| Outer Knob Increase | L:TDSGTNXI750U1_RKnobOuterInc |
| Outer Knob Decrease | L:TDSGTNXI750U1_RKnobOuterDec |

## Working Title GNS 530

| **Description** | **Variable or Event** |
|---|---|
| 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 |
| Radio Knob Push | H:AS530_1_LeftSmallKnob_Push |
| Radio Inner Knob Right | H:AS530_1_LeftSmallKnob_Right |
| Radio Inner  Knob Left | H:AS530_1_LeftSmallKnob_Left |
| Radio Outer Knob Right | H:AS530_1_LeftLargeKnob_Right |
| Radio Outer Knob Left | H:AS530_1_LeftLargeKnob_Left |
| GPS Knob Push | H:AS530_1_RightSmallKnob_Push |
| GPS Inner Knob Right | H:AS530_1_RightSmallKnob_Right |
| GPS Inner Knob Left | H:AS530_1_RightSmallKnob_Left |
| GPS Outer Knob Right | H:AS530_1_RightLargeKnob_Right |
| GPS Outer Knob Left | H:AS530_1_RightLargeKnob_Left |
| Direct-To Button | H:AS530_1_DRCT_Push |
| Menu Button | H:AS530_1_MENU_Push |
| Clear Button Short | H:AS530_1_CLR_Push |
| Clear Button Long | H:AS530_1_CLR_Push_Long |
| Enter button | H:AS530_1_ENT_Push |
| COM Swap Button | H:AS530_1_COMSWAP_Push |
| NAV Swap Button | H:AS530_1_NAVSWAP_Push |
| NAV Ident Button | H:AS530_1_ID |

| | |
|---|---|
| CDI Button | H:AS530_1_CDI_Push |
| OBS Button | H:AS530_1_OBS_Push |
| Message Button | H:AS530_1_MSG_Push |
| Flightplan Button | H:AS530_1_FPL_Push |
| VNAV button | H:AS530_1_VNAV_Push |
| Procedure Button | H:AS530_1_PROC_Push |

## KLN90B

| **Description** | **Variable or Event** |
|---|---|
| Brightness Knob Increase | H:KLN90B_Brt_Inc |
| Brightness Knob Decrease | H:KLN90B_Brt_Dec |
| Power Knob Push/Pull | H:KLN90B_Power_Toggle |
| Left Knob Outer Right | H:KLN90B_LeftLargeKnob_Right |
| Left Knob Outer Left | H:KLN90B_LeftLargeKnob_Left |
| Right Knob Outer Right | H:KLN90B_RightLargeKnob_Right |
| Right Knob Outer Left | H:KLN90B_RightLargeKnob_Left |
| Left Knob Inner Right | H:KLN90B_LeftSmallKnob_Right |
| Left Knob Inner Left | H:KLN90B_LeftSmallKnob_Left |
| Right Knob Inner Right | H:KLN90B_RightSmallKnob_Right |
| Right Knob Inner Left | H:KLN90B_RightSmallKnob_Left |
| Right Knob (Scan) Push/Pull | H:KLN90B_RightScan_Toggle |
| Left Cursor Button | H:KLN90B_LeftCursor_Toggle |
| Right Cursor Button | H:KLN90B_RightCursor_Toggle |
| Message Button | H:KLN90B_MSG_Push |
| Altitude Button | H:KLN90B_ALT_Push |
| Direct Button | H:KLN90B_DCT_Push |
| Clear Button | H:KLN90B_CLR_Push |
| Enter Button | H:KLN90B_ENT_Push |

| | |
|---|---|
| MD41 Approach Arm Button | H:KLN90B_ApprArm_Push |
| MD41 OBS Button | K:GPS_OBS |
| MD41 VLOC/GPS Button | K:TOGGLE_GPS_DRIVES_NAV1 |
| MD41 Test Button | L:var_md41Test |

## KNS80

| Description | Variable or Event |
|---|---|
| Data Knob Outer Increase | H:KNS80_bigInc |
| Data Knob Outer Decrease | H:KNS80_bigDec |
| Data Knob Inner Increase | H:KNS80_smallInc |
| Data Knob Inner Decrease | H:KNS80_smallDec |
| VOR Mode Button | H:KNS80_vorModeButton |
| RNAV Mode Button | H:KNS80_rnavModeButton |
| Hold Button | H:KNS80_dmeHoldButton |
| Use Button | H:KNS80_useButton |
| Display Button | H:KNS80_displayButton |
| Data Entry Knob Push/Pull | L:var_rnavKnobPulled |
| Volume Knob | L:var_RNAV_VOLUME |

## KX155B

| Description | Variable or Event |
|---|---|
| COM Knob Outer Increase | H:RADIO1_COM_Knob_Large_INC |
| COM Knob Outer Decrease | H:RADIO1_COM_Knob_Large_DEC |
| COM Knob Inner Increase | H:RADIO1_COM_Knob_Small_INC |
| COM Knob Inner Decrease | H:RADIO1_COM_Knob_Small_DEC |
| COM Knob Push/Pull | H:RADIO1_COM_Knob_Small_PUSH |
| NAV Knob Outer Increase | H:RADIO1_NAV_Knob_Large_INC |

| | |
|---|---|
| NAV Knob Outer Decrease | H:RADIO1_NAV_Knob_Large_DEC |
| NAV Knob Inner Increase | H:RADIO1_NAV_Knob_Small_INC |
| NAV Knob Inner Decrease | H:RADIO1_NAV_Knob_Small_DEC |
| NAV Knob Push/Pull | H:RADIO1_NAV_Knob_Small_PUSH |
| COM Volume Increase | K:COM1_VOLUME_INC |
| COM Volume Decrease | K:COM1_VOLUME_DEC |
| COM Frequency Spacing Toggle | H:RADIO1_COM_Freq_Spacing_PUSH |
| NAV Volume Increase | K:NAV1_VOLUME_INC |
| NAV Volume Decrease | K:NAV1_VOLUME_DEC |
| NAV Ident Toggle | K:RADIO_VOR1_IDENT_TOGGLE |
| COM Swap Button | K:COM1_RADIO_SWAP |
| NAV Swap Button | K:NAV1_RADIO_SWAP |

## KR87 ADF

| Description | Variable or Event |
|---|---|
| Tuning Knob Push/Pull | L:var_adfKnobPulled |
| Tuning Increase by 100 | K:ADF_100_INC |
| Tuning Decrease by 100 | K:ADF_100_DEC |
| Tuning Increase by 10 | K:ADF_10_INC |
| Tuning Decrease by 10 | K:ADF_10_DEC |
| Tuning Increase by 1 | K:ADF_1_INC |
| Tuning Decrease by 1 | K:ADF_1_DEC |
| Antenna Button | H:adf_AntAdf |
| BFO Button | H:adf_bfo |
| Frequency Swap Button | H:adf_frqTransfert |
| Timer Mode Button | H:adf_FltEt |
| Timer Reset Button | H:adf_SetRst |

## GTX 327 Transponder

| Description | Variable or Event |
|---|---|
| Off Button | H:TRANSPONDER_Push_OFF |
| Standby Button | H:TRANSPONDER_Push_STBY |
| Test Button | H:TRANSPONDER_Push_TST |
| On Button | H:TRANSPONDER_Push_ON |
| Altitude Reporting Mode Button | H:TRANSPONDER_Push_ALT |
| 0 Button | H:TRANSPONDER_Push_0 |
| 1 Button | H:TRANSPONDER_Push_1 |
| 2 Button | H:TRANSPONDER_Push_2 |
| 3 Button | H:TRANSPONDER_Push_3 |
| 4 Button | H:TRANSPONDER_Push_4 |
| 5 Button | H:TRANSPONDER_Push_5 |
| 6 Button | H:TRANSPONDER_Push_6 |
| 7 Button | H:TRANSPONDER_Push_7 |
| 8 Button | H:TRANSPONDER_Push_CLR |
| 9 Button | H:TRANSPONDER_Push_VFR |
| Function Button | H:TRANSPONDER_Push_FUNC |
| Cursor Button | H:TRANSPONDER_Push_CRSR |

## Weather Radar

| Description | Variable or Event | Range |
|---|---|---|
| Mode Knob | L:var_radarMode | 0 - 5 |
| Brightness Knob | L:var_RadarBrightness | 0 - 100 |
| Gain Knob | L:var_RadarGain | 0 - 100 |
| Tilt Knob | L:var_RadarTilt | 0 - 100 |
| Alert Button | H:bksq_wradar1_radarAlertToggle | |

| | | |
|---|---|---|
| Vertical Profile Button | H:bksq_wradar1_radarProfile | |
| Map Button | H:bksq_wradar1_radarMap | |
| Hold Button | H:bksq_wradar1_radarHold | |
| Range Increase Button | H:bksq_wradar1_radarRangeInc | |
| Range Decrease Button | H:bksq_wradar1_radarRangeDec | |
| Track Left Button | H:bksq_wradar1_radarTrackLeft | |
| Track Right Button | H:bksq_wradar1_radarTrackRight | |

## Outputs

Since the Caravan Professional 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** |
|---|---|---|
| Indicated Airspeed (with pitot error) | L:BKSQ_AIRSPEED_CORRECTED | knots |
| Propeller Torque | L:BKSQ_CARAVAN_TQ | Number (FT-LBS) |
| Interstage Turbine Temperature | L:BKSQ_CARAVAN_ITT | Number (°C) |
| Gas Generator RPM | L:BKSQ_CARAVAN_NG | Number (%) |
| Left Fuel Pressure | L:BKSQ_CARAVAN_FUELPRESSURE | PSI |
| Propeller RPM | A:PROP RPM:1 | RPM |
| Left Fuel Flow | L:BKSQ_CARAVAN_FuelFlow | Number (PPH) |
| Oil Pressure | L:BKSQ_CARAVAN_FUELPRESSURE | PSI |
| Oil Temperature | L:BKSQ_CARAVAN_OILTEMPERATURE | CELSIUS |
| Left Fuel Quantity | A:FUEL TANK LEFT MAIN QUANTITY | GALLONS |
| Right Fuel Quantity | A:FUEL TANK RIGHT MAIN QUANTITY | GALLONS |
| Turn Coordinator Ball | L:BKSQ_TurnCoordinatorBall | 0 - 100 |
| Magnetic Compass (with field error) | L:BKSQ_MagneticCompassHeading | 0 - 100 |
| Oxygen Pressure | L:var_oxygenPressure | PSI |

### Radio Navigation Variables

While these variables may seem redundant, Black Square aircraft incorporate a signal degradation system, and physics based needles.  Even the TO-FROM flags exhibit non-boolean behavior for a more realistic experience.

| **Description** | **Variable** | **Range** |
|---|---|---|
| HSI CDI Needle | L:BKSQ_CARAVAN_HSI_LOC | 0 - 100 |
| HSI CDI Flag | L:BKSQ_CARAVAN_HSI_LOC_FLAG | Boolean |
| HSI Glideslope Needle | L:BKSQ_CARAVAN_HSI_GLIDE | 0 - 100 |

| | | |
|---|---|---|
| Localizer 2 CDI Needle | L:BKSQ_CARAVAN_LOC_2 | 0 - 100 |
| Localizer 2 CDI Flag | L:BKSQ_CARAVAN_LOC_2_FLAG | Boolean |
| Localizer 2 TO Flag | L:BKSQ_CARAVAN_LOC_2_TO_FLAG | 0 - 100 |
| Localizer 2 FROM Flag | L:BKSQ_CARAVAN_LOC_2_FROM_FLAG | 0 - 100 |
| Localizer 2 Glideslope Needle | L:BKSQ_CARAVAN_GLIDE_2 | 0 - 100 |
| Localizer 2 Glideslope Flag | L:BKSQ_CARAVAN_LOC_2_GS_FLAG | Boolean |
| RMI ADF Needle | L:BKSQ_CARAVAN_RMI_ADF_NEEDLE | 0 - 100 |
| RMI VOR Needle | L:BKSQ_CARAVAN_RMI_VOR_NEEDLE | 0 - 100 |
| RNAV CDI Linear Deviation Mode | L:var_rnavCourseLinearFlag | Boolean |
| RNAV CDI Approach Deviation Mode | L:var_rnavApproachMode | Boolean |
| RNAV Data Entry Mode | L:var_rnavDataEntryMode | Number |
| RNAV Waypoint Number | L:var_RNAV_WAYPOINT_NUMBER | 1 - 10 |
| RNAV CDI Needle | L:BKSQ_RNAV_CDI_Degraded | -127 - 127 |
| RNAV CDI TO  Flag | L:BKSQ_RNAV_TO_Degraded | 0 - 1 |
| RNAV CDI FROM  Flag | L:BKSQ_RNAV_FROM_Degraded | 0 - 1 |
| RNAV Bearing Pointer | L:BKSQ_RNAV_BRG_Degraded | 0 - 360 |
| RNAV DME Distance Output | L:var_RNAV_DME | 0.0 - 999.9 |
| RNAV DME Speed Output | L:var_RNAV_DMESPEED | 0.0 - 999.9 |
| RNAV Frequency Data Display | A:NAV STANDBY FREQUENCY:3 | Hz |
| RNAV Radial Data Display | L:var_RNAV_RADIAL_NUMBER | 0 - 360 |
| RNAV Distance Data Display | L:var_RNAV_DISTANCE_NUMBER | 0.0 - 999.9 |

## 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 CaravanProfessional_INT.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

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

Click the back of the tablet **forward of the circuit breaker panel**.  Click the same area to close the tablet.  The tablet can be moved by dragging its frame.  The tablet can also be moved by dragging the bezel using legacy interaction mode.  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.

## How do I change which avionics/radios are installed?

The current avionics configuration is selected on the **options page of the tablet interface**.  Once you've chosen your avionics, click the confirm button.  Wait a few seconds for the change to take effect.  For more information, see the "Tablet Interface" section of this manual.

## How do I choose between the TDS and PMS GTN 750?

The current avionics configuration is selected on the **options page of the tablet interface**.  The "PMS50 - TDS" toggle switch selects which GPS provider is used for the GTN 750/650.  For more information, see the "Tablet Interface" section of this manual.

## 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.

## 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.

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

**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 is the autopilot behaving strangely, not changing modes, showing HDG/NAV simultaneously, or not capturing altitudes?

**This is indicative of GPS addon incompatibility**. Please make sure that you have updated all the avionics packages that you are using, including the TDS GTNxi 750, the PMS50 GTN 750, and the WT GNS 530, and that you do not have any outdated packages, such as the original PMS50 GNS 530 modification.

**No additional packages should be required for the autopilot to work correctly** with the various GPS choices. The product is tested with ONLY the TDS GTNxi 750, the freeware PMS50 GTN 750, and the free WT GNS 530 marketplace package installed. Please see the "Third Party Navigation & GPS Systems" section of this manual for more information.

## 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 and **engine data monitor for flashing exceedance warnings**. See the "Turboprop Engine Operation" section of this manual for more information.

## 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 is the GTN 750 GPS or KLN-90B GPS screen black?

Make sure you have the PMS GTN 750 or TDS GTNxi 750 installed properly in your community folder. **The free addon can be obtained for free from the following link.**

[https://pms50.com/msfs/downloads/gtn750-basic/](https://pms50.com/msfs/downloads/gtn750-basic/)

Make sure you have the Falcon71 KLN-90B installed properly in your community folder.
**The free addon can be obtained for free from the following link.**

[https://github.com/falcon71/kln90b/releases](https://github.com/falcon71/kln90b/releases)

For more detailed Installation instructions see the "Installation, Updates & Support" section of this manual.

## 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.

## Can the autopilot track KNS-80 RNAV waypoints?

**Yes! This is a new feature in this aircraft.** By the nature of how the KNS-80 autopilot has been implemented, it cannot conflict with other GPS sources of navigation; therefore, the KNS-80 can only drive the autopilot's NAV mode in the no-GPS avionics configuration. For more information, see the "Using the KNS-80 RNAV Navigation System" or the "Bendix/King KNS-80 RNAV Navigation System" section of this manual.

## 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 window.

## 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, or on the "SYSTEMS" page of the weather radar display.

## Why do screens flicker at night when adjusting lighting intensity?

This is a long standing bug in MSFS with some graphics settings and hardware. It happened rarely in MSFS 2020, but constantly in MSFS 2024. **Disabling NanoVG from the "Experimental"** menu in General Settings will stop the flickering in MSFS 2020. (Black Square products do not use legacy XML gauges.) **Using the "Legacy" interaction mode in MSFS 2024** will also eliminate the flickers, as they are caused by the blue control highlight.

## Why does pitch control seem overly sensitive in MSFS 2024?

For some reason, control reactivities appear to be much higher by default in MSFS 2024 than MSFS 2020. Since this will affect all aircraft, try changing your hardware sensitivities in the controls menu by clicking the gear icon beside your hardware input device.

## Why does the HUD airspeed not match the cockpit instrument?

MSFS only has a very rudimentary sense of Calibrated Airspeed (CAS). Instead, all indicated airspeeds (IAS) are generally assumed to be ideal. In a real aircraft, an airspeed indicator does not always accurately depict the ram pressure at the pitot tube. The angle of attack, flap setting, and installed position of the pitot tube can all affect the airspeed seen by the pilot on the airspeed indicator. For most aircraft, the difference between CAS and IAS is usually only a few knots at high angles of attack. This difference can be as much as 15 kts for the Caravan. As such, it was necessary to calculate an accurate CAS to IAS difference, and apply this to the airspeed indicator to properly reflect the documented stalling speeds. Unfortunately, it is not possible to mirror this value on the simulator's default HUD. For cockpit builders, the accurate airspeed can be accessed using the L:Var, L:BKSQ_AIRSPEED_CORRECTED.

## Why is it hard to slow the aircraft down after landing on unimproved surfaces or water?

The power lever should be moved into the beta range after touchdown to help slow the aircraft; however, the beta range is locked out while the aircraft is airborne to aid users without hardware throttle detents. Bumpy surfaces or waves can cause the aircraft to become momentarily airborne, thus returning the power lever to flight idle. For the Caravan Professional, consider activating the "Unrestricted Beta Range" option on the tablet's options page to disable this safety lockout.

# Change Log

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

**New Features:**

- Improved propeller dynamics to provide better aerodynamic “braking” effect at low power settings, allowing for steeper descents and easier spot landings.
- Changed a configuration parameter and associated code which should provide enhanced engine response during reverse thrust.  This also appears to improve secondary aerodynamic effects of the reverse thrust, previously limited by the prop_reverse_max_vel parameter.
- More amphibious water sounds to add variation during taxi and takeoff while the floats are in full displacement mode.

**Bug Fixes:**

- Decoupled propeller animation from the frame rate for smoother transitions to the blurred propeller, due to a lapse in reverse compatibility in MSFS 2024.
- Fixed a dependency, which caused the avionics to fail to load if some files present in other Black Square aircraft were not also present in the Community Folder.  Thank you, Trevor from FSElite for your assistance!
- Improved side propeller sounds in external view for better fly-by sounds.
- Improved propeller beta transition sound within cockpit.

# Credits

| | |
|---|---|
| Caravan Professional | Nicholas Cyganski |
| Publishing | Just Flight |
| Audio | Boris Audio Works |
| Liveries | Ryan “ryanbatc” Butterworth |
| | Tim "TimHH" Scharnhop |
| Manual | Nicholas Cyganski |
| Console Testing | Just Flight Testing Team |

# Dedication

My second aircraft for Microsoft Flight Simulator is dedicated to John A. Orr, a close family friend, and the man without whom I would likely only have had a small fraction of the adventures and experiences in aviation that I have been fortunate enough to have.  Soon after getting my pilot’s license, John was willing to share fractional ownership of his Piper Warrior with me, potentially risking disaster by letting a newly minted pilot enjoy the freedoms of aircraft ownership.  Rather than obsessing over my every move, John taught by example, and I credit him with many of my safe flying strategies.  Going far beyond the role of a pilot mentor, John introduced me to all aspects of aircraft ownership, which I’ve done my best to pass onto others since.  As an increasing number of flight schools become disinterested in renting their aircraft, most new pilots find themselves with the ability to fly, but suddenly without anything *to* fly, lacking a personal introduction to aircraft ownership.  My other influences, to whom several of my products are now dedicated, have inspired me to pursue certain skills in life, but John inspired me to be generous with those skills and resources, and to share them with the next generation of pilots, engineers, and software developers.

This dedication also appeared at the end of the Analog Caravan manual.

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