Black Square

PISTON DUKE

OPERATIONS MANUAL

For Microsoft Flight Simulator

Published By:
Just Flight

Black Square

"Virtual Aircraft. Real Engineering."

Piston Duke User Guide

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

Contents

Introduction

The Duke 60 was introduced in 1968 to fill a market for executive travel between the Baron series and the King Air 90 series. While the Baron and King Air remain in production today, selling over 10,000 combined aircraft, only 600 Duke airframes were manufactured between 1968 and 1983. Despite this, the Duke remains one of the highest performance twin engine piston aircraft in the market, and a cult favorite among aircraft owners. New technologies were brought together to make the Duke's performance possible, such as bonded honeycomb tail surfaces, and massive Lycoming TIO-541 engines with integrated turbochargers. The ambitious Duke brought with it various complications, some of which were improved upon in the later A60 and B60 models, such as longer exhaust stacks to avoid flap corrosion, and a modernized pressurization controller. In the 40 years after production ceased, most original 1,200 hour TBO engines have been replaced with 1,600 hour TBO engines that are less prone to crankcase cracking, and stainless steel turbochargers, which offer better reliability for high altitude flights.

Black Square's Piston Duke brings you one of the most technically advanced aircraft simulations for Microsoft Flight Simulator, with an advanced reciprocating engine simulation, over 120 possible failures, 12 hot-swappable radio configurations, and the most advanced turbocharger, pressurization, and 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 Piston Duke's electrical system is highly accurate, featuring a battery temperature monitor, overvoltage protection, and AC inverters. The 3D gauges are modeled and coded to meticulously match their real world counterparts. No piece of equipment appears in a Black Square aircraft without a real world unit as reference. Radionavigation systems are available from several eras of the Duke's history, so users can fly without GPS via a Bendix KNS-81 RNAV system, or with the convenience of a Garmin GTN 750 (PMS50 or TDS). Other radio equipment includes KX-155 NAV/COM radios, KLN-90B, GTN 650, GNS 530, GNS 430, KR 87 ADF, KDI 572 DME, GTX 327 Transponder, Century IV Autopilot, and a Bendix RDR1150XL Weather Radar. A 160+ page manual provides instruction on all equipment, and 50 in-game checklists with control/instrument highlighting are included for normal and emergency procedures. This product **includes two versions of the 1974 B60 Duke**; with and without the "Grand Duke" performance package (winglets, vortex generators, strakes, extra fuel, increased speeds, and increased MGTOW). Four distinctive interiors and seven paint schemes are included from four decades of flying.

Primarily analog instrumentation augmented with modern radionavigation equipment 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. You also may find the analog instrumentation much easier to read with the limited number of pixels available on a computer monitor, and even more so in VR.

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

Feature Overview

Shared Features

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

- **160 page manual** with your complete guide to flying the Black Square Dukes, 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.
- **12 hot-swappable radio** configurations, configurable via tablet interface. Incl. PMS & TDS
- **130+ Random, scheduled, or performance triggered failures**, settable via the tablet interface, including engine damage, compatible with 3rd party UI's and instructor stations.
- **Fully simulated environmental control and pressurization system** for heating, air conditioning, ventilation, ram air cooling. Cool things off by opening a door, or watch the airplane heat up in the sun. Monitor via the new tablet interface.
- **NEW engine preheating** required for cold starts, with heater and ground power cart.
- **NEW voltage-based light dimming,** an immediately recognizable effect to nighttime pilots.
- **NEW gyroscope physics simulation** for electric and pneumatic gyroscopes with precession, and partial failures, based on a coupled quadrature oscillator.
- **NEW KLN-90B vintage GPS.** Download from https://github.com/falcon71/kln90b/releases
- **NEW strobe light system** causes realistic distracting flashes in clouds.
- **NEW St. Elmo's Fire** & static discharge on static wicks and windshields in severe weather.
- **NEW KNS-81 RNAV now supports autopilot** with No-GPS configuration.
- **Mathematically accurate VOR & ADF signal attenuation and noise degradation.**
- **Physics based instrument needles** bounce and respond to aerodynamic forces.
- Turbine engine failures, such as compressor stall and surging, and fuel control failures
- Improper engine management will slowly **damage engines to failure**.
- **Completely simulated electrical system**, with 100+ circuit breakers and failures
- **Functional exterior elements**: chocks, pitot covers, engine covers, propane preheater, and external power cart. Pitot cover flags blow in the wind.
- Carbon Monoxide leaks are possible, and can be detected with the CO detector.
- State saving for fuel, radio selection, radio frequency memory, cabin aesthetics, etc.

- Crew/Passenger oxygen depletes according to pressure altitude, passenger occupancy.
- Ultra-custom dynamic registration number system for livery creators.

Piston Duke Specific Features

- **Two aircraft in one:** The factory B60 Duke, and the “Grand Duke” performance package.
- **NEW physics-based engine simulation** with compression, magneto impulse couplings, blade angle, oil temperature & pressure, cylinder head temperatures, and preheating.
- **NEW propeller hub and unfeathering accumulator**, with feather locking pins.
- **NEW physics-based sound system.** Sounds like engine starting are not mere recordings, but instead many layered sounds, constructed based on the underlying simulation.
- **NEW instrument needle stiction and friction.** Analog instruments can become sticky without engines running. Tap the glass to free the needles and get a more accurate reading!
- **The most advanced turbocharger simulation in MSFS.** Turbocharger sounds reflect the simulated turbine RPM, and pressurization is dependent on turbocharger performance.
- **Fuel injected engine simulation with fouling, vapor-lock, flooding, and backfires,** even the magneto impulse couplings are simulated (clicking when the propeller rotates).
- **JPI EDM-760 Engine Monitor** with engine leaning optimization “Lean Find”.

Checklists

Over 500 checklist items are provided for 50 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 Duke features a custom soundset created by Boris Audio Works with care to the unique operating aspects of this classic 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 Turbine Duke features a flight model with performance to match the real world aircraft based on real Duke owner 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, such as CFD propeller and stall physics, and SU15 improved ground handling and flexible tire physics. Engine damage and fouling produces a rough running engine and decreased performance.

Aircraft Specifications

Length Overall	33’10”
Height	12'4"
Wheel Base	9’8"
Track Width	10’10"
Wingspan	39'4” (39’10” with Winglets)
Wing Area	212.9 sqft.
Flight Load Factors	+3.5/-1.2 G’s (+2.0/-1.1 G’s with Flaps Down)
Design Load Factor	150%
Cabin W/L/H	50" x 11’10” x 52"
Baggage Capacity	Nose: 500 lbs (32 cuft) Aft Cabin: 70 lbs
Oil Capacity	13 U.S. Quarts / Engine
Seating	6
Wing Loading	31.8 lbs/sqft
Power Loading	8.91 lbs/hp
Engines	380 HP (280 kW) Lycoming TIO-541. Turbocharged, direct-drive, Fuel-injected, air-cooled, horizontally opposed, 6-cylinder, 541.5 cubic-inch (8,874 cc) displacement.
Propellers	3-Blade Hartzell, Constant Speed, Aluminum, Hydraulically Actuated, 74 inch propeller. Fully fine blade angle of 14.0°, Low pitch blade angle of 58.2°, and feathering angle of 81.7°.
Approved Fuel Grades	Aviation Gasoline Standard Grade 100LL (blue) Aviation Gasoline Minimum Grade 100/130 (green) Aviation Gasoline Alternate Grade 115/145 (purple)
Fuel Capacity	Total Capacity: 207 (B60) / 237 (Grand Duke) U.S. Gal. Capacity Each Tank: 103.5 (B60) / 118.5 (Grand Duke) U.S. Gal. Total Usable: 202 (B60) / 232 (Grand Duke) U.S. Gal.
Electrical System	
Voltage:	28 VDC
Battery:	24V, 15 amp-hour, sealed lead acid battery
Generators:	28V, 120 amp @ 2,600 RPM, each engine
Pressurization System	4.7 PSI Maximum Pressure Differential Pressurization Rate Controller 150 ft/min to 2,000 ft/min Minimum/Maximum attainable altitude -1,000 ft / 15,000 ft Pressure Vessel Structural Life Limit: 15,000 hours

Aircraft Performance (Stock B60)

Maximum Cruising Speed	245 ktas
Normal Cruising Speed	215 ktas
Economy Cruising Speed	175 ktas
Takeoff Distance	2,626 ft
Takeoff Ground Roll	2,075 ft
Landing Distance	3,065 ft
Landing Ground Roll	1,318 ft
Accelerate/Stop Distance	3,600 ft
Normal Range (30 min. reserve)	950 nm
Maximum Range (30 min. reserve)	1,180 nm
Rate of Climb	1,600 ft/min
Single Engine Rate of Climb	307 ft/min
Service Ceiling	30,000 ft
Single Engine Service Ceiling	15,100 ft
Empty Weight	4,195 lbs
Max Ramp Weight	6,819 lbs
Max Takeoff Weight	6,775 lbs
Max Landing Weight	6,600 lbs
Useful Load	2,580 lbs
Usable Fuel Weight	1,212 lbs
Full Fuel Payload	1,368 lbs
Maximum Operating Temp.	+53°C
Minimum Operating Temp.	-54°C

Maximum Demonstrated Crosswind Component: 25 kts

V-Speeds (Stock B60)

Vr	85 kts	(Rotation Speed)
Vs	81 kts	(Clean Stalling Speed)
Vso	73 kts	(Dirty Stalling Speed)
Vmc	85 kts	(Minimum Controllable Speed w/ Critical Engine Inoperative)
Vx	99 kts	(Best Angle of Climb Speed)
Vy	120 kts	(Best Rate of Climb Speed)
Vxse	100 kts	(Best Single Engine Angle of Climb Speed)
Vyse	112 kts	(Best Single Engine Rate of Climb Speed)
Va	160 kts	(Maneuvering Speed)
Vg	110 kts	(Best Glide Speed)
Vfe	140 kts	(Maximum Full Flap Extension Speed)
Vfa	174 kts	(Maximum Approach Flap Extension Speed)
Vle	174 kts	(Maximum Landing Gear Extension Speed)
Vno	207 kts	(Maximum Structural Cruise Speed - exceed only in clean air)
Vne	233 kts	(Do Not Exceed Speed)

Aircraft Performance (Grand Duke)

Maximum Cruising Speed	250 ktas
Normal Cruising Speed	240 ktas
Economy Cruising Speed	185 ktas
Takeoff Distance	2,360 ft
Takeoff Ground Roll	1,875 ft
Landing Distance	2,885 ft
Landing Ground Roll	1,358 ft
Accelerate/Stop Distance	3,500 ft
Normal Range (30 min. reserve)	1,175 nm
Maximum Range (30 min. reserve)	1,460 nm
Rate of Climb	2,050 ft/min
Single Engine Rate of Climb	370 ft/min
Service Ceiling	30,000 ft
Single Engine Service Ceiling	15,100 ft
Empty Weight	4,275 lbs
Max Ramp Weight	7,039 lbs
Max Takeoff Weight	7,000 lbs
Max Landing Weight	7,000 lbs
Useful Load	2,725 lbs
Usable Fuel Weight	1,422 lbs
Full Fuel Payload	1,303 lbs
Maximum Operating Temp.	+53°C
Minimum Operating Temp.	-54°C

Maximum Demonstrated Crosswind Component: 25 kts

V-Speeds (Grand Duke)

Vr	76 kts	(Rotation Speed)
Vs	78 kts	(Clean Stalling Speed)
Vso	70 kts	(Dirty Stalling Speed)
Vmc	70 kts	(Minimum Controllable Speed w/ Critical Engine Inoperative)
Vx	96 kts	(Best Angle of Climb Speed)
Vy	126 kts	(Best Rate of Climb Speed)
Vxse	94 kts	(Best Single Engine Angle of Climb Speed)
Vyse	118 kts	(Best Single Engine Rate of Climb Speed)
Va	160 kts	(Maneuvering Speed)
Vg	115 kts	(Best Glide Speed)
Vfe	140 kts	(Maximum Full Flap Extension Speed)
Vfa	174 kts	(Maximum Approach Flap Extension Speed)
Vle	174 kts	(Maximum Landing Gear Extension Speed)
Vno	207 kts	(Maximum Structural Cruise Speed - exceed only in clean air)
Vne	233 kts	(Do Not Exceed Speed)

Engine Limitations

Engine Speed	2,900 RPM
Cylinder Head Temperature	475°F (246°C)
Exhaust Gas Temperature	1650°F (900°C)
Oil Temperature	245°F (118°C)
Oil Pressure	25 PSI (min.) 100 PSI (max.)
Manifold Pressure	41.5 inHg
Fuel Flow	93 - 110 PPH (55%) 110 - 131 PPH (65%) 131 - 142 PPH (75%)

Turbocharger Limitations

Critical Altitude	25,000 ft (varies with throttle and atmospheric conditions)
Turbine Inlet Temperature	1650°F (900°C)
Maximum Turbine RPM	125,000 RPM

DO NOT fully retard throttle above critical altitude. Engine combustion may cease.

NOTE: The Duke is a "turbocharged" aircraft, as opposed to a "turbonormalized" aircraft, meaning that the turbocharger is capable of supplying, and the engine is capable of using, intake manifold pressures greater than that of sea level (29.9 inHg).

Other Operating Limitations

- Do not engage starter for more than 30 seconds in any 4-minute period.
- When restarting an engine in flight do not use the starter above 20,000 feet.
- Engine must be preheated when ambient temperatures are below 10°F (12°C).
- Do not take-off when fuel quantity gauges indicate in the yellow arc, or with less than 25 gallons in each tank.
- Maximum slip duration: 30 seconds.
- Do not attempt to fully retract landing gear with manual hand crank handle. Doing so may cause damage to worm gear shaft.
- Avoid cooling cylinders at rates greater than 60°F (33°C) per minute.

Paint Schemes

The Black Square Piston Duke comes with seven paint schemes. The Piston Duke also comes with four 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.

At the time of release, 10+ community-made paint schemes are already available for download on **www.flightsim.to**. Install liveries just by dragging them into your community content folder.

Instrumentation/Equipment List

Main Panel

- Annunciator Panel
- True Airspeed Indicator
- Century 1U367 Steering Attitude Indicator
- Century NSD-360 Horizontal Situation Indicator (HSI)
- Bendix/King KEA-346 Encoding Altimeter
- Collins RMI-30 Radio Magnetic Indicator (RMI)
- Vertical Speed Indicator
- Bendix/King KI 206 Localizer
- Mid-Continent Turn Coordinator
- Bendix/King KRA-10 Radar Altimeter
- Engine Instrumentation
- Fuel Quantity Indicators
- BTI-600 Battery Temperature Monitor
- Duplicate Copilot Instrumentation

Avionics

- Integrated 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-81 RNAV Navigation System
- Bendix/King KR 87 ADF
- Bendix/King KDI 572R DME
- Century IV Autopilot
- Collins PRE-80C Altitude Preselector
- JPI EDM-760 Engine Monitor
- Bendix RDR 1150XL Color Weather Radar
- Garmin GTX 327 Transponder

Electrical/Miscellaneous

- 70+ Circuit Breakers
- Voltmeter & Ammeters
- Instrument Air Indicator
- Deicing Boot Pressure Indicator
- Oxygen Pressure Gauge
- Yoke-Mounted Digital Chronometers
- Tach Timers

- Carbon Monoxide Detector
- Cabin Pressurization Controller
- Cabin Environmental Control System
- Low Thrust Detector

Installation, Updates & Support

Installation

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

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

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

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

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

The Working Title GNS 530/430 is now included by default with your download of MSFS. No action should be required by the user to make use of the WT GNS 530/530 in this aircraft.

If, for whatever reason, the GNS 530/430 does not seem to be working as intended in this aircraft, download and install the Working Title GNS 530/430 from the in-game marketplace. Click the “MARKETPLACE” tile in the MSFS main menu, and use the search bar to find “GARMIN GNS 430/530” by “Working Title Simulations”. After clicking the “GET AND DOWNLOAD” button, the GPS will be ready to use.

TDS GTNxi 750/650 Integration

This aircraft’s GTN 750 unit will automatically detect a valid TDS GTNxi installation and license key, and automatically switch between using the PMS GTN 750 and the TDS GTNxi 750 without any required action by the user.

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 'B60 Duke', or the 'B60 Grand Duke' by Black Square.
4. The Piston Duke is available in two configurations, which appear separately in the aircraft selection menu. They are: Stock B60, and Grand Duke upgrade kit.
5. 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 is the first to debut 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.

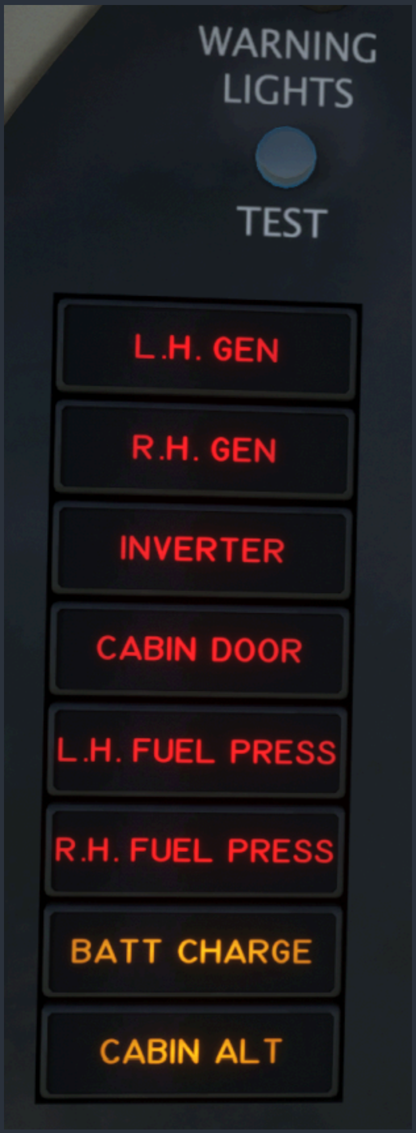
New fonts can be added in livery packages, and any font/outline/shadow color may be selected from the standard JavaScript colors by name, or by Hex Code.

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 Piston Duke's annunciator panel consists of eight annunciator lamps located on the pilot's upper side panel, above the engine controls. From top to bottom, the lamps indicate the following conditions:

L.H. GEN	Left Generator Inoperative
R.H. GEN	Right Generator Inoperative
INVERTER	Loss of AC Avionics Power
CABIN DOOR	Cabin Door Open or Unlatched
L.H. FUEL PRESS	Left Fuel Pressure < 5.0 PSI
R.H. FUEL PRESS	Right Fuel Pressure < 5.0 PSI
BATT CHARGE	Battery Charging > 30 AMPS
CABIN ALT	Cabin Altitude > 10,000 FT

To test the annunciator panel, press and hold the "Warning Lights Test" push button above the annunciator panel. The annunciator panel receives power through the "Annun Panel" circuit breaker on the copilot's upper side panel.

True Airspeed Indicator

The Piston Duke's airspeed indicator displays indicated airspeed in knots, reference speeds with colored arcs, and true airspeed on a white tape through the bottom window. The red marking corresponds to the never-exceed speed. The yellow arc corresponds to the clean-air-only speed, where the lower bounds of the arc is the maximum structural cruising 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. Two additional radial marks are relevant to twin engine aircraft operation. The red line indicates Vmc, or minimum controllable speed with a single engine operating, and the critical engine inoperative. The blue line indicates the best single engine operating climb speed. A small white triangle indicates the maximum landing gear extension airspeed, and maximum approach flap setting airspeed. The airspeed indicator also includes a true airspeed calculator, which can be positioned for pressure altitude and air temperature, much like an E6B flight computer, to produce the true airspeed indicated in the bottom window.

Century 1U367 Steering Attitude Indicator

The Century 1U367 is a vacuum powered artificial horizon with adjustable attitude bars and a single-cue flight director. The attitude bars are adjusted with the unlabeled knob on the bottom right of the unit. When paired with a Century autopilot, the 1U367 is capable of driving integrated attitude commend bars via the autopilot's flight director output. The command bars will automatically compensate for the adjusted position of the static attitude bar, and will be hidden from view when not in use. Turning the "FD" knob clockwise will engage the flight director if the unit is receiving a valid signal. Turning the knob back to the left will hide the flight director.

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.

Century NSD-360 Horizontal Situation Indicator (HSI)

The Century NSD-360 has an automatically controlled compass card, as opposed to most directional gyroscopic compass units, which can be automatically slaved to magnetic heading. The HSI has two knobs, one for controlling the green heading bug for autopilot heading hold mode, and one for adjusting the course indicated with the yellow needle in the center of the display. The HSI in this aircraft can be controlled by the NAV1 receiver source (VLOC), the NAV1 GPS signal (GPS), or the RNAV source. The RNAV source is selected with the switch located above the autopilot auxiliary mode annunciator panel.

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 the left of the unit is a normally hidden and flagged, yellow, glideslope indicator needle, which comes 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 and white “NAV” flag appears in the center of the display. When no valid signal is received from the remote compass, a red and white “HDG” flag appears at the top right of the display. When the unit is not receiving power, both flags are visible.

The NSD-360 acts as the remote compass controller, along with a “Gyro Slave/Free” mode switch on the integrated audio control panel. 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 mode is placed in the “SLAVE” position. In this mode, the NSD-360’s integrated synchroscope needle in the upper right corner of the instrument should be centered between the + 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 controlled by depressing the heading bug control knob, labeled “PUSH CARD SET”, and rotating the knob. In this mode, the synchroscope will show the set compass position’s deviation from the detected magnetic heading. During normal operation, the integrated synchroscope needle should be observed oscillating about the centered position. This confirms that the system is functioning properly.

NOTE: It was previously not possible to drive the autopilot from RNAV source. This limitation has been eliminated, starting with this aircraft. The autopilot will only use the KNS-81 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 attitude indicator to select “RNAV” as the HSI source.

Bendix/King KEA-346 Encoding Altimeter

The KEA-346 is a single needle type altitude indicator with a digitally controlled three-drum indicator for altitude, and two mechanically controlled four-drum indicators for barometric indication in millibar and inches of mercury. When the unit is not receiving power, a red and white flag covers the altitude indicating drums. The barometric setting is controlled via an adjustment knob on the face of the unit. The pilot's altimeter is the encoding altimeter used for the Mode-C transponder output, and to drive the altitude hold function of the Century IV autopilot.

Collins RMI-30 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 can display the bearing to either the station tuned in the NAV1 radio, or the ADF1 radio. The hollow green needle can display the bearing to either the station tuned in the NAV2 radio, or the ADF2 radio. Both needles will point directly to the tuned radio ground station whenever signal strength is sufficient. To swap which source is used for either needle, press the illuminated push buttons on the face of the unit. 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 RMI will show a red flag when the unit is not receiving power, or when the unit is not receiving signal from the remote compass.

NOTE: While this unit is capable of displaying information from two ADF units, this aircraft is only equipped with a single ADF receiver, which can be displayed on either needle.

NOTE: This is the only piece of avionics in the aircraft powered by alternating current.

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 a VOR/ILS receiver, the GNS 430W, or the 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 cluster of five engine instruments resides at the top of the main instrument panel. From left to right, they are; manifold pressure (inHg), engine RPM (RPM x 100), fuel flow (PPH), left engine oil parameters (PSI & °C) and cylinder head temperature (°C), and right engine oil parameters (PSI & °C) and cylinder head temperature (°C). The first three instruments have concentric indicating needles, one for each engine, marked "L" and "R".

Operators of normally aspirated aircraft will notice that the manifold pressure gauge contains a redline at 41.5 inHg, as opposed to 30.0 inHg. The Piston Duke is a "turbocharged" aircraft, as opposed to a "turbonormalized" aircraft, meaning that the turbocharger is capable of supplying, and the engine is capable of using, intake manifold pressures greater than that of sea level (29.9 inHg). While the green band extends all the way up to 41.5 inHg, this is the absolute maximum allowable manifold pressure, and lower power settings should be used for climb and cruise to ensure engine longevity.

The engine RPM gauge is also equipped with an integrated propeller synchrophaser. As the Piston Duke is equipped with a propeller synchronizer, it is also equipped with a visual synchrophaser. The synchrophaser is a small disk with alternating black and white wedge marks. When one propeller is spinning faster than the other, the disk will rotate in the direction of that propeller; counterclockwise for the left engine, and clockwise for the right engine. This particular instrument is marked with "<S   F>" indicating how the right engine's propeller lever should be adjusted to synchronize the propellers. During non-critical phases of flight, the propeller synchronizer can be enabled to match propeller RPM and phase automatically.

The fuel flow gauge possesses markings in a white band in the center of the instrument to demarcate typical engine power settings in percent of maximum power. In the clockwise direction, they are; 55% power, 65% power, 75% power, climb power, and take-off power.

The Piston Duke is notably lacking exhaust gas temperature gauges for its two engines. Exhaust gas temperature should be monitored via the EDM-760 engine monitor for precise power setting; however the included turbine inlet temperature gauge can be used to approximate exhaust gas temperature trends.

NOTE: See the “Engine Power Settings” section of this manual for proper operating technique.

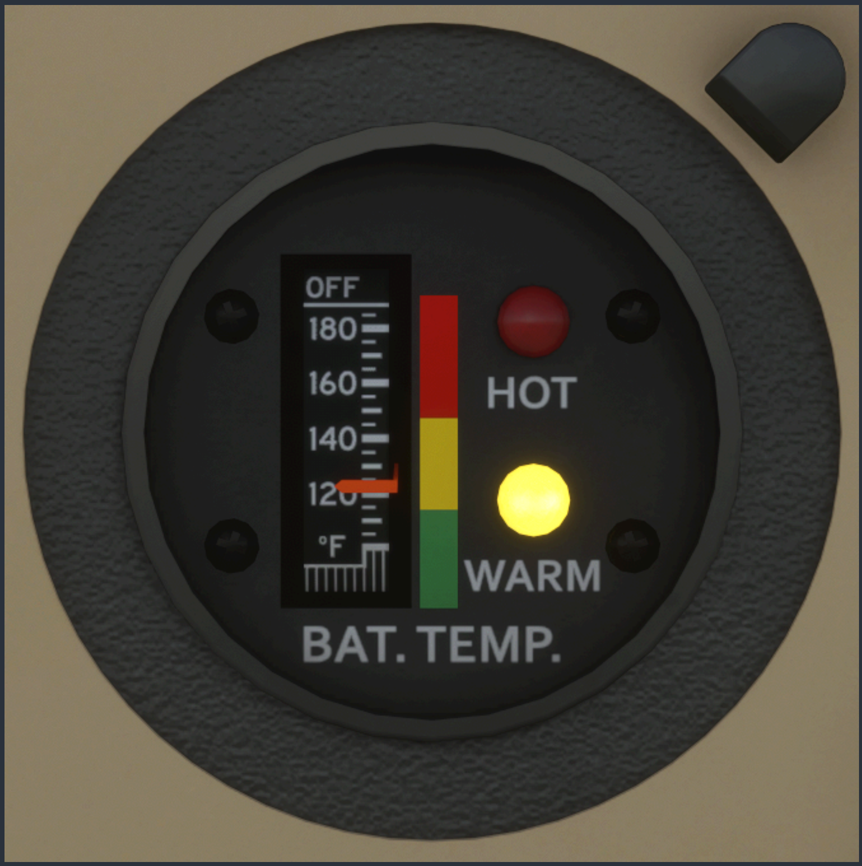
Fuel Quantity Indicators

On the pilot's right subpanel, above the lighting controls, there are two fuel quantity indicators. The fuel indicators are marked in gallons. In the stock B60 Duke, each fuel tank has a capacity of 103.5 U.S. Gallons, with 101 gal usable. In the upgraded Grand Duke, each fuel tank has a capacity of 118.5 U.S. Gallons, with 116 gal usable. Takeoff is not permitted when either fuel quantity is within the marked yellow arc, or below 25 gallons.

NOTE: Conventional fuel sender units in aircraft are notoriously sensitive to lateral G-force, and how level the aircraft is sitting on the ground. The fuel quantity gauges may appear to indicate incorrectly, as a result, though this is accurate to the real aircraft. 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.

BTI-600 Battery Temperature Monitor

This aircraft is equipped with a realistic battery temperature simulation. The original aircraft shipped with nickel cadmium batteries from the factory, which made it particularly susceptible to battery overheating. The BTI-600 is an electrically powered instrument that displays battery terminal temperature with an orange indicating needle. Two integrated warning lights are activated when the needle enters the yellow and red colored temperature bands; yellow for "Warm" and red for "Hot". When the unit is off, the orange needle will rest at the top of the scale on the word "OFF". Otherwise, if the temperature is low, the needle will rest at the bottom of the scale in the hatched area. The "Warm" temperature band is approximately 120°F to 150°F, and the "Hot" temperature band is 150°F and above.



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

Duplicate Copilot Instrumentation

A conventional six-pack of primary flight instruments is included on the co-pilot's side of the aircraft, including an airspeed indicator, DC electric artificial horizon, three pointer altimeter, gyroscopic heading indicator, turn coordinator, and vertical speed indicator. To best serve as backup instrumentation in case of a vacuum failure, the artificial horizon and directional gyroscope are electrically powered. A second Bendix/King KI 206 Localizer unit is included which permanently displays signals from the KNS-81 RNAV computer. Also on the copilot's side is a turbine inlet temperature gauge, marked in 25°F increments from 1,200°F to 1,700°F.

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.

Integrated Audio Panel

In the center of the main panel is an integrated audio control panel. At the top of the panel resides a rotary selector knob to select the transmitting radio, either COM1 or COM2. A concentric volume knob controls the master volume of all audio. To the right of these knobs is a switch to control the destination of the received audio, either the cockpit speaker, or flight crew headphones.

Beneath the transmitter select knob, two rows of toggle switches control the currently audible audio sources. The last switch on the right in the bottom row, labeled "Gyro Slave/Free" controls the current mode of the remote compass. For more information on adjusting the remote compass in this aircraft, see the instructions for using the Century NSD-360 Horizontal Situation Indicator, above. The integrated audio panel is backlit by electroluminescent lighting, the intensity of which is controlled via the "RADIO" lighting dimmer on the lighting control panel.

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-81 RNAV Navigation System

See the standalone section of this manual for instructions on using the KNS-81, 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-81, 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 button and integrated annunciators will read "VLOC/RNAV", instead of "VLOC/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. On the left of the unit, the "ADF" push button toggles the ADF receiver's antenna mode between normal operation, and listening to the sense-only antenna (disabling the loop antenna), which makes receiving audio-only transmissions easier in low signal strength conditions. Lastly, the "BFO" push button toggles the unit's beat frequency oscillator, which is used to listen to the tuned station's morse code identifier in low signal strength conditions.

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.

The “R” designation of this unit is of fictional nature to indicate that it possesses an additional switch position for viewing RNAV DME information from the KNS-81. When the rotary selector switch is placed in the RNAV position, “RNV” will annunciate to the right of the distance information. In normal operation, the unit will display DME information from the KNS-81, just like any other DME source. When the “RAD” two-position button is depressed on the KNS-81, however, the time (MIN) field will read “F”, for “From”, to indicate that the speed field (KT) is displaying the radial FROM the waypoint or VOR upon which the aircraft currently sits. When is radial mode, the “KT” and “MIN” annunciators will not be illuminated.

Century IV Autopilot

The Century IV Autopilot is a relatively simple autopilot, with standard modes of control, which resemble the operation of other light aircraft autopilots that users may already be familiar with. The autopilot possesses a master on/off button, labeled “AP” on the left of the mode control panel. Below this, a red button, labeled “test”, will illuminate all the indicator lamps, except “HDG” and “ATT”, as these are always illuminated when the autopilot is active. This unit has internal integrity lighting, which is controlled via the “PED” lighting dimmer on the lighting control panel.

NOTE: The pitch trim power switch, located to the right of the panel lighting dimmers, must be in the on position for the autopilot servos to control the aircraft.

The autopilot mode control buttons on the unit are split into horizontal modes in the top row, and vertical modes on the bottom row. Every mode should be familiar to users already with the exception of “ATT” attitude holding mode.

While most modern autopilots have a means for selecting a desired altitude and vertical speed to reach it, the Century IV instead uses pitch information only to control the aircraft's vertical profile to a desired altitude. Pressing the "ATT" button in flight will synchronize the autopilot's pitch holding reference with the aircraft's current pitch. Unlike a rocker switch or digital rotary knob, this will physically position the pitch control roller knob on the right of the unit to match the desired pitch attitude. Once in pitch holding mode, the pitch roller knob can be scrolled to select the desired aircraft pitch.

The main drawback of this system is that the pitch must be continuously adjusted during long climbs to ensure that an appropriate airspeed is maintained. Failing to do so may result in dangerously low airspeeds when climbing into higher altitudes. Pressing and holding the control wheel steering (CWS) button on either control yoke allows the pilot to adjust the pitch of the aircraft without fighting the autopilot servos, or using the pitch roller knob. Upon releasing the CWS button, the aircraft will resynchronize the pitch roller knob, and begin holding the new pitch attitude selected by the pilot.

When the aircraft's pitch is controlled by glideslope mode, activating attitude mode can cause the aircraft to pitch down unexpectedly if the pitch knob has been left in a nose down position. For this reason, the "ATT" lamp will flash when these two conditions are met.

This aircraft is equipped with an auxiliary autopilot mode annunciator panel on the pilot's main instrument panel, above the attitude indicator. This unit mirrors the autopilot mode annunciation on the mode control panel.

NOTE: For your convenience, the autopilot mode annunciator panel can be used to toggle autopilot modes without needing to look down at the pedestal.

The flight director on the Century 1U367 Steering Attitude Indicator can be activated and deactivated by turning the knob at the bottom left of the instrumet's bezel, marked "FD". The flight director can also be deactivated via the red autopilot disconnect buttons on either yoke. In the real aircraft, this push button has two stages of activation. For your convenience, this feature is approximated with two presses of the button. The first press will deactivate only the autopilot master, allowing the user to hand-fly the aircraft. The flight director and relevant modes will remain engaged. Upon pressing the disconnect button a second time, the flight director will also be disengaged. When the autopilot master is disengaged after the first press, all autopilot modes can still be selected on the Century IV mode control panel, which will apply to the command bars, just as if the autopilot was still flying the aircraft itself.

Collins PRE-80C Altitude Preselector

Like many autopilots, the Piston Duke's Century IV receives altitude commands from an adjustment knob and a "pre-selector", which commands altitudes at which to level-out, or hold. The PRE-80C has a three-drum altitude indication, which is mechanically controlled via a knob on the unit's face. The knob controls the thousands digit (with rollover) when pressed in, and the hundreds digit when pulled out. The PRE-80C has an integrated "ALT ALERT" push button and indicator which is a latching-type indicator. The button illuminates when within 1,000 ft of the desired altitude, and when leaving 500 ft within the desired altitude. The alert can be canceled by pressing the PRE-80C's integrated push button. When the unit is not receiving power, or not connected to the Century IV autopilot, a red flag appears across all digits.

JPI EDM-760 Engine Monitor

This engine monitor is a powerful tool for monitoring and managing a high performance aircraft engine, and should be used to its fullest potential to prevent engine damage, increase mechanical longevity, and provide the most efficient cruise flight. See the standalone section of this manual for instructions on using the EDM-760, below.

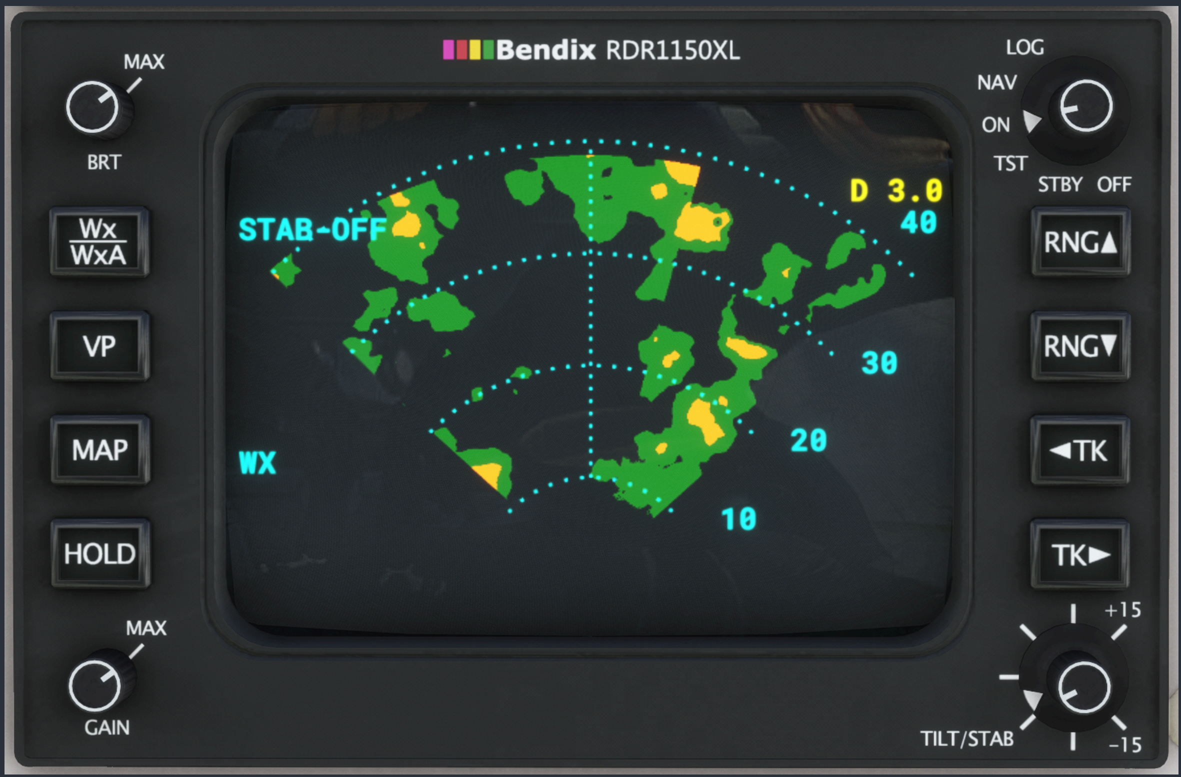
Bendix RDR 1150XL Color Weather Radar

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.

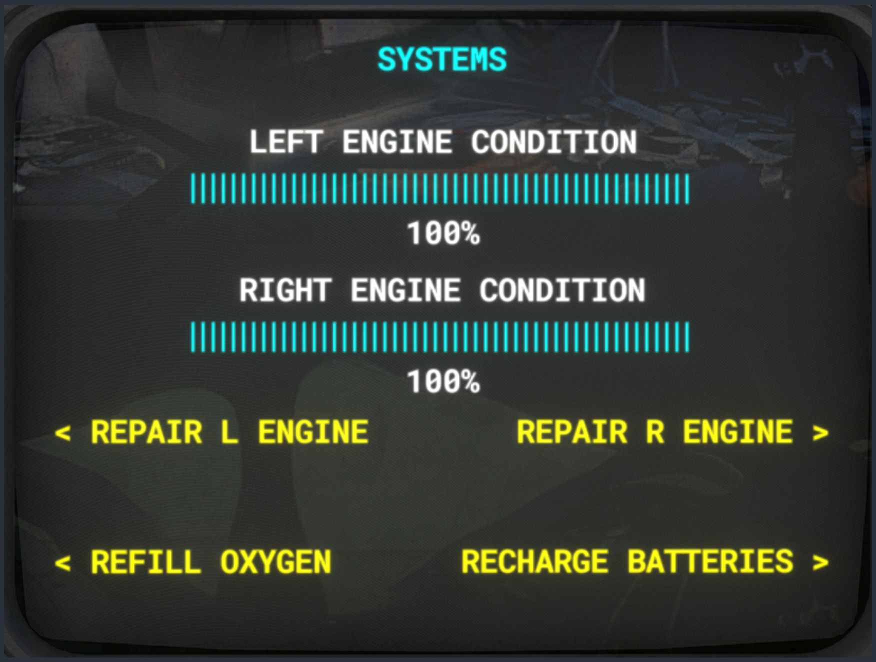
In “TST” mode, the unit will continuously display a sweeping test signal from the radar unit, which should subtend the full horizontal radar arc, and contain concentric arcs of magenta, red, yellow and green. The “RT FAILURE” flag will also display in cyan.

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

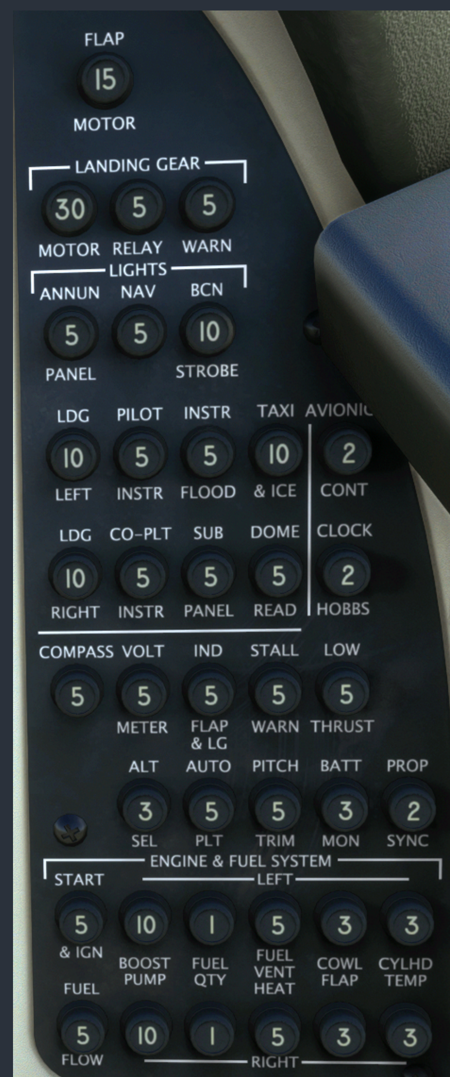
Timers can started and stopped by pressing the "START/STOP" button, and the time can be cleared/reset with the "CLR" button.

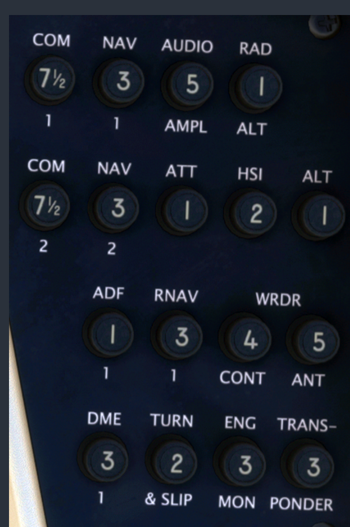
Electrical/Miscellaneous

Circuit Breakers

The Piston Duke's circuit breaker panels are located on the copilot's side of the aircraft. Power distribution and high load breakers are located on the copilot's right subpanel. Avionics circuit breakers are located on the copilot's lower side panel. All other circuit breakers are located on the copilot's upper side panel. The avionics circuit breaker panel consists of four rows. The first and third rows from the top receive power from the left distribution bus through the left avionics bus relay. The second and fourth rows from the top receive power from the left distribution bus through the right avionics bus relay. For more information on these breakers, see the electrical schematics included in this manual.

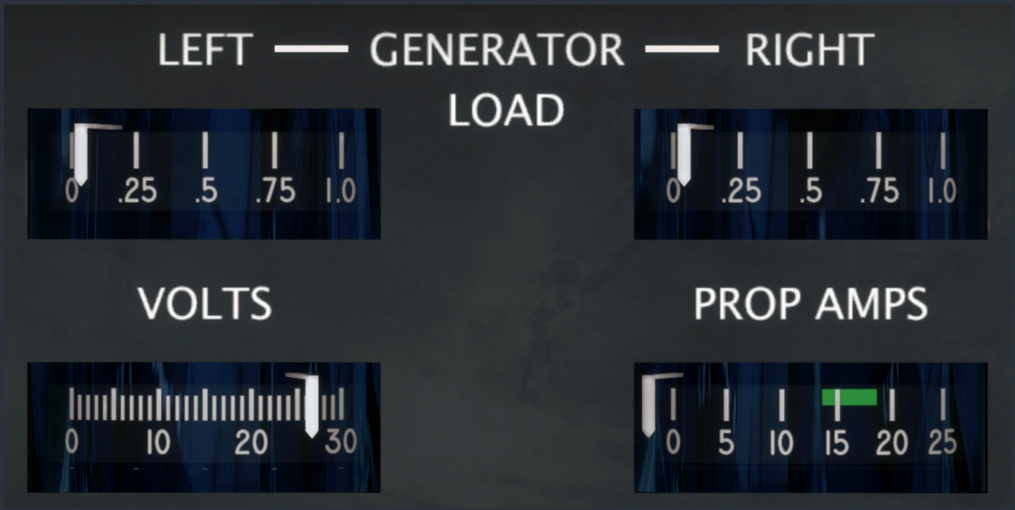
Breakers may be pulled or pushed to disable electrical circuits and bus connections within the aircraft. All the corresponding electrical circuits are modeled. The status of the electrical system may be monitored via the volt and amp meters discussed below. In an emergency situation, such as the detection of smoke, acrid burning smells, loss of engine, or alternator failure, all non-essential electrical systems should be switched off, workload permitting. For load shedding purposes, one of the two avionics bus relay circuits on the copilot's right subpanel can be pulled to disable half of the avionics equipment.





Voltmeter & Ammeters

On the center subpanel, four meters with horizontal scales indicate various electrical parameters of the aircraft. The two top meters are loadmeters, indicating generator load in decimals of their maximum rated output. When both engines are running at the same RPM, these two meters should read very similarly. Should they become different, it could indicate a failed generator, failed voltage regulator, or an overvoltage condition that has triggered a generator bus isolation. The bottom left meter indicates the bus voltage, sensed at the main bus bar. The bottom right meter indicates the total amperage of the propeller de-icing system, with a green band between 14 and 18 amps.



An additional horizontal meter on the pilot's left subpanel, marked "WSHLD DE-ICE AC VOLTS" indicates the alternating current voltage supplied by the left windshield and standby avionics AC inverter. This meter contains a green band between 220 and 260 volts, and should be monitored while windshield heat is in use, as windshield heating cycling is powered by a temperature controlling unit.

NOTE: The windshield heat switch must be on to activate the windshield and standby avionics AC inverter for use as an alternate source of AC avionics power.

Instrument Air Indicator

The instrument air indicator shows the regulated air pressure generated by the two engine-driven air pumps. An adjacent switch, labeled “GYRO PRESS GA” is used to switch between the left (pilot), and right (co-pilot) instrument air source plenum to ensure that both engines are producing adequate instrument air pressures. The scale on the gauge indicates the acceptable pressure range through the aircraft’s cruising altitudes. At sea level, the vacuum suction should be near the top of the green arc, above 5 inHg. Since dual engine failure in a twin engine aircraft is very unlikely, there is no additional electric standby instrument air pump. At the bottom of the gauge, there are two red incandescent indicator bulbs to indicate when a source of instrument air has become inoperable. These indications should be checked during engine starting.

Deicing Boot Pressure Indicator

Deicing pressure for the aircraft’s inflatable deicing boots is supplied by a mechanical instrument air pump on each engine. This is the same air source used to power the gyroscopic flight instruments. This gauge indicates the pressure in PSI being admitted to the deicing boots, and will cycle as the automatic deicing boot controller cycles the pressurized air to the different zones of the aircraft. The pressure will be a few PSI less when operating the deicing boots in manual mode, as this activates all deicing zones at once.

Oxygen Pressure Gauge

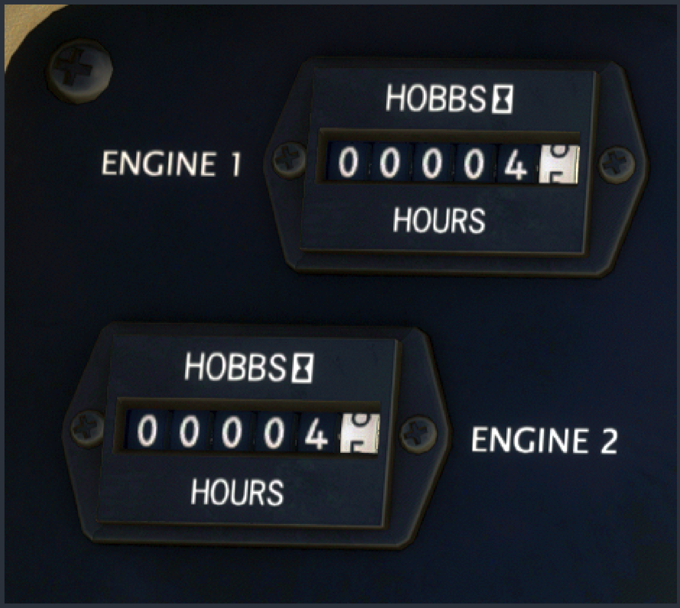
On the pilot's side wall, a gauge indicates the oxygen pressure available in the onboard, refillable oxygen cylinder. This cylinder is normally pressurized to 1,800 - 2,000 PSI when serviced on the ground. Oxygen pressure will deplete as it is consumed by passengers and crew, when activated. To activate the built-in demand-type oxygen regulators for all occupants, rotate the brushed metal oxygen supply knob on the pilot's side wall counterclockwise until the green marking is visible. Oxygen will be consumed by the occupants 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 screen of the tablet interface, or the "SYSTEMS" page on the weather radar. When the cabin oxygen system is activated, the sound of pressurized gas flowing through pipes will be audible.

Yoke-Mounted Digital Chronometers

On each yoke, there is a digital chronometer capable of displaying two different clock modes, and one timer mode, cycled through with the "SELECT" push button. The two clock modes are Universal Time ("UT"), and Local Time ("LT"), each in 24-hour format. The Elapsed Time ("ET") mode is a count-up stopwatch, controlled via the "CONTROL" push button. The maximum displayable time in Elapsed Time mode is 99 minutes and 59 seconds. The mode of these chronometers will be automatically saved and restored at the beginning of a new flight.

Tach Timers

The included Hobbs timers on the pilot's lower subpanel run at a speed proportional to the engine's current RPM over its cruising RPM, indicated in tenths of an hour.



Carbon Monoxide Detector

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

Cabin Pressurization System

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

The upper scale of this rotating card (labeled “CABIN”) is used to set the desired cabin altitude from -1,000 ft to 15,000 ft. The lower scale (labeled “ACFT”) rotates with the upper scale and depicts the approximate aircraft pressure altitude at which the pressurization controller will no longer be able to maintain the desired cabin pressure. For example, when the upper scale is set to 8,000 ft at the small black index mark on the plastic window, the inner scale will read approximately 19,900 ft at the same black index mark. This means that the pressurization controller will be able to maintain a cabin pressure equivalent to 8,000 feet pressure altitude until the aircraft reaches 19,900 feet pressure altitude. If the aircraft continues climbing without an adjustment being made to the pressurization controller, the cabin altitude will begin climbing beyond the desired 8,000 feet. If the cabin pressure differential becomes negative, or increases beyond 4.7 psi, the electric dump valve will activate, rapidly dropping the pressure differential. The electric dump valve can be disabled by pulling the “PRESS CONT” circuit breaker on the power distribution circuit breaker panel.

To the right of the cabin pressurization controller dial and instruments is a three position locking toggle switch. The center position of the switch, labeled “NOR”, is for normal operation, and allows the cabin to be pressurized as soon as the aircraft leaves the ground. The “DUMP” position manually triggers the electrically actuated pressurization dump valve to rapidly release pressure. Dumping the cabin pressure can be painful for passengers and crew. This switch position should only be used during an emergency, or to ensure that the cabin pressure is equalized with the ambient pressure before opening doors and windows. Given that all manner of failures are possible in Black Square aircraft, be sure to verify the cabin pressure differential is near zero before placing the switch in the dump position once on the ground. Placing the switch in the “TEST” test position will bypass the weight-on-wheels sensor, allowing the cabin to pressurize while on the ground, which is required for the pressurization ground checks.

On the copilot’s right subpanel are two red pull handles labeled “PRESSURIZATION AIR PULL TO SHUT-OFF”. Unlike a normally aspirated aircraft, which derives breathing only from the ambient air, pressurized reciprocating engine aircraft use regulated air from each turbocharger to pressurize the cabin. In the event of a fire, carbon monoxide leak, or other hazardous condition, it may become necessary to isolate an engine from the breathable air in the cabin by pulling these handles away from the instrument panel. They can also be used to test the pressurization supply air of each engine during the ground pressurization test, to ensure both are functional. The maximum attainable cabin differential pressure is proportional to the amount of pressurization air available.

Opening the cabin door or cockpit storm window will rapidly decompress the aircraft. Due to the force of the pressurized air on the inside of the cabin, opening the storm window is impossible at normal operating altitudes and pressures, because the door opens inwards. The main cabin door, on the other hand, opens outwards. For this reason, the door is equipped with a simple pressure differential sensing mechanism, which prevents occupants from opening the door while the aircraft is pressurized even a few tenths of a PSI. Should this mechanism become defective, or to enable emergency egress, pulling the red T-handle on the door will defeat the pressurization lockout mechanism.

NOTE: As the Piston Duke pressurization system derives its pressurized air from the aircraft’s two turbochargers, the maximum attainable inflow pressurization is dependent on turbocharger RPM, just as is the intake manifold pressure. If the throttles are reduced while operating at very high pressure altitudes, turbocharger RPM may no longer be sufficient to sustain cabin pressurization. Check valves will prevent the rapid depressurization of the cabin, but leaks in the system will allow pressurized air to escape that cannot be replaced. This will likely be accompanied by a more severe reduction in engine performance than expected for the amount of throttle adjustment. For more information on managing turbochargers during high altitude operation, see the turbocharger operation section of this manual.

Approximate duration of useful consciousness following a cabin depressurization event:

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

Low Thrust Detector

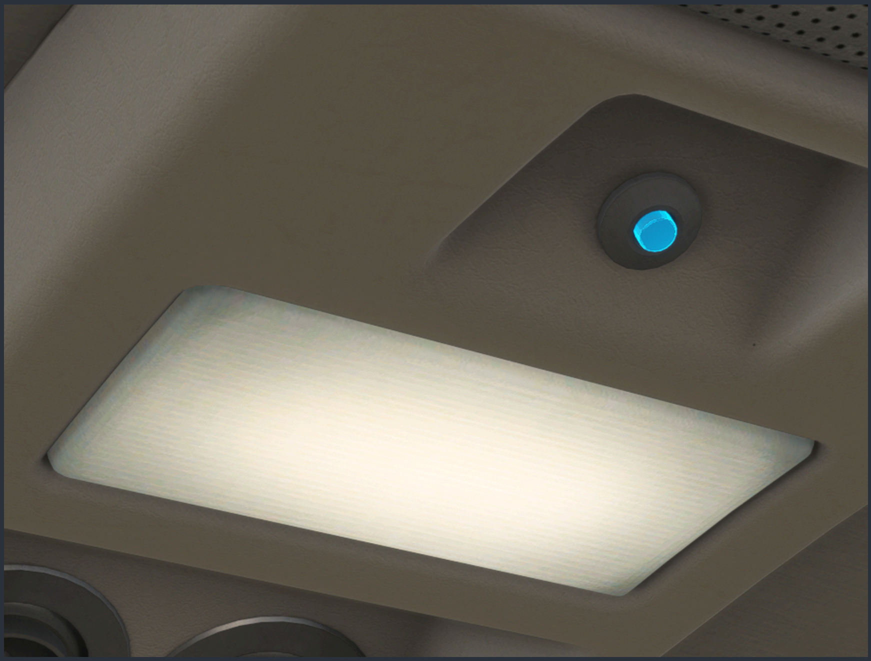
This aircraft is equipped with a now-rarely known system to aid in the identification of a failed engine during emergency procedures, or anticipate the incipient failure of a functioning engine. The low thrust detector system consists of two curved pitot tubes mounted in the propeller wash of each engine, a digital signal processing microcomputer, and several indicator LED's. When the thrust being produced by one engine falls slightly below the other, an amber LED mounted under the propeller control handle will illuminate to indicate that an engine failure or partial power loss may be imminent on the low thrust side. The low thrust detector is capable of detecting small variations in thrust, so false positive indications of partial engine failure can be expected during aggressive leaning. When the thrust of an engine falls significantly below the other, a blinking red LED will illuminate under the propeller control handle to indicate a complete engine failure.

To better alert the pilot to the possibility of an engine failure, an additional annunciator is located below the fuel flow gauge on the main instrument panel. The arrow shaped yellow indicators on this annunciator bar will illuminate steadily or blink in the same manner as described above. Users familiar with engine-out emergency procedures will immediately see the utility of this system, and the enhanced safety it offers by mitigating the chances of incorrectly identifying the failed engine.

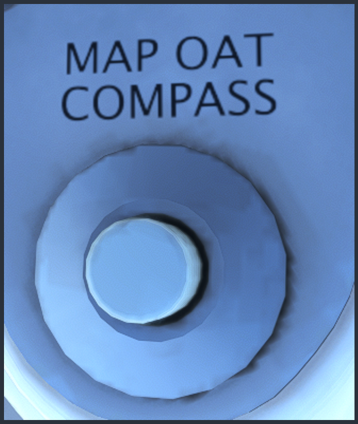
Lighting Controls

Cabin Lighting

Cabin reading lights for each seating position can be turned on and off via the overhead push buttons over each seat. An additional overhead flood light is included above the flight crew seats for all-around cockpit illumination. 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, DC, cabin lighting presents a significant drain on the aircraft battery during operation. Use of cabin lighting should be kept to a minimum when the aircraft battery is the only source of electrical power.



Cockpit Lighting



In addition to the overhead cabin lighting, each yoke possesses a “MAP OAT COMPASS” toggling push button of similar style to the overhead cabin light switches. On the pilot’s yoke, this button will control four lights: a stem light to illuminate the outside air temperature gauge, a stem light to illuminate the oxygen pressure gauge, integrated lighting in the magnetic compass, and a map reading light on the underside of the yoke, which is focused at the pilot’s knees. On the copilot side, this switch will only control the yoke-mounted reading light.

Panel Lighting

All instrument panel lighting is controlled via the pilot's right subpanel. A single toggle switch to the left of the lighting dimmers toggles all panel lighting on or off. Eight vertical dimmer knobs control the intensity of various lighting groups. These groups are; left main panel, right main panel, engine instruments, avionics and audio panel, red glareshield floodlight, white glareshield floodlight, subpanel electroluminescent integrity lighting and gauges, and pedestal trim indicator lighting and autopilot control panel backlighting. Notably, the Piston Duke is equipped with red and white glareshield lighting. White glareshield lighting should be used only during flight preparation on the ground, or when proper color vision is necessary to read charts or cockpit instrumentation. At all other times, the red glareshield lighting should be used to best preserve the flight crew's night vision.

Voltage-Based Light Dimming

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

The lights in this aircraft will react to even the smallest changes in the electrical system's load. For example, a generator failure in flight will result in the dimming of lights. Should a second, or standby generator, not provide sufficient power to support the remaining systems on the aircraft, this is signaled by the dimming of lights in response to even small additional loads, such as exterior lighting. In this reciprocating engine aircraft, the lights will pulse noticeably as the starter motor overcomes the resistance of each cylinder in the engine. The lights will also pulse less noticeable at very low engine RPM, as the voltage regulator struggles to maintain a constant voltage.

The incandescent lights also simulate the dynamics of filaments, creating a noticeably smoother effect to changes in their intensity. This system has the advantage of allowing for easier dimmer setting with L:Vars, and preset configurations when loading the aircraft in different lighting conditions.

State Saving

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

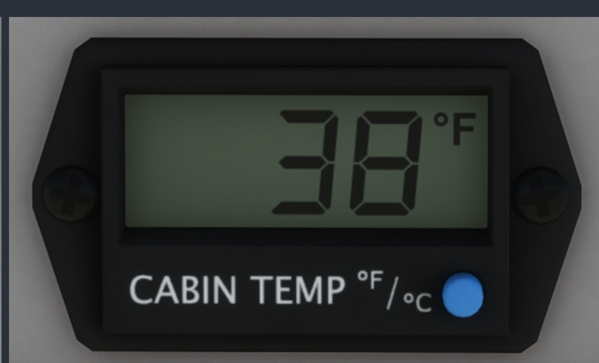
This aircraft is equipped with a simulated environmental control system, allowing the user to learn the essentials of passenger comfort while operating this aircraft. Cabin temperature is calculated distinctly from outside air temperature. Since the walls of the aircraft are insulated, it will take time 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. The cabin climate controls are located on the copilot's left subpanel.

Without the need for any aircraft power, the cabin temperature can be partially equalized with the outside air temperature by opening the pilot's side storm window or the cabin door, and fully equalized by ram air cooling, so long as the airspeed of the aircraft is great enough. Cabin temperature can also be equalized with the use of the electric vent blower centrifugal fan mounted in the tail of the aircraft. The rate at which temperature equalization, active heating, or active cooling can be achieved can be increased by placing the "VENT BLOWER" switch in the "HI" position when the climate control system is in use.

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, located above the copilot's airspeed indicator, will display temperatures from -99° to 999° Celsius, or Fahrenheit, toggleable with the small blue push button. In addition to this LCD display, two small LED's are located above the pilot's airspeed indicator 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. Both lights will flash rapidly when the cabin pressurization altitude exceeds approximately 15,000 ft without supplemental oxygen to indicate a hypoxic cabin.

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



Cabin Environmental Controls

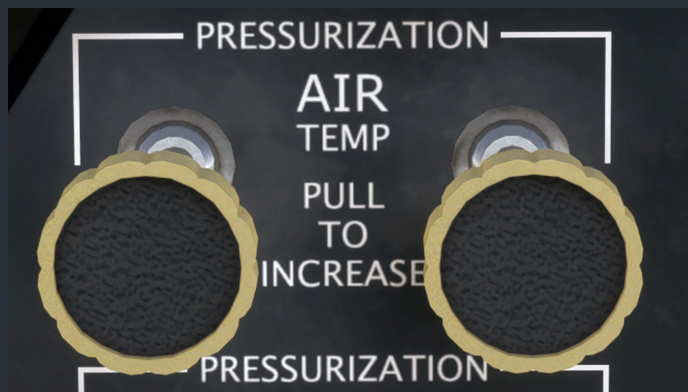
The climate control system is activated by rotating the “CABIN TEMP MODE” knob to any position other than the two “OFF” positions. Either “BLOWER” position can be used to equalize the cabin temperature with the outside ambient temperature. In “MANUAL HEAT” or “MANUAL COOL” modes, the system will apply the maximum available heating or cooling to the cabin ventilation air. In “AUTO HEAT” or “AUTO COOL” modes, the system will monitor the cabin vent temperature and appropriately mix the incoming air to produce the desired temperature. The desired temperature is set with the “CABIN TEMP” knob to the right of the vent blower switch. Desired temperature can range from approximately 50°F (10°C) to 100°F (38°C).

NOTE: The heating and cooling modes will only EITHER heat or cool the cabin, not both. This requires the operator to switch from heating to cooling when the desired cabin temperature is below the outside air temperature, or from cooling to heating when the desired cabin temperature is above the outside air temperature.

Cabin heating in the Piston Duke is supplied by a combustion heater, located under the floor of the nose baggage compartment, which exhausts through the fuselage behind the nose gear doors. When operating without the engines running, this heater's ignition and blower is clearly audible when it starts and stops. The combustion heater will consume fuel from the left tank only at a rate of approximately one-half gallon per hour when operating.

NOTE: A combustion heater is a gasoline powered furnace, and a notoriously dangerous piece of aircraft equipment. Should the combustion heater become compromised, it may result in poisonous carbon monoxide gas leaking into the cabin. Should carbon monoxide be detected in the cabin with an audible warning, the combustion heater should be considered a prime suspect, and use of the cabin heating modes should be discontinued immediately.

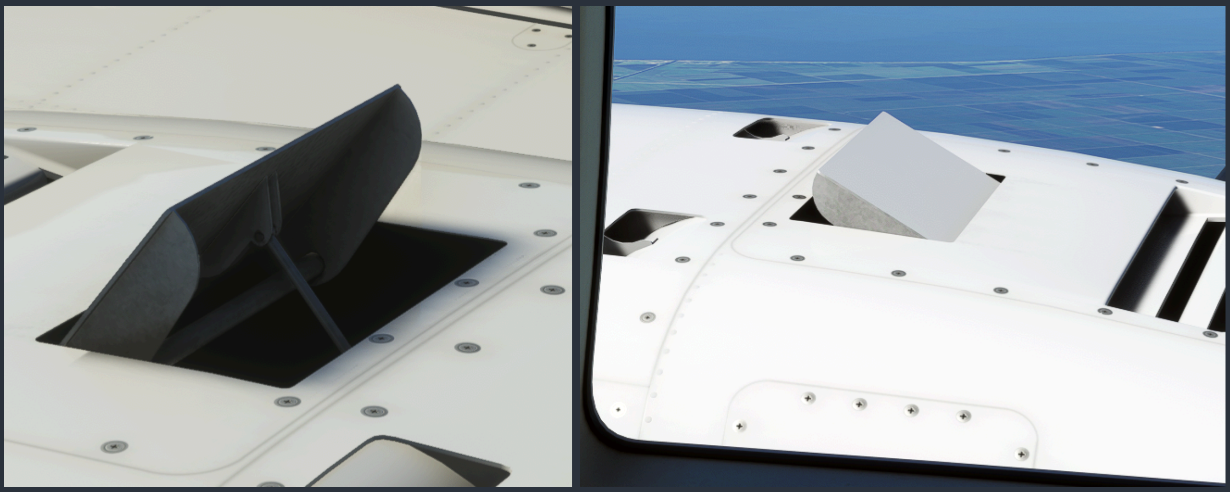
Since the Piston Duke has a service ceiling of 30,000 ft, outside ambient air temperatures can be as low as -80°F (-60°C) in the extreme latitudes. This 150°F (80°C) temperature differential between the intake air and a comfortable cabin temperature is more than the combustion heater can supply alone. For this reason, the Piston Duke has two pull handles (one for each engine), labeled “PRESSURIZATION AIR TEMP PULL TO INCREASE” above the red pressurization air shutoff handles. When these handles are pulled away from the panel, air heated by passing over the turbocharger intercoolers that is normally exhausted outboard is redirected into the cabin. Use of the intercooler air should be minimized, as it is an additional source of potential carbon monoxide intrusion into the cabin. When operating at very low outside air temperatures (10°F (-12°C) or below), the intercooler air handles should be progressively pulled away from the panel to achieve the desired cabin temperature.



Four pull handles on the subpanels are used to direct the flow of ventilation air around the aircraft’s interior. The “PILOT AIR” and “COPILOT AIR” are both pull-off type handles, meaning that maximum airflow is provided by default when the handles are pushed towards the panel. The “CABIN AIR” and “DE-FROST AIR” are pull-on type handles, meaning that maximum airflow is not provided by default when the handles are pushed towards the panel. Increasing airflow by adjusting the first three of these handles can be used to augment the equalization rate of the climate control system. While the Piston Duke is equipped with deicing boots and a heated windshield, the windshield can be partially deiced using hot environmental air in the event of a heated windshield or secondary AC inverter failure. The “DE-FROST AIR” handle must be pulled away from the panel, the environmental control system must be operating in one of the two heating modes, and the combustion heater must be operating.

Air Conditioning Condenser Scoop

The Piston Duke is equipped with an electromechanically actuated air conditioning condenser scoop system on the top of the right engine nacelle. When the air conditioner is not in use, the door is fully stowed to minimize drag. When the air conditioner is used in flight, the door is only partially extended. When the air conditioner is activated and the landing gear is extended, the condenser door is fully opened to provide better cooling during ground operations. The air conditioner should be turned off and the door retracted before takeoff to ensure maximum climb performance. The additional drag produced by the air conditioner condenser scoop will rob the aircraft of several knots when in cruise flight, but could produce as much as 10 knots worth of drag should the door become stuck in the fully extended position during flight.



Left: fully extended - ground position   Right: partially extended - flight position

Air Conditioning Temperature Effects

When the air conditioner is operating, the load is increased on the right engine’s accessory gearbox. The load is proportional to the differential between the outside air temperature and the desired cabin temperature. 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 condenser scoop’s position. Particularly while operating on the ground, the operator should keep an eye on engine temperatures. Since the condenser door can become stuck in this aircraft simulation, a fully closed condenser door on the ground could cause dangerously high engine temperatures. During low airspeed climbs or while operating at low altitudes, the additional load on the engine may be significant enough to cause differential performance. This should be compensated for by use of differential mixture control. Increasing the mixture setting of the right engine will help keep the engine cool. When the additional load is significant, the right engine may cease running at idle throttle setting on the hottest days.

Reciprocating Engine & Turbocharger Simulation

The piston engine simulation in this aircraft is significantly more complex than most employed in flight simulators. Do not expect the care-free easy operation requiring little expert knowledge that is sufficient for operating the default aircraft. Knowledge of the invisible factors affecting fuel injected engine operation is required to perform a successful start of this aircraft. Additional knowledge is required of turbochargers, as this is the first fully simulated turbocharger in MSFS.

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

Engine Physics Simulation

Cylinder Compression

Unlike a turbine engine, the rotation of a reciprocating engine is not smooth, especially while starting. This is due to the compression in each cylinder imparting significant torque onto the propeller shaft, which must be overcome for the shaft to continue rotating. On the ground, this is most apparent when the starter motor is engaged, or when the engine is shutting down. In the air, the same compression must be overcome for the propeller to start windmilling. When shutting the engine down, it is this torque that forces the propeller to stop in one of several detents every time, often reversing momentarily as it does. Additionally, the propeller shaft must also overcome the resistance of the magnetos to continue rotating. When shutting down, this can cause the propeller to stop suddenly and prematurely, and is signaled with an audible clicking sound from the magnetos. If performing a gear up landing, it may be desirable to rotate the propeller to a position that guarantees the most ground clearance, which can be accomplished with the starter motor.

Starter Motor Torque

Starter motor torque is non-linear, with the motor providing less torque at higher RPM. The maximum power output from the starter motor is also dependent on the battery's current charge level. If you allow the battery charge to diminish greatly due to prolonged use without charging, the engines will become harder to start, as the starter motor will no longer have the power required to overcome the cylinder compression forces. Should this happen in flight, the engine can hopefully be restarted by windmilling. Apparent starter torque can also be reduced in cold weather, due to high oil viscosity, contracted metal components, and poor battery performance. These effects can be mitigated by preheating the engine using the propane heater.

Propeller Blade Position & Feathering

The propeller blade angle of a constant speed propeller is controlled via high pressure oil admitted to a cylinder in the propeller hub, metered by a governor. In a multi-engine aircraft, the absence of oil pressure will reduce the propeller blade pitch to the feathered position, but only when the oil pressure is reduced quickly; otherwise, counter-weighted feather locking pins will prevent the blades from feathering during a normal shutdown, or often an intentional shutdown in flight. For this reason, the propeller levers must be placed in the feather detent quickly during engine shutdown (while there is still oil in the propeller hub) to overcome the feather locking pins and feather the propeller.

The purpose of the feather locking pins is to prevent the propeller in a twin engine airplane from going into feather when the engine is shut down and oil pressure in the hub is lost. A feathered propeller makes the engine substantially harder to start, as the propeller blades produce much more air resistance, even at low RPM. The feather locking pins are controlled by flyweights, which keep the pins disengaged when RPM is sufficiently high. If RPM is allowed to decline slowly with the propeller in the fully fine position, such as during a normal shutdown, the flyweights will release the locking pins, and the propeller will remain fully fine, even with no oil pressure.

The propeller blade angle influences the engine physics simulation by applying torque to the propeller shaft based on the blade angle and apparent wind velocity. This means that airstarts are now physics based, as well as feathering. If a propeller is not successfully feathered on shutdown, physics based windmilling will occur. A windmilling propeller can be locked in place with the compression of the cylinders, but a much lower airspeed is required to stop the propeller than can be achieved without it rotating afterwards.

Unfeathering Accumulators

Once a propeller is feathered and the engine stopped, the engine driven fuel pump is no longer capable of supplying pressurized oil to the propeller hub, making unfeathering the propeller impossible. Many light piston twins, especially trainers, are equipped with unfeathering accumulators for this reason. When the engine is running, oil is pressurized into a hydraulic accumulator. When the engine is no longer running, oil pressure is maintained in this accumulator, and can be injected into the propeller hub to unfeather the propeller at least one time. This can salvage a flight by allowing the engine to be restarted more easily, but it can also significantly hinder emergency operations if the engine cannot be restarted, because the propeller may not feather again, leaving the pilot with a windmilling propeller. For this reason, it is only recommended to unfeather the propeller and attempt a restart if the operator believes the engine will restart normally after shutdown, such as during training, or after inadvertent fuel exhaustion.

Engine Preheating

Being lightweight and designed to operate at high temperatures, aircraft engines are more susceptible to damage when started very cold than other engines. This aircraft simulation is equipped with a propane powered heater to preheat the engine before starting. The heater is deployed from the “Exterior Elements” menu on the payload page of the tablet interface. Once ignited, the preheater will heat the engine and its components to around 60-70°F (~35°C) above the ambient temperature in around 10 minutes.

Reciprocating aircraft engines can be destroyed by a single start in extremely cold weather, so preheating should be considered mandatory any time ambient temperatures are below 10°F (-12°C), and recommended any time temperatures are below freezing. When reciprocating engines are started too cold, the resulting temperature differential can crack crankcases, and the increased wear on pistons and cylinders can be severe. Due to the high viscosity of the oil, contracted metal components, and the poor performance of batteries in cold weather, the starter motor may be unable to rotate the crankshaft at sufficient speeds for starting when ambient temperatures approach -25°F (-32°C) without preheating.

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.

Fuel Injected Engine Operation

Fuel injected engines differ most significantly from their carbureted counterparts in their starting procedures. Fuel injected engines can be notoriously difficult to start soon after being shut down due to vapor lock.

Pre-Oiler

This aircraft is equipped with electric pre-oiler systems for both engines. These systems are used to circulate oil through the crankcase oil galleries before starting the engines to minimize wear while starting. Approximately 15 PSI of oil pressure is recommended before starting. The pre-oiler can be used as a standby oil pump, in the event that the engine-driven pump fails.

Cold Engine Starting

When starting a cold fuel injected engine (cylinder head temperatures within 100°F or 50°C of ambient temperature) the engine should start without difficulty, provided that it has been primed with the electric fuel pump. To quickly prime the engine, place both the throttle and mixture levers in the full forward position. Briefly run the fuel pump for a few seconds only. Prolonged use of the fuel pump will flood the cylinders with fuel. If difficulty persists, try engaging the starter while advancing the throttle partially.

Hot Engine Starting

When the engine has recently been running, hot engine components will vaporize liquid fuel in the fuel injection system, causing back pressure that prevents the injection of new fuel into the cylinders for priming. This is most likely to occur when a hot engine has been sitting for more than 5-10 minutes, and less than an hour or two. Many ill informed pilots have drained their aircraft's battery trying to start a hot engine without the proper procedure.

To start a vapor locked engine, cool fuel from the fuel lines and tanks should be circulated through the fuel injector manifold with the throttle and mixture levers in their fully closed, and cut-off positions. This will have the effect of displacing and condensing the vapor, while not adding additional fuel to the cylinders. After running the fuel pump for 10-20 seconds, if the engine does not start normally, the operation should be repeated once or twice more, depending on the severity of the vapor lock. Attempting this procedure too many times may result in a flooded engine.

Flooded Engine Starting

During starting procedures, if too much fuel is injected into the cylinders by running the fuel pump too long, the engine will no longer start due to an excessively rich fuel-to-air ratio. In mild cases, the engine can be started by advancing the throttle to produce a more favorable mixture; however, this can substantially increase the chances of an engine fire. In severe cases, the engine itself can be used as a pump to remove fuel from the cylinders. Cranking the engine will remove fuel from the cylinders, but may accumulate liquid and gaseous fuel vapors around the exhaust or inside the engine cowling. Unfortunately, light aircraft do not have a convenient way to crank the engine without ignition firing, like turbine engine aircraft do. Should the engine produce a backfire or other ignition source after severe engine flooding, a fire is likely. As a last resort, allowing the engine to sit for an extended period of time will allow fuel to evaporate from the cylinders and alleviate engine flooding.

Backfiring

Backfires occur when the fuel-air charge in a cylinder combusts late in the cylinder's ignition phase, allowing the gasses and the sound of the explosion to escape out the open exhaust valve. This may occur under several different conditions. The most commonly experienced is when the magneto switch is accidentally cycled to the off position and returned to an ignition position when the engine is operating at high RPM. This results in an unburnt charge of fuel remaining in the cylinders and valve body for several full cycles, before a spark is reintroduced to the now overly rich fuel-air mixture. A similar effect can occur when an overly lean mixture is used at high power settings, which stifles ignition until a sub-optimal fuel-air charge is ignited. A backfire is also likely to occur at high power settings when there is significant spark plug fouling present, as the spark produced by the plug, if any, will be too weak to ignite the fuel-air charge.

Spark Plug Fouling

Aviation fuel (Avgas) commonly contains tetraethyl lead to reduce engine knocking, and prevent premature ignition. Unfortunately, this lead can become deposited on interior cylinder surfaces under some conditions. This results in a layer of lead deposits accumulating on the spark plug electrodes, which prevents a spark from developing, or a sufficient spark for optimal ignition. The buildup of lead in the cylinders can happen surprisingly quickly; therefore, proper care is needed on every flight to avoid engine fouling, especially while operating on the ground.

Spark plug fouling can be avoided by leaning the mixture significantly while operating at low cylinder temperatures and low RPM. At sea level, leaning the mixture control halfway may be necessary. Alternatively, keeping engine temperatures warm while on the ground also prevents fouling. As a rule of thumb, an engine RPM of 1,200-1,500 is sufficient to prevent fouling by bringing cylinder head temperatures above ~300°F (120°C).

When spark plug fouling is present, the engine will run rough, and performance will be reduced. To remove lead buildup from the engine, the mixture should be leaned and throttle increased to produce high temperatures in the cylinders above ~750°F (400°C) for a few minutes.

Turbocharged Operation

Owners of other turbocharged aircraft for Microsoft Flight Simulator will be familiar with the inaccurate need to lean the mixture continuously to maintain proper fuel-air mixture while below critical altitude. THIS IS NOT NECESSARY with the turbocharger simulation in this product. This simulation is also substantially more complex than other turbocharger simulations.

Turbocharger Basics

Unlike car engines, which predominantly operate at near sea-level air pressures, aircraft engines may operate at sea-level pressure, and within the upper atmosphere where atmospheric pressure is less than one third of that at sea level. In a normally aspirated aircraft engine, the mixture control is used to maintain a favorable fuel-air ratio throughout these different altitudes. Unfortunately, as the amount of fuel per cylinder is reduced to match the air pressure, so too is engine performance reduced. A turbocharger uses high velocity exhaust gasses from the engine's combustion to compress the atmospheric air to a higher pressure. In this particular aircraft, the outside air is boosted to a pressure in excess of sea level ambient pressure, of 41.5 inHg. The higher pressure intake air allows for a greater mass of fuel and air to be burned per every stroke of the piston, increasing the power output of the engine for a given RPM.

Critical Altitude

Simply put, the critical altitude of a turbocharged engine is the maximum altitude at which the turbocharger can compress the atmospheric pressure air to a specified maximum pressure. When the aircraft continues to climb beyond this altitude, manifold pressure will begin to drop, and the mixture must be leaned, just as with a normally aspirated engine. Critical altitude is listed in aircraft handbooks as a single altitude in feet; however, critical altitude as described above, is constantly changing throughout the flight.

The book value for critical altitude applies only in standard atmospheric conditions when pressure altitude is equal to density altitude. Otherwise, the critical altitude is based on density altitude, not pressure altitude, as is commonly thought. Additionally, the maximum rated intake pressure can only be maintained at the critical altitude at wide open throttle, when the compressor turbine is operating at maximum rated RPM. If the velocity of exhaust gas air is reduced by pulling back on the throttle when the wastegate is fully closed, the turbocharger will no longer be able to maintain maximum rated pressure at the manifold. When the aircraft is operating well beyond critical altitude, fully retarding the throttle may even cause the engine to cease combustion. For similar reasons, operators should be aware of the signs of turbocharger failure when operating at very high density altitudes, as a sudden failure of the turbocharger may present as a complete engine failure. Should the turbocharger fail in-flight, the engine may continue to be operated as a normally aspirated engine, but it is recommended that a landing be made at the nearest suitable airport.

Operation Before & During Takeoff

Operating a turbocharged engine with an automatic wastegate is remarkably similar to operating a normally aspirated engine, as there is no need to manually control a wastegate, or significant worry about overboosting the engine. While on the ground, it's unlikely that any difference will be observed in the turbocharged engine, except for increased spool-up times to manifold pressures beyond sea-level. The mixture should still be leaned during ground operations to prevent spark plug fouling, but placed in the full rich position for takeoff. During engine runup, the sound of the turbocharger will likely be heard, and the manifold pressure will reach the 39.5 inHg redline regardless of density altitude, assuming the turbocharger is operational.

Applying takeoff power is the most likely time to inadvertently cause an overboost, as the oil viscosity may still be high, and slow the operation of the wastegate. When advancing the throttle through the last quarter of its movement, be especially careful to apply power slowly while monitoring manifold pressure.

Operation During Climb & Cruise

The most noticeable difference between a normally aspirated engine and a turbocharged one is the lack of need to adjust the mixture setting during climb. Do not reduce throttle or mixture setting during the initial climb phase. There is no need to adjust the fuel-air ratio with the mixture control until critical altitude has been exceeded, or until the throttle is reduced in the cruise phase. When the aircraft climbs through the critical altitude, manifold pressure will begin to drop, and manual mixture control will be required to maintain desired cruise power.

If a reduced throttle setting is desired during cruise, manual control of the mixture setting may also be required. As the critical altitude is only guaranteed at wide open throttle, a reduced throttle setting may reduce turbocharger RPM to the point where the desired manifold pressure can no longer be maintained. For this reason, it is recommended to assess engine performance after every power adjustment when operating at high altitudes. Using an aid to engine leaning, such as the EDM-760 engine monitor in this aircraft, to precisely set the mixture for best power or best economy cruise can help ensure optimum performance, and increase engine longevity.

NOTE: For your convenience while leaning, the friction lock knob located on the right of the throttle quadrant can be used to increase the fidelity of mixture control adjustments via the mouse wheel. Roll the friction lock clockwise (drag up) to make very fine adjustments to the mixture control.

Operation During Landing & Securing

The approach and landing phases are very similar to normally aspirated engines, except that engine performance may be reduced more than would be expected for a given change in throttle setting when operating at higher altitudes. After exiting the runway, be sure to give the turbocharger enough time to cool at turbine idle RPM before stopping the engine. This is more important in colder ambient temperatures to prevent warping of the turbocharger shaft.

Engine Power Settings

Shaded areas denote operation at wide open throttle. **All figures at maximum gross weight.**

(Stock Duke / Grand Duke)

Take-Off Power (Full Throttle) - Standard Day (ISA) No Wind

Press. Alt. (ft)	Man. Press. (inHg)	Engine RPM	Fuel Flow (PPH/Eng)	T/O Ground Roll (ft)	50ft Obstacle T/O Dist. (ft)	Rate of Climb (ft/min)
SL	41.5	2,900	262	2,075 / 1,875	2,626 / 2,360	1,620 / 2,070
2,500	41.5	2,900	262	2,514 / 2,272	2,945 / 2,647	1,560 / 2,000
5,000	41.5	2,900	262	2,912 / 2,632	3,412 / 3,067	1,500 / 1,920
7,500	41.5	2,900	262	3,229 / 2,919	3,786 / 3,403	1,450 / 1,860
10,000	41.5	2,900	262	3,620 / 3,272	4,246 / 3,816	1,400 / 1,790

75% Maximum Continuous Power - Standard Day (ISA)

Pressure Alt. (ft)	Manifold Press. (inHg)	Engine RPM	Fuel Flow (PPH / Eng)	KTAS Stock / Grand	Range (nm) Stock / Grand
SL	31.9	2,750	133	189 / 198	750 / 900
10,000	31.9	2,750	133	205 / 217	790 / 950
20,000	31.9	2,750	133	225 / 241	835 / 1,010
24,000	34.1	2,750	133	234 / 250	845 / 1,030
30,000	29.3	2,750	104	227 / 243	855 / 1,050

65% Maximum Continuous Power - Standard Day (ISA)

Pressure Alt. (ft)	Manifold Press. (inHg)	Engine RPM	Fuel Flow (PPH / Eng)	KTAS Stock / Grand	Range (nm) Stock / Grand
SL	29.8	2,500	112	177 / 185	845 / 1,015
10,000	30.2	2,500	112	193 / 204	880 / 1,055
20,000	30.6	2,500	112	211 / 225	925 / 1,120
26,000	31.3	2,500	112	225 / 240	940 / 1,145
30,000	26.4	2,500	91	210 / 225	950 / 1,170

55% Maximum Continuous Power - Standard Day (ISA)

Pressure Alt. (ft)	Manifold Press. (inHg)	Engine RPM	Fuel Flow (PPH / Eng)	KTAS Stock / Grand	Range (nm) Stock / Grand
SL	27.6	2,400	94	165 / 172	935 / 1,120
10,000	27.6	2,400	94	180 / 190	980 / 1,175
20,000	27.6	2,400	94	197 / 210	1,150 / 1,390
28,000	28.6	2,400	94	211 / 225	1,100 / 1,350
30,000	26.0	2,400	86	199 / 212	1,100 / 1,350

45% Maximum Continuous Power - Standard Day (ISA)

Pressure Alt. (ft)	Manifold Press. (inHg)	Engine RPM	Fuel Flow (PPH / Eng)	KTAS Stock / Grand	Range (nm) Stock / Grand
SL	23.4	2,400	83	151 / 157	960 / 1,150
10,000	23.4	2,400	83	164 / 173	1,050 / 1,260
20,000	23.4	2,400	83	178 / 188	1,250 / 1,510
25,000	23.4	2,400	83	183 / 193	1,250 / 1,525
30,000	23.4	2,400	83	186 / 199	1,050 / 1,290

Cruise Climb - Standard Day (ISA)

Target Alt. (ft)	Man. Press. (inHg)	Engine RPM	Fuel Flow (PPH / Eng)	Time to Climb (min)	Fuel to Climb (gal)	Dist. to Climb (nm)
5,000	35.5	2,750	194	5 / 4	6 / 5	15 / 12
10,000	35.5	2,750	194	10 / 8	11 / 9	27 / 21
15,000	35.5	2,750	194	18 / 14	18 / 14	45 / 35
20,000	35.5	2,750	194	23 / 18	27 / 21	70 / 55
25,000	35.5	2,750	194	33 / 26	36 / 28	98 / 76
30,000	35.5	2,750	190	50 / 39	50 / 39	150 / 117

Recommended Climb Airspeeds: 140 kts to 20,000 ft, 130 kts to 25,000 ft, 120 kts to 30,000 ft.

Note that the above airspeeds differ from the turbine engine version of this aircraft.

Gyroscope Physics Simulation

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

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

Gyroscope Physics

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

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

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

Pneumatic Gyroscopes

Pneumatic gyroscopes are powered by either positive (“Instrument Air”) or negative (“Vacuum Suction”) air pressure 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 inaccuracies. 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

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 maximum allowed cylinder head temperatures will drastically reduce the lifespan of the engine, while a slight exceedance of the maximum governed propeller RPM would not cause an engine failure for quite some time. Keen monitoring of engine parameters via the EDM-760 engine monitor is an essential skill of operating a high performance aircraft.

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

The following limits are recommended for best engine health. Exceeding these limits will cause engine damage in proportion to the limit departure:

Propeller RPM	2,900 RPM
Cylinder Head Temperature	475°F (246°C)
Exhaust Gas Temperature	1650°F (900°C)
Turbine Inlet Temperature (TIT)	1650°F (900°C)
Oil Temperature	245°F (118°C)
Oil Pressure	25 PSI (min.) 100 PSI (max.)
Fastest Cooling Cylinder Head	60°F/min (33°C/min)
Manifold Pressure	41.5 inHg

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

Electrical Systems

The native MSFS electrical simulation is greatly improved from previous versions of Flight Simulator, but the underlying equations are unfortunately inaccurate. Users familiar with electrical engineering 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.

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

Battery Temperature

This aircraft is equipped with a realistic battery temperature simulation. The original aircraft shipped with nickel cadmium batteries from the factory, which made it particularly susceptible to battery overheating. The internal resistance of a battery and the contact resistance of the terminals will produce heat when charging or discharging. Battery temperature should be monitored particularly after starting, before takeoff, and in the event of a generator failure. If battery temperatures are rising rapidly and the battery is not disconnected from the power source, or the rate of charging reduced, the battery terminals will become damaged and the battery will not be available for use on the remainder of the flight. High battery charging rates are acceptable after startup while the battery is recharging; however, care should be taken while taxiing to avoid overcharging the battery. For more information on battery temperature, see the "BTI-600 Battery Temperature Monitor" section of this manual.

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 carn always be cleared by deicing equipment, thankfully.

The Piston Duke is equipped with propeller deicing, pitot heat, fuel vent heat, stall warning heat, windshield heat, deicing boots, and windshield defrosters. Electrical anti-icing for the propellers, pitot-static probes, stall warning heat, windshield heat, and fuel vent heat work continuously, and will slowly remove ice from these areas of the aircraft. On the other hand, emergency window defrosting is provided by the cabin heating system, and requires the following conditions to be met: the "DE-FROST AIR" handle must be pulled away from the panel, the environmental control system must be operating in one of the two heating modes, and the combustion heater must be operating. For more information on the defroster and its associated controls, see the "Environmental Controls" section of this manual.

Lastly, the aircraft is also equipped with deicing boots that use the instrument air supply to inflate, either manually, or automatically, to shed ice from the leading edges of the aircraft. The surface deicing switch may be placed in either the momentary "MAN" position to pressurize all zones of the aircraft's deicing boots at once, or in the "ONE CYCLE" position to automatically cycle deicing pressure around the three dicing boot zones. The deicing pressure gauge should indicate a maximum of around 18 PSI when the system is activated in automatic mode, and 16 PSI when in manual mode.

NOTE: The electric propeller heat is disabled when the aircraft is on the ground. To test the propeller heat during ground operations, the "PROP HEAT GROUND TEST" push button on the pilot's left subpanel must be held down.

Cowl Flaps

This aircraft is equipped with electrically actuated cowl flaps. The cowl flaps are positioned by the three position momentary “COWL FLAP” switches on the pilots lower side panel; however, there are no cowl flap position indicators. While this may be frustrating, it is accurate to the real aircraft. Full cowl flap actuation time is approximately fourteen seconds. Similar to setting flaps in older model Cessna aircraft, the switches must be held for the approximate duration required for the desired setting. Since this is tedious in a flight simulator, an invisible switch is positioned between the two cowl flap switches that will actuate both cowl flaps at the same time.

Mixture & Fuel Flow

Unfortunately, the MSFS internal combustion simulation is lacking as it concerns mixture and fuel flow. Under all but extremely high density altitude conditions, reducing the mixture setting should always result in decreased fuel flow at the same throttle setting. In MSFS, fuel flow will fall off as horsepower decreases with an overly rich mixture setting. This is not detrimental to the operation of this aircraft, but is nevertheless unrealistic. A potential solution is being researched for future Black Square aircraft, and updates for the Piston Duke.

While operating the air conditioner under high load conditions, such as high outside air temperatures and low desired cabin temperature, do not be surprised if differential mixture is required to achieve equal engine performance. Careful leaning of both engines independently with the EDM-760 may be required to achieve optimal performance during low altitude flight with the air conditioner running.

Realistic Strobe Light Bounce

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

St. Elmo’s Fire & Electrostatic Discharge

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

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

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

Third Party Navigation and GPS Systems

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, the Working Title GNS 530/430, and the KLN-90B. Several of these advanced GPS units implement their own autopilot 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.

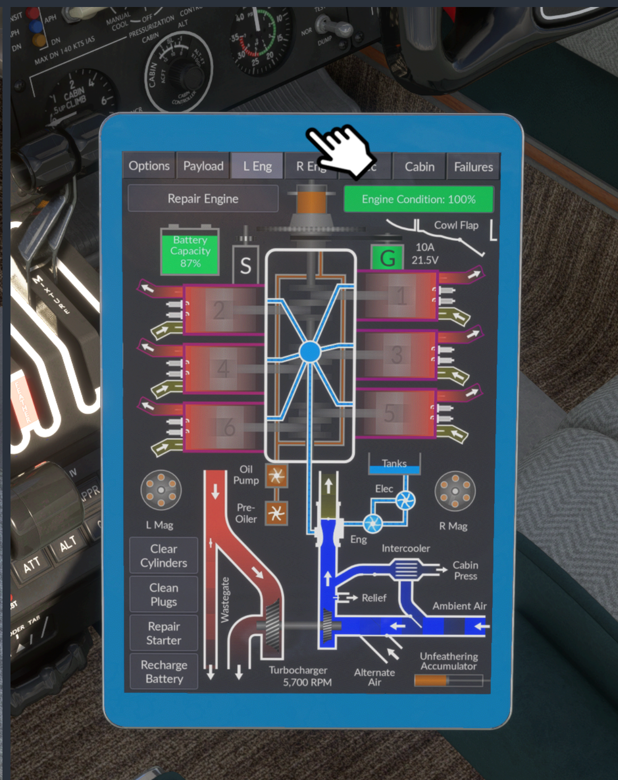
While existing Black Square aircraft have required an update to be fully compatible with some of these new products, the Piston Duke should be fully compatible with these products upon release. Users should notice only minor interruptions when switching between GPS units, such as waiting for a GPS to reboot, or an uncommanded autopilot disconnect or mode change. As development continues on these 3rd party products, Black Square will continue to work with the developers to update the fleet, and bring you the most realistic flying experience possible.

Control Locks

Functioning control locks are provided for the pilot's yoke and throttle levers. The control locks can be removed by clicking on each individually. The control locks are stowed beside the copilot's seat. To access the control locks in their stowed position with a companion occupying the right seat, either just click through the character model, or unload them first via the tablet's payload interface.

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

3. PMS50 GTN / TDS GTNxi Switch

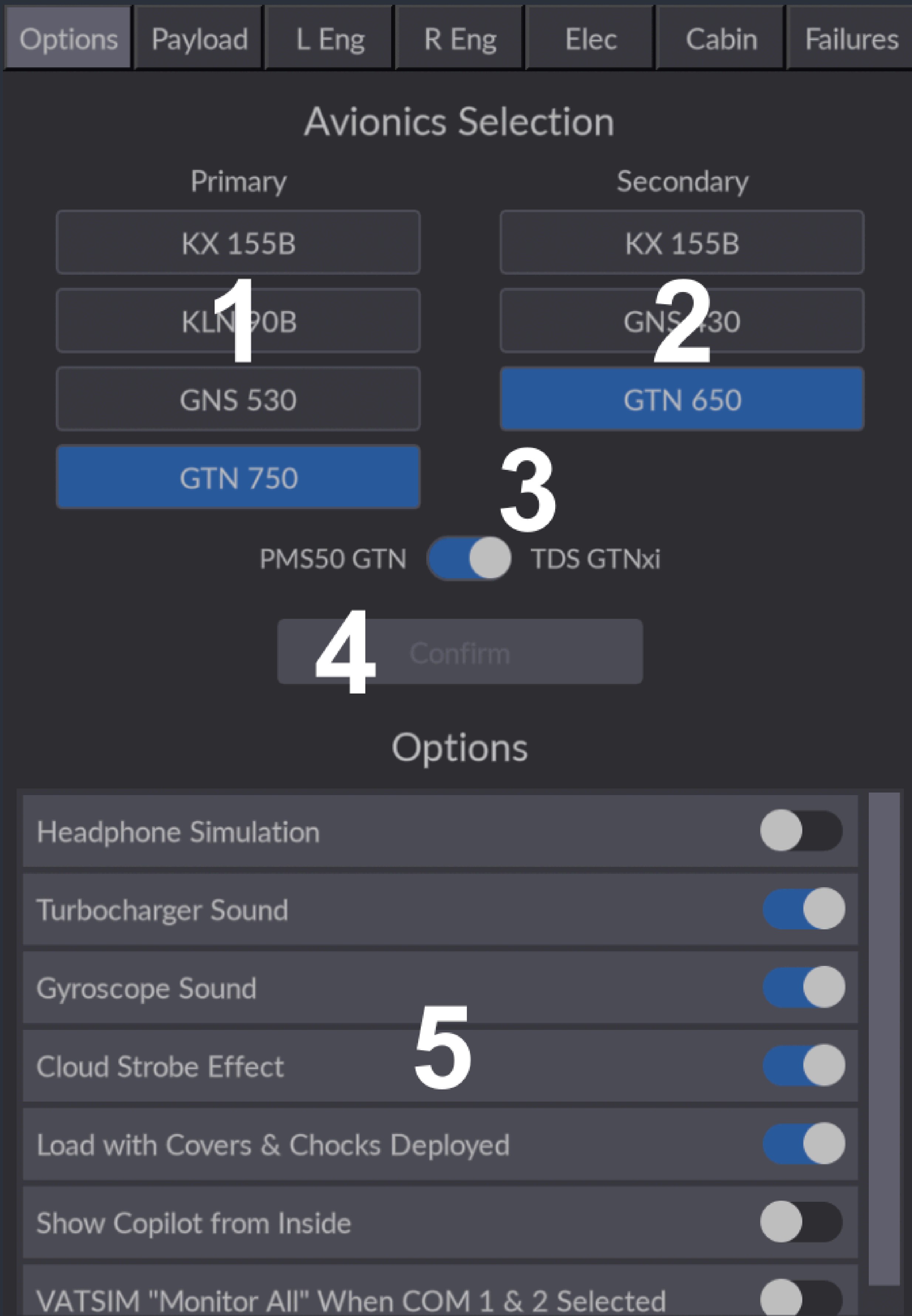
To switch between the PMS50 and TDS offerings of GTN GPS units, toggle this switch. This selection will be saved and recalled at the start of your next flight.

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
L Eng
R Eng
Elec
Cabin
Failures
Avionics Selection
Primary
Secondary
KX 155B
KX 155B
1
2
GTN 650
GNS 530
GTN 750
3
PMS50 GTN
TDS GTNxi
4
Confirm
Options
Headphone Simulation
Turbocharger Sound
Gyroscope Sound
5
Cloud Strobe Effect
Load with Covers & Chocks Deployed
Show Copilot from Inside
VATSIM "Monitor All" When COM 1 & 2 Selected

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

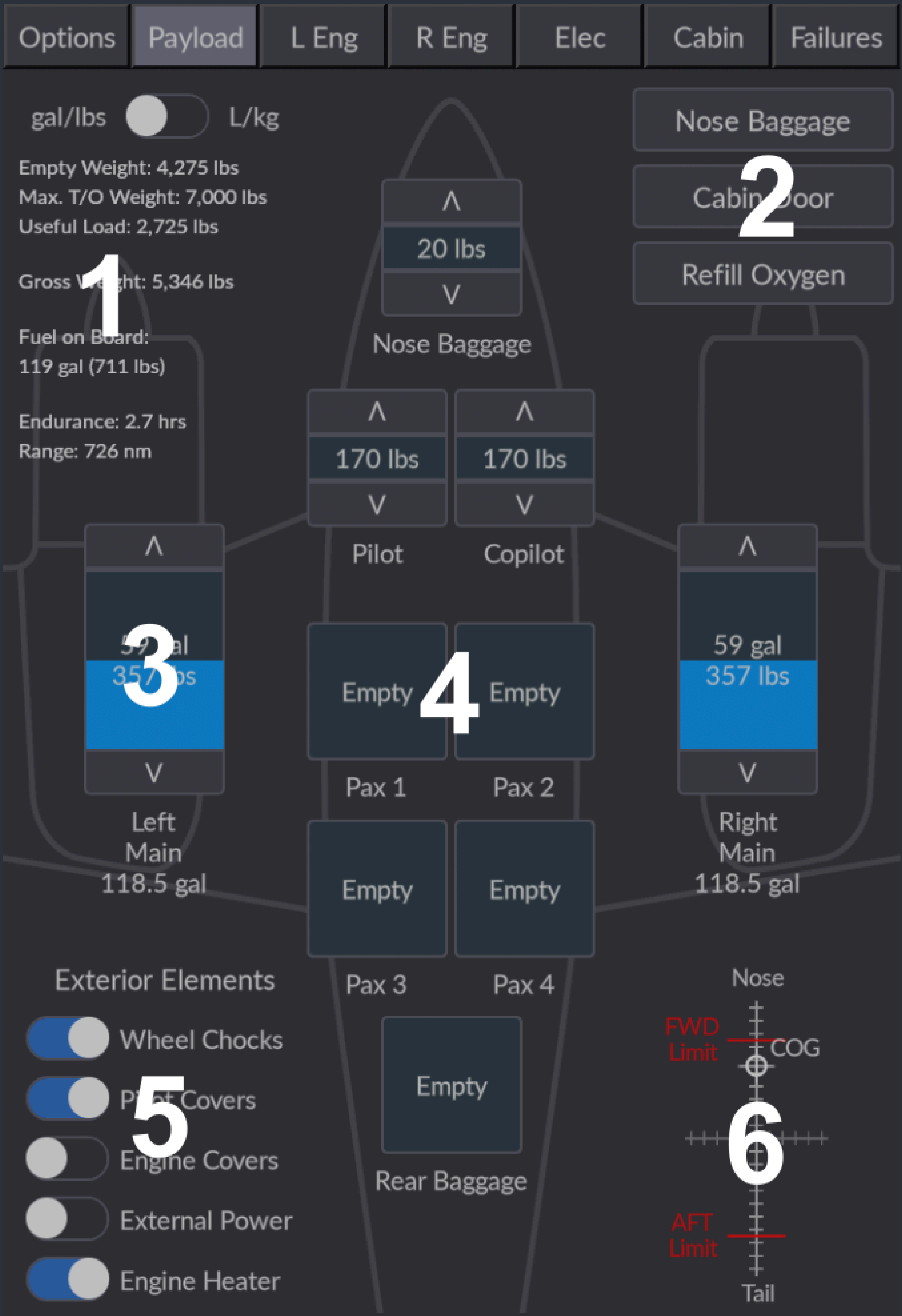
Each payload station in the aircraft is represented by a payload block. When occupied by passengers or cargo, each block shows the current weight of the station in its center. Clicking in the center of the block will toggle the payload between empty, and the default station weight. The weight of the 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
L Eng
R Eng
Elec
Cabin
Failures
gal/lbs
L/kg
Empty Weight: 4,275 lbs
Max. T/O Weight: 7,000 lbs
Useful Load: 2,725 lbs
Gross Weight: 5,346 lbs
Fuel on Board:
119 gal (711 lbs)
Endurance: 2.7 hrs
Range: 726 nm
Nose Baggage
Cabin Door
Refill Oxygen
20 lbs
Nose Baggage
170 lbs
170 lbs
Pilot
Copilot
59 gal
357 lbs
Left
Main
118.5 gal
Empty
Empty
Pax 1
Pax 2
59 gal
357 lbs
Right
Main
118.5 gal
Empty
Empty
Pax 3
Pax 4
Exterior Elements
Wheel Chocks
Pitot Covers
Engine Covers
External Power
Engine Heater
Empty
Rear Baggage
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 reliably starting the engine, 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 cylinders of fuel, or recharging the battery. The engine condition can also be reset via the legacy weather radar systems display.

2. Engine Condition

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. The engine condition can be reset using the adjacent Repair Engine button, or the legacy weather radar systems display.

3. Inactive Battery

The battery's capacity 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 the battery is not connected to the main bus of the aircraft, it will appear grayed out.

4. Cowl Flap Indicator

The cowl flap indicator shows the current position of the engine's cowl flap. When the cowl flap is flush with the bottom of the engine nacelle, it is in the fully closed position.

5. Crankcase & Crankshaft

The crankcase of the engine contains the crankshaft, piston rods, oil galleries, and above it, the fuel distributor manifold. The crankshaft and piston rods will blur as the engine speed increases, but they do not change color with any temperature.

6. Pistons & Cylinders

When standing still, the pistons are numbered for each cylinder. The firing order for this engine is 1-4-5-2-3-6. Each cylinder possesses two spark plugs (top and bottom), one intake valve, and one exhaust valve. The cylinders on the right side of the engine (1-3-5), receive their top spark plug excitation from the left magneto, and the bottom plugs from the right magneto. The cylinders on the left side of the engine (2-4-6), receive their top spark plug ignition from the right magneto, and the bottom plugs from the left magneto. As the cylinders warm their color will change from blues and greens, to ambers and reds. The cylinder heads' absolute temperatures can be monitored on the EDM-760 engine monitor. For more information on EDM-760, see the "Using the JPI EDM-760 Engine Monitor" section of this manual.

7. Oil Pumps & Lines

This engine is equipped with two oil pumps. The primary oil pump is an engine driven oil pump that would be expected in all aircraft. The secondary pump is a pre-oiler, which is an electrically driven oil pump, designed to circulate oil throughout the engine before starting. It can also be used as a backup oil pump, should the engine driven pump fail. For more information on the pre-oiler, see the "Pre-Oiler" section of this manual.

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.

8. Fuel Pumps & Lines

Fuel is drawn from the lowest point in the fuel tanks from the suction of an engine driven fuel pump, or an electric pump. The total quantity of fuel in the tanks is indicated by the level of fuel in the "tanks" hopper. Be aware that this is the total quantity of fuel on board, not the tank that is currently feeding the engine. Animated dashes indicate the rate at which fuel is moving through the pressurized lines towards the fuel injector servo on the throttle body.

9. Induction Air Controls

Control of the engine's intake air relies on a series of valves and louvers. Ambient air enters the induction system through filters at the bottom right of the visualizer. This air is always at the same temperature and pressure as the air surrounding the aircraft. Alternatively, induction air can enter through the alternate air intake, should the primary intake or filter become obstructed.

While not technically part of the induction air system, the intercooler air is supplied by the same ambient air, only through ducts at the roots of the wings. This air is used to cool pressurization and heating air that is extracted after the turbocharger. The intercooler bypass valve can be used to limit the cooling air received by the intercoolers, thus raising the air plenum temperature. See the "Cabin Environmental Controls" section of this manual for more information on the intercooler bypass controls.

When ambient pressure and temperature ram air reaches the turbocharger with the engine running, it is pressurized before entering the rest of the intake system. After the turbocharger, a small relief valve protects the intake system from overpressurization if the throttle is closed rapidly while the turbocharger is spinning at high RPM. Lastly, some of the pressurized and heated air is removed from the intake manifold and redirected into the cabin air plenum though the intercooler. Should the intake air become contaminated, such as by a carbon monoxide leak, a valve can be opened in the pressurization air duct to dump this pressure overboard into the engine nacelle. See the “Cabin Environmental Controls” section of this manual for more information on the pressurization shutoff controls.

10. Engine Condition Reset Buttons

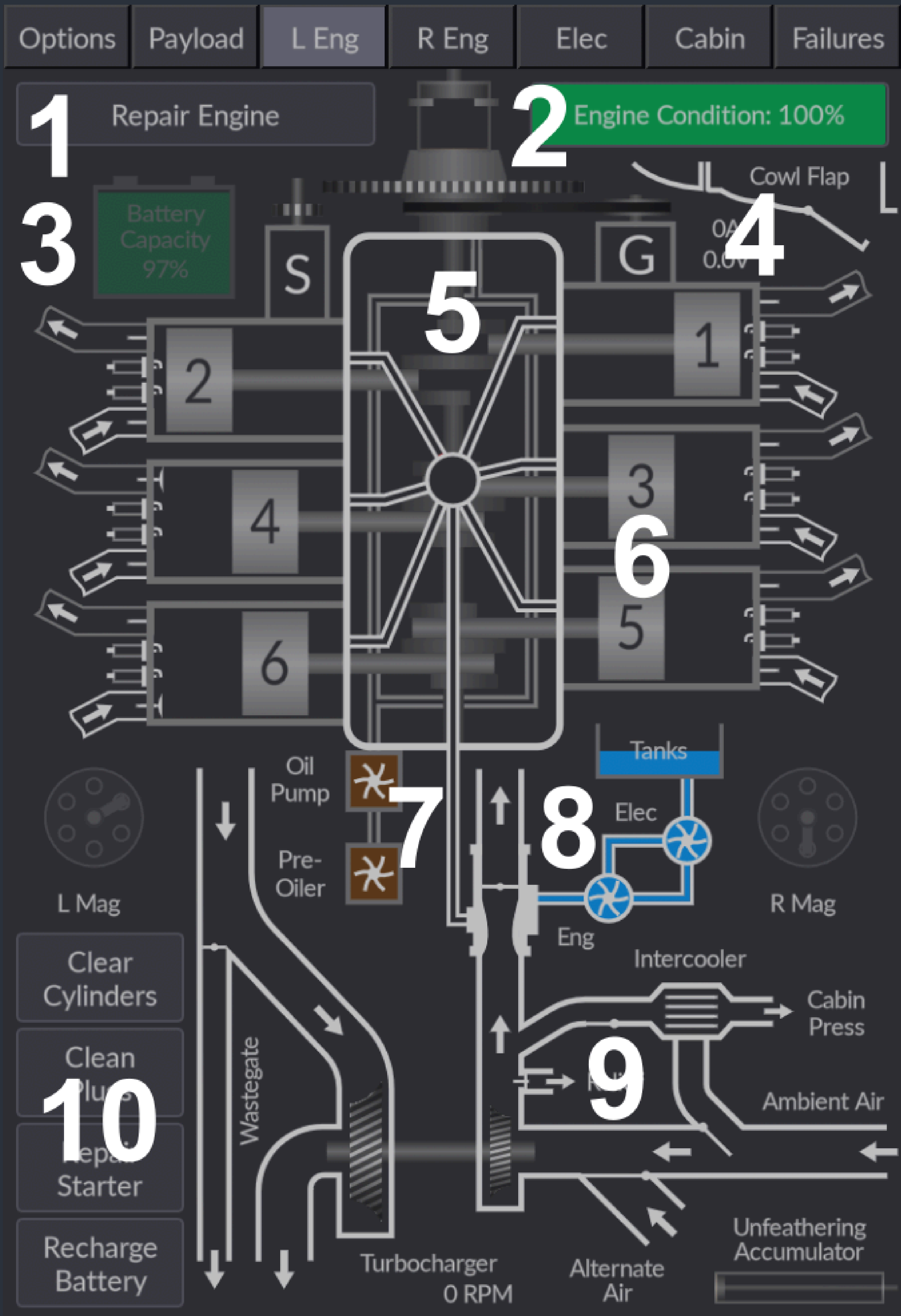
These buttons will not reset the engine’s overall condition, but instead will reset individual elements of the engine’s operating condition that may have become damaged or inoperable due to mismanagement, as opposed to failure.

The Clean Cylinders button will remove all fuel from the cylinders and fuel lines, and remove all fuel vapor from the fuel lines.

The Clean Plugs button will remove all fouling from the spark plugs which can prevent ignition.

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 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.



Options
Payload
L Eng
R Eng
Elec
Cabin
Failures
1
Repair Engine
2
Engine Condition: 100%
Cowl Flap
3
Battery Capacity 97%
S
G
4
5
1
2
3
4
6
5
6
Tanks
Oil Pump
7
8
Elec
Pre-Oiler
L Mag
R Mag
Eng
Intercooler
Clear Cylinders
Cabin Press
9
Wastegate
Ambient Air
Clean Plugs
10
Repair Starter
Recharge Battery
Turbocharger
0 RPM
Alternate Air
Unfeathering Accumulator

Starting Engine

This engine visualizer is most useful for diagnosing difficulties while starting the engine. The primary difficulties usually encountered while starting fuel injected engines are vapor lock, and the amount of liquid fuel in the lines, and fuel vapor in the cylinders. For more information on starting fuel injected engines see the “Fuel Injected Engine Operation” section of this manual.

1. Propeller Hub & Feather Locks

Atop the flywheel in this visualizer is the propeller hub cylinder and piston. When the piston is at the top of the cylinder, the propeller is in its fully fine position. The piston’s position is controlled by engine oil pressure, metered by the propeller governor. While starting from cold, there is no pressurized oil in the propeller hub, but the feather locks prevent the propeller from feathering. The feather locks can be seen here to the sides at the top of the cylinder, holding back the piston from descending. For more information on propeller feathering and feather locking pins, see the “Propeller Blade Position & Feathering” section of this manual.

2. Battery Temperature

Here, the battery can be seen connected to the main electrical bus. The exterior casing of the battery will change color to indicate the temperature of the battery’s terminals and electrodes. When the battery is cold, the casing color will be gray. As the battery warms the color will change from blues and greens, to ambers and reds. The battery’s absolute temperature can be monitored on the BTI-600 Battery Temperature Monitor. For more information on battery charging and temperature, see the “Battery Temperature” section of this manual.

3. Starter Motor in Use

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. When power is applied to the starter, a powerful solenoid pushes the starter gear into the flywheel gear to rotate the crankshaft. The exterior casing of the starter will change color to indicate its temperature. When the starter is cold, the casing color will be gray. As it warms the color will change from blues and greens, to ambers and reds.

4. Spark Plug Fouling

When the spark plugs become fouled with carbon and lead deposits, they will either produce a weak spark, or no spark at all. These deposits can be removed operationally, assuming they are not too severe. For the best practices to avoid fouling, and how to remove it, see the “Spark Plug Fouling” section of this manual. If fouling has become so severe that the engine cannot run at the temperatures required to remove the fouling, use the Clean Plugs button on this page to restore all the spark plugs to their original condition. The quantity of spark plug fouling is depicted here by the amount of red showing in the interior volume of the plug. Bottom spark plugs are usually fouled more than top plugs, because oil and combustion residue settle to the bottom of the cylinders with gravity.

5. Early Ignition

While starting, it can be useful to see when a cylinder fires, as this means the conditions required for the continuous combustion needed to start the engine are present. Here, we can see a cylinder expelling hot exhaust gasses through its exhaust valve, and the spark plug having just fired, despite some considerable fouling.

6. Fuel in Cylinders

The most crucial aspect of fuel injected engine starting is the amount of fuel vapor in the cylinders. The fuel lines must be fully pressurized before sufficient fuel can be found in each cylinder. The amount of fuel vapor in the cylinders is depicted by the blue gradient, here. There must be at least some fuel in the cylinders for a successful start, but not so much that the engine becomes flooded. In the screenshot below, this would be a generous amount of fuel for a normal start, and may require some additional cranking.

7. Fuel & Vapor in Lines

When the electric or engine driven fuel pumps run with the throttle open and the mixture above cutoff, fuel will flow from the tanks into the distributor manifold, then outwards to the cylinder heads. As the fuel lines are pressurized, a slug of fuel will travel from the throttle body out to the cylinders. Dashed lines indicate the rate of fuel flow. Not until this slug reaches the cylinders will they begin to fill with fuel.

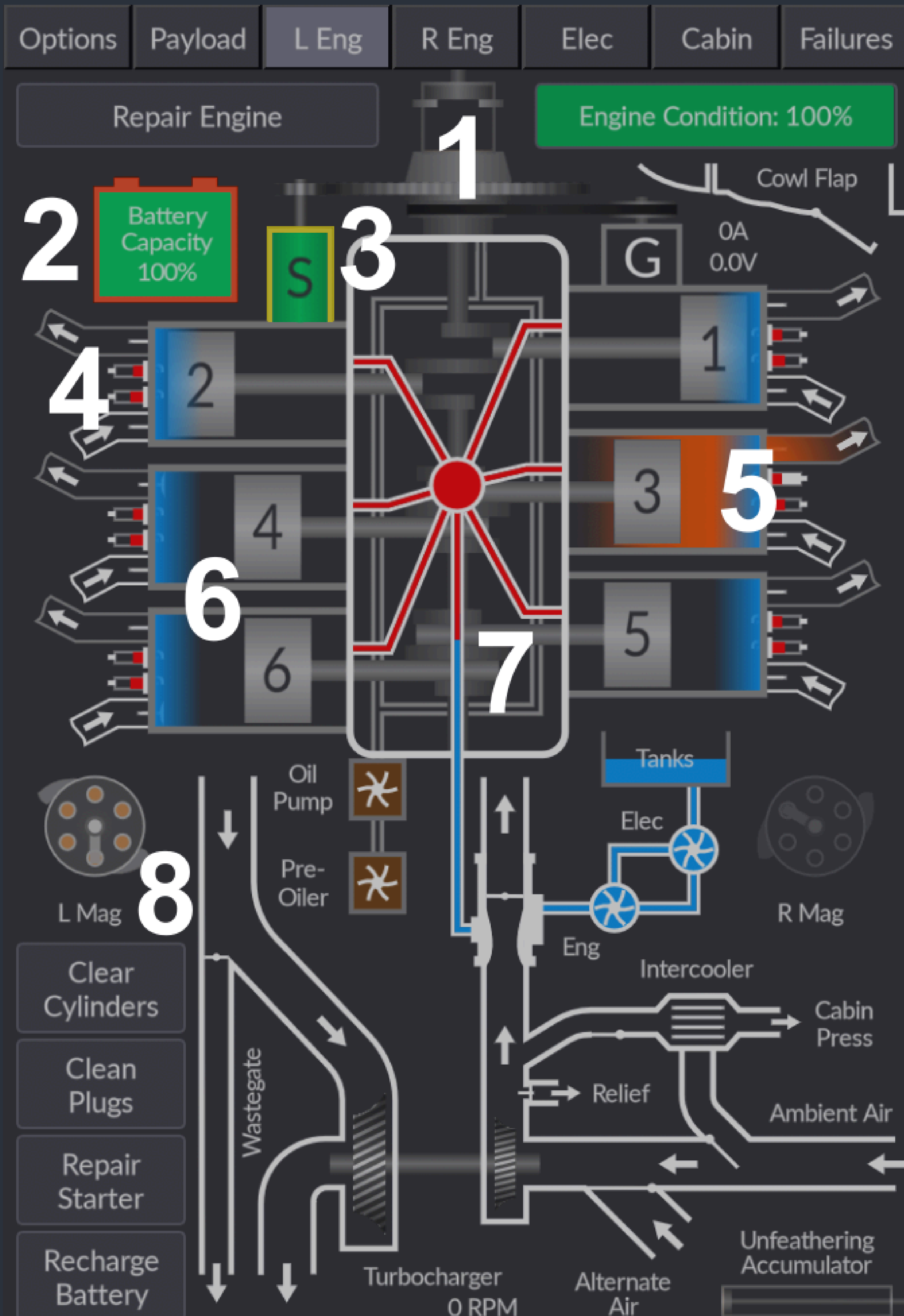
Usually when an engine is shut down, the heat in the cylinders will begin vaporizing fuel in the lines, causing back pressure that can prevent the flow of liquid fuel to the cylinders. This is called vapor lock. It is the bane of many fuel injected aircraft pilots who do not know how to manage it. For information on when vapor lock is likely to occur, and how to alleviate it, see the "Hot Engine Starting" section of this manual for more information. Vapor lock back pressure is depicted here by the red slug, working backwards from the cylinders towards the throttle body.

8. Magneto & Impulse Coupling

When a magneto is grounded by the ignition switch, it will appear grayed out. Here, only the left magneto is ungrounded, as is the typical starting configuration for aircraft engines. Magnetos may also become grounded or ungrounded by way of failures, which are simulated.

The magneto wiper is a rotating internal mechanism which connects the magneto coil to the right spark plug at the right time, as the engine rotates. Here, the wiper contacts copper pads, positioned around the periphery of the magneto.

Around the outside of the magneto are the impulse coupling flyweights, which will only be visible when the engine is starting. These weights snap in and out as the engine rotates at low RPM, delaying the ignition of each spark plug, and increasing the angular velocity of the magneto's rotor to produce larger sparks. These also make a characteristic snapping sound while the starter is cranking, and when the engine is coming to a stop.


Options
Payload
L Eng
R Eng
Elec
Cabin
Failures
Repair Engine
Engine Condition: 100%
1
Cowl Flap
2
Battery Capacity 100%
S
3
G
0A
0.0V
4
2
1
5
3
4
6
5
6
7
Oil Pump
Pre-Oiler
Tanks
Elec
L Mag
8
R Mag
Eng
Intercooler
Clear Cylinders
Cabin Press
Clean Plugs
Relief
Wastegate
Ambient Air
Repair Starter
Recharge Battery
Turbocharger
0 RPM
Alternate Air
Unfeathering Accumulator

Running Engine

While the engine is running, the engine visualizer is best used for monitoring temperatures, component failure, and the intake manifold valve positions.

1. Propeller Hub & Feather Locks

Unlike the cold engine example above, here the propeller hub is filled with pressurized oil from the engine, and the feather locking pins are retracted. As the engine is supplying oil to the propeller hub, the locking pins are not needed to prevent the propeller from feathering. For more information on propeller feathering and feather locking pins, see the “Propeller Blade Position & Feathering” section of this manual.

2. Generator

Like the starter motor, the generator’s internal volume will appear green when it is operating, and red when it has failed. The generator also has text to indicate the present output voltage and current load on the generator.

3. Cylinder Temperatures

With the engine running, we can see intake air flowing into each cylinder through the intake valves, and hot exhaust gasses exiting through the exhaust valves. Each spark plug can also be seen firing continuously, or so it would appear. This is merely because each spark plug is firing around 25 times per second, which approaches the refresh rate of the tablet screen.

The color of the exhaust gas and cylinder head temperatures follow the same logic as the other elements discussed above. As they warm, the colors will change from yellows and oranges, to reds and magentas. Magenta should be considered dangerously hot for any equipment depicted in this engine visualizer. Here, the number four cylinder is running moderately warmer than the rest. Some variation in cylinder head temperature is normal, and may even change with the pitch of the aircraft, or direction of crosswinds. The cylinder heads’ absolute temperatures can be monitored on the EDM-760 engine monitor. For more information on EDM-760, see the “Using the JPI EDM-760 Engine Monitor” section of this manual.

4. Backfire

A cylinder may backfire under several abnormal conditions, which are enumerated in the “Backfiring” section of this manual. When a cylinder backfires, combustion of fuel vapors and hot gasses takes place outside the cylinder, in its exhaust manifold. Backfiring is depicted here as red-yellow gasses rapidly expand out of the cylinder’s exhaust valve.

5. Oil Pumps & Lines

While dark brown oil in the galleries indicated very cold and viscous oil, red indicates oil that is too hot. The oil has a large normal operating temperature span, throughout which its color will be the brown seen below. Here, the engine driven oil pump can also be seen running.

6. Magnetos

Once the engine is running and the ignition switch is released from the “start” position and returns to the “both” position, both magnetos will supply high voltage pulses to each spark plug in turn, assuming there are no magneto grounding failures. The wiper has blurred with the speed of the engine, and the impulse coupling flyweights have retracted.

7. Exhaust Manifold

When the engine is running, the exhaust manifold is filled with hot exhaust gasses, which are the average temperature of all the cylinders’ exhaust gasses. The exhaust gas temperature colors are the same as those described for each cylinder, above.

Most of this exhaust gas flows into the turbocharger, while some is diverted overboard. The diversion of this gas is controlled by the oil pressure actuated wastegate, and absolute pressure controller. When the engine is operating near sea level, the engine would overboost if all the gas was allowed to flow through the turbocharger, so the wastegate is fully opened, allowing some gas to bypass the turbocharger. As the aircraft climbs towards the critical altitude, the wastegate closes. For more information on turbochargers, wastegates, and critical altitude, see the “Turbocharged Operation” section of this manual.

8. Intake Manifold

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 throttle butterfly valve limits the amount of pressurized intake air admitted to the intake manifold, and the engine pulls a vacuum above the throttle valve. This is measured as the manifold pressure.

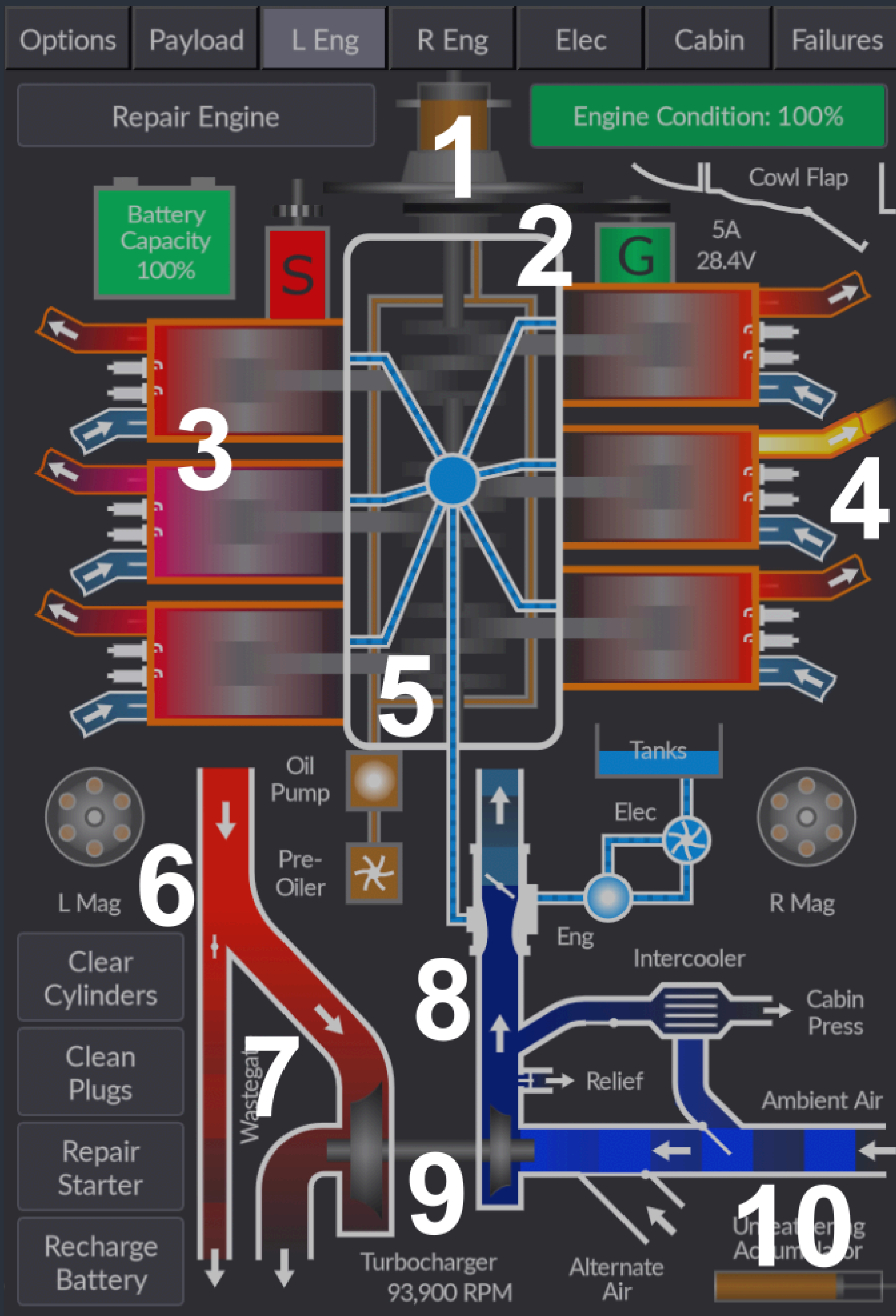
9. Turbocharger

The turbocharger RPM is shown below the intake and exhaust turbines. See the “Turbocharged Operation” section of this manual for more information on turbocharger operation.

10. Unfeathering Accumulator

The unfeathering accumulator allows for the collection of pressurized oil while the engine is running, which can be dumped back into the propeller hub later, to facilitate starting in flight after an engine shutdown. Whenever pressurized oil is present in the engine galleries, oil also flows into the accumulator until the pressure inside and outside the accumulator has equalized.

When the engine is shut down and the propeller feathered, oil vacates the propeller hub. Without the high pressure engine driven oil pump running, developing enough pressure to unfeather the propeller can be almost impossible, and starting a feathered engine is similarly difficult. When the propeller lever is advanced out of the feather detent, high pressure oil will be dumped from the accumulator into the propeller hub, unfeathering the propeller. See the “Unfeathering Accumulators” section of this manual for more information.



Options
Payload
L Eng
R Eng
Elec
Cabin
Failures
Repair Engine
Engine Condition: 100%
Cowl Flap
Battery Capacity 100%
S
G
5A
28.4V
1
2
3
4
5
6
7
8
9
10
Oil Pump
Pre-Oiler
Tanks
Elec
Eng
L Mag
R Mag
Intercooler
Cabin Press
Relief
Ambient Air
Clear Cylinders
Clean Plugs
Repair Starter
Recharge Battery
Turbocharger 93,900 RPM
Alternate Air

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. A second alternating current (AC) voltmeter measures the voltage output by the windshield heat inverter. 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 avionics controller sends a trigger voltage to the avionics contactors to close, thus supplying power to the avionics buses. A contactor is a large mechanical relay, often used in older aircraft for switching large loads.

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

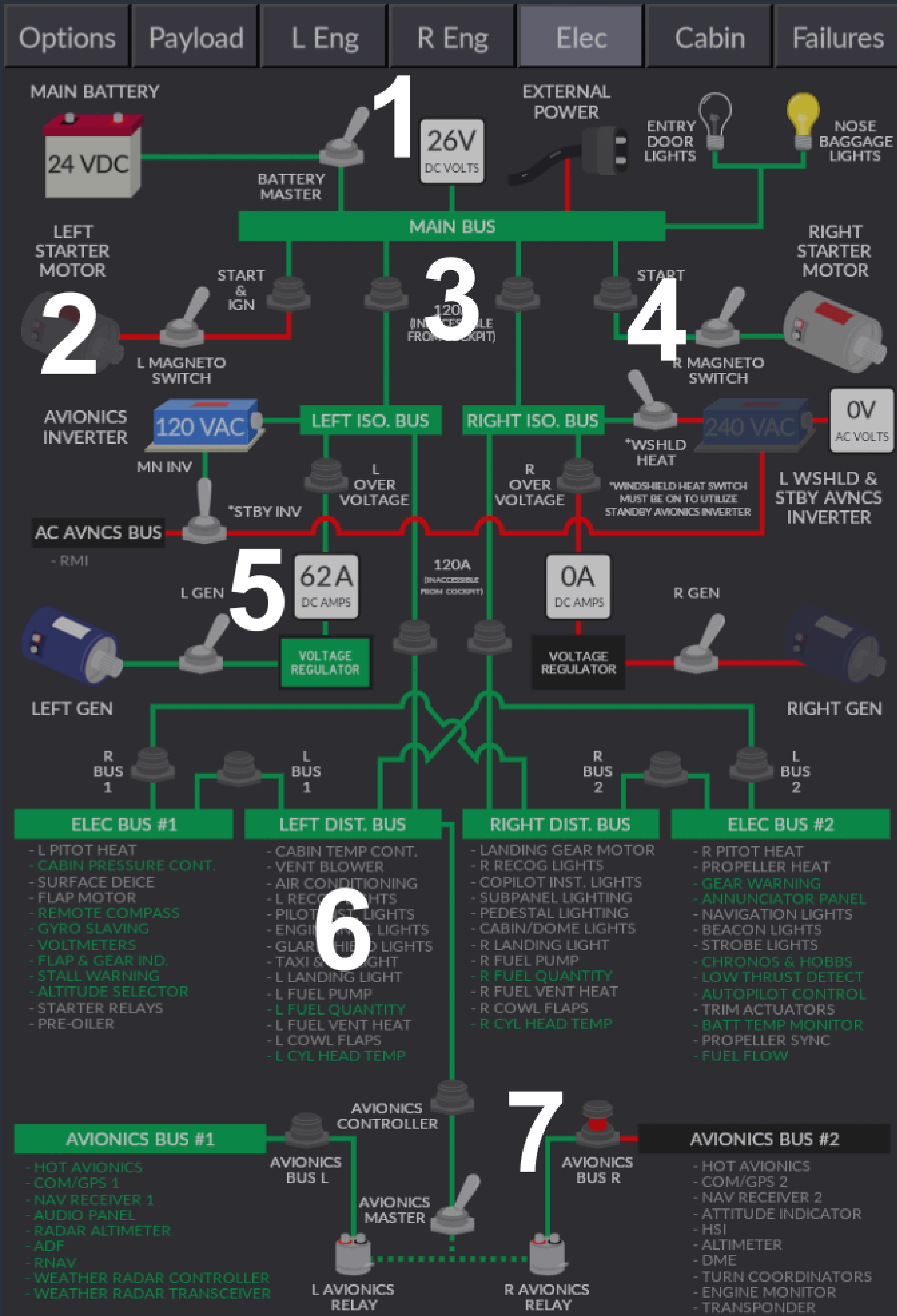
The load meters in most light aircraft do not indicate the total load required of the aircraft's electrical system for all of its electrical equipment. Instead, the loadmeters indicate the load on each generator. This will always be a positive number, as opposed to ammeters in aircraft that can be used 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.

6. Circuits

Each circuit for an individual piece of equipment in the aircraft is represented on this schematic. When the circuit is in use and powered, its name will be highlighted in green. Otherwise, the name will be grayed out.

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.



Options
Payload
L Eng
R Eng
Elec
Cabin
Failures
MAIN BATTERY
24 VDC
1
BATTERY MASTER
26V
DC VOLTS
EXTERNAL POWER
ENTRY DOOR LIGHTS
NOSE BAGGAGE LIGHTS
MAIN BUS
LEFT STARTER MOTOR
2
START & IGN
3
START
4
RIGHT STARTER MOTOR
L MAGNETO SWITCH
R MAGNETO SWITCH
AVIONICS INVERTER
120 VAC
LEFT ISO. BUS
RIGHT ISO. BUS
240 VAC
0V
AC VOLTS
MN INV
L OVER VOLTAGE
R OVER VOLTAGE
*WSHLD HEAT
*WINDSHIELD HEAT SWITCH MUST BE ON TO UTILIZE STANDBY AVIONICS INVERTER
L WSHLD & STBY AVNCS INVERTER
*STBY INV
AC AVNCS BUS
- RMI
5
62A
DC AMPS
L GEN
120A
(INACCESSIBLE FROM COCKPIT)
0A
DC AMPS
R GEN
VOLTAGE REGULATOR
VOLTAGE REGULATOR
LEFT GEN
RIGHT GEN
R BUS 1
L BUS 1
R BUS 2
L BUS 2
ELEC BUS #1
- L PITOT HEAT
- CABIN PRESSURE CONT.
- SURFACE DEICE
- FLAP MOTOR
- REMOTE COMPASS
- GYRO SLAVING
- VOLTMETERS
- FLAP & GEAR IND.
- STALL WARNING
- ALTITUDE SELECTOR
- STARTER RELAYS
- PRE-OILER
LEFT DIST. BUS
- CABIN TEMP CONT.
- VENT BLOWER
- AIR CONDITIONING
6
- L LANDING LIGHT
- L FUEL PUMP
- L FUEL QUANTITY
- L FUEL VENT HEAT
- L COWL FLAPS
- L CYL HEAD TEMP
RIGHT DIST. BUS
- LANDING GEAR MOTOR
- R RECOG LIGHTS
- COPILOT INST. LIGHTS
- SUBPANEL LIGHTING
- PEDESTAL LIGHTING
- CABIN/DOME LIGHTS
- R LANDING LIGHT
- R FUEL PUMP
- R FUEL QUANTITY
- R FUEL VENT HEAT
- R COWL FLAPS
- R CYL HEAD TEMP
ELEC BUS #2
- R PITOT HEAT
- PROPELLER HEAT
- GEAR WARNING
- ANNUNCIATOR PANEL
- NAVIGATION LIGHTS
- BEACON LIGHTS
- STROBE LIGHTS
- CHRONOS & HOBBS
- LOW THRUST DETECT
- AUTOPILOT CONTROL
- TRIM ACTUATORS
- BATT TEMP MONITOR
- PROPELLER SYNC
- FUEL FLOW
AVIONICS CONTROLLER
7
AVIONICS BUS #1
- HOT AVIONICS
- COM/GPS 1
- NAV RECEIVER 1
- AUDIO PANEL
- RADAR ALTIMETER
- ADF
- RNAV
- WEATHER RADAR CONTROLLER
- WEATHER RADAR TRANSCEIVER
AVIONICS BUS L
AVIONICS MASTER
AVIONICS BUS R
L AVIONICS RELAY
R AVIONICS RELAY
AVIONICS BUS #2
- HOT AVIONICS
- COM/GPS 2
- NAV RECEIVER 2
- ATTITUDE INDICATOR
- HSI
- ALTIMETER
- DME
- TURN COORDINATORS
- ENGINE MONITOR
- TRANSPONDER

Cabin Climate Visualizer Page

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

Heating Cabin

When the desired cabin temperature is warmer than the outside ambient air, heating is provided by two sources: the pressurized air, heated by passing through the turbocharger's compressor turbine, or the combustion heater. For more information on the environmental control systems, see the "Environmental Simulation & Controls" section of this manual.

1. Cabin Ram Air Intake

On the right side of the aircraft's nose, a NACA duct sources ram air for the cabin, avionics cooling, and the combustion heater's combustion chamber. This air is divided in a distribution box surrounding the vent.

At the back of this box are two valves that separate the distribution box from the cabin. The outermost vent is controlled via the "CABIN AIR" pull handle in the cockpit. This valve can be opened when the aircraft is operating unpressurized and unheated, to allow ambient ram air to enter the cabin. This valve should also be opened in the event of a cabin air emergency, such as smoke in the cabin, or acrid burning smells, once the cabin has been depressurized.

To prevent opening of the cabin air valve from depressurizing the cabin, a check valve is installed between the cabin air valve and the cabin volume. This check valve will be held closed whenever the cabin pressure differential is non-negligible, separating the cabin from the ram air.

2. Combustion Heater

Pressurized air from the cabin air plenum is further heated by the combustion heater, which is a gasoline powered appliance with its own air intake, ignition, and exhaust. The combustion heater is discussed further in the "Cabin Environmental Controls" section of this manual. Any time the combustion heater is operating, so too should be the combustion heater blower, as it promotes airflow through the combustion chamber, preventing reverse flow and overheating. Should the combustion heater's ignition system malfunction, its spark ignitor will indicate red.

3. Pressurization Shutoff & Carbon Monoxide

Carbon monoxide leaks are indicated in this visualizer by the presence of gray gradients emanating from either engine, or the combustion heater. In the event that carbon monoxide is detected, the suspect engine should be isolated from the cabin air, or the combustion heater disabled. The red pressurization shutoff valves are used to isolate the engines, with the left appearing in the closed position here, and the right open. These shutoff valves can also be used to check the functioning of the pressurized air supply from each engine during runup checks. For more information on the pressurization shutoff valves and carbon monoxide, see the "Cabin Pressurization System", and "Carbon Monoxide Detector" sections of this manual.

4. Intercooler Bypass

The intercooler bypass valves, here seen open on the left and closed on the right, serve to meter the amount of cooling air supplied to the pressurization and heating air intercoolers, located in the ducts under each wing root. The pull handles controlling these valves are labeled "PRESSURIZATION AIR TEMP PULL TO INCREASE" in the cockpit. Maintaining adequate cabin temperature at altitude, and not overheating the plenum on the ground, requires the careful management of these valves. See the "Cabin Environmental Controls" section of this manual for more information.

5. Cabin Air Plenum

The cabin air plenum is a volume of air created by the intake of ram air, and/or heated pressurization air from each turbocharger. This is the baseline temperature for all heating and cooling in the aircraft. The air in the plenum can be heated above the outside ambient by closing the intercooler bypass valves. On the ground, the plenum air will be heated by solar radiation, along with the rest of the cabin.

The cabin vent blower fan resides inside the plenum. It is used to blow air through the heating and cooling systems, and into the cabin. The vent blower can be used to equalize the cabin temperature without the outside air, or to increase the rate of heating or cooling.

6. Air Vents & Temperature Controller

The cabin outlet air vents in the cockpit further meter flow of heating and cooling air into the cabin. The defroster valves are normally closed, while the pilot and copilot valves are normally open. All of these valves are controlled via pull handles on the instrument subpanel, discussed further in the "Cabin Environmental Controls" section of this manual.

The temperature controller is a simple electronic system which controls the heating and cooling subsystems of the aircraft, and a mixing valve between the combustion heater outlet, and the cabin vents. Here, the valve is in the full heating position, admitting as much heated air as possible to the cabin, as opposed to the cooler plenum air.

7. 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.

8. Cabin Pressurization Graph

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

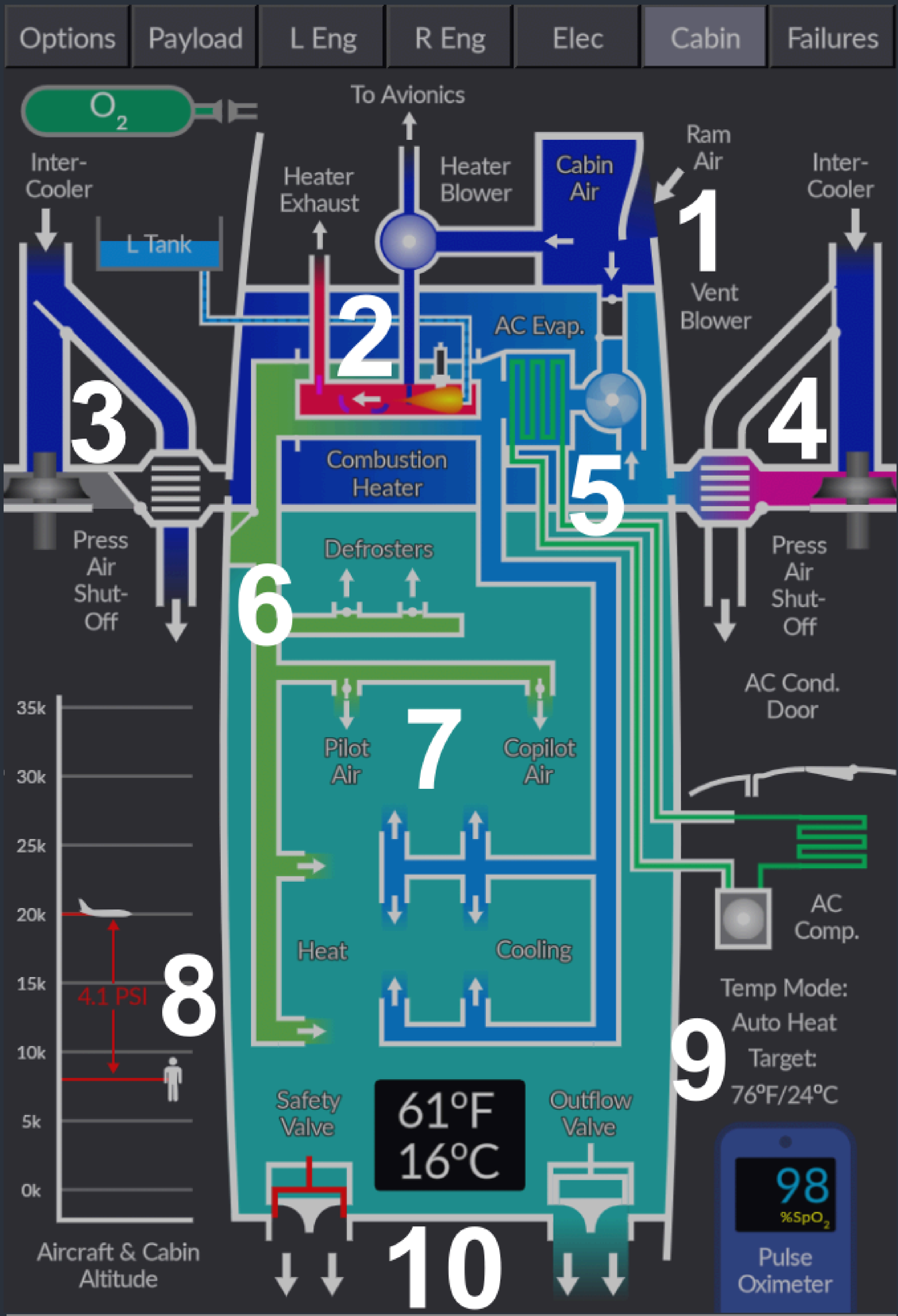
9. Climate Control Modes & Target

The operating mode of the climate control system is controlled by the “CABIN TEMP MODE” rotary selector switch discussed in the “Cabin Environmental Controls” section of this manual. This mode is annunciated, along with the temperature controller’s target cabin temperature, below the air conditioning compressor.

The target temperature will either be displayed as “MAX” or “MIN” in manual heating or cooling modes respectively, or the numeric set point of the “CABIN TEMP” rotary selector knob, when in automatic heating or cooling modes. 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 intercooler bypass valves while climbing, or that the air conditioner is operating at maximum capacity. Here, the automatic heating target temperature can be seen in degrees Fahrenheit and Celsius.

10. Safety & Outflow Valves

Cabin pressurization is controlled primarily by a set of two valves, the safety and outflow valves, on the aft pressure bulkhead of the aircraft. This complex topic is discussed at length in the “Cabin Pressurization System” section of this manual. Here, the outflow valve is open, venting the pressurized cabin air to atmosphere. The safety valve is closed, as it should be during normal operation. Its red coloration indicates that it has suffered a failure, and will not move from the closed position.



Options
Payload
L Eng
R Eng
Elec
Cabin
Failures
O2
To Avionics
Ram Air
Inter-Cooler
Heater Exhaust
Heater Blower
Cabin Air
Inter-Cooler
L Tank
1
Vent Blower
2
AC Evap.
3
4
Combustion Heater
5
Press Air Shut-Off
Defrosters
Press Air Shut-Off
6
AC Cond. Door
35k
30k
25k
20k
15k
10k
5k
0k
Pilot Air
7
Copilot Air
Heat
Cooling
AC Comp.
4.1 PSI
8
Temp Mode:
Auto Heat
Target:
76ºF/24ºC
9
Safety Valve
61ºF
16ºC
Outflow Valve
98
%SpO2
Aircraft & Cabin Altitude
10
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 Cylinder

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 to the right of the cylinder, here seen in the open position, depicts the position of the oxygen valve, controlled via the knob on the pilot’s side panel.

2. Cabin Ram Air Intake

As opposed to the cabin heating section above, which depicts an aircraft in flight, this screenshot depicts an aircraft on the ground with the air conditioning running. The outside ambient air temperature is warm, indicated by the yellow color of the ram air intake air. Also, the cabin air valve is in the open position, and the distribution box check valve is open, allowing ram air to flow into the cabin air plenum.

3. Intercooler Bypass & Pressurization Shutoff

Here, both the pressurization shutoff valves, and the intercooler bypass valves are in their normal operating positions. The pressurization air coming from the right turbocharger is of a higher temperature than that of the left turbocharger (magenta vs. red), as the right engine is running at a higher RPM and higher load, as is required to operate the air conditioner.

4. Cabin Air Plenum & Air Conditioning Evaporator

Cooling of the cabin air plenum air is accomplished with an air conditioning evaporator, through which the cabin air flows, driven by the cabin vent blower. The insulated lines of the vapor cycle cooling system will change color to indicate that the system is operating.

5. Air Vents & Temperature Controller

The air vents and temperature controller operate as discussed in the cabin heating section, above. Here, the temperature controller mixing valve is positioned in the full cooling position, admitting as much cooling air and plenum air to the cabin as possible.

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. Air Conditioning Compressor, Condenser & Scoop

The air conditioning system (also known as the vapor cycle cooling system), is driven by a clutched compressor on the right engine. This compressor will only engage when the 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 pipes pass through a condenser in the right engine nacelle, which requires cooler ambient air to operate. A scoop on the top of the engine nacelle ensures the condenser receives the most airflow possible. The scoop will open to varying degrees throughout the flight. If the condenser scoop motor fails, or its limit switches fail, the door may become stuck. This will be indicated by a red condenser scoop door in this visualizer. For more information on the condenser scoop, see the “Air Conditioning Condenser Scoop” section of this manual.

8. Climate Control Modes & Target

The display of operating modes and target temperatures is discussed in the cabin heating section, above. Here, the manual cooling target temperature of “MIN” can be seen, which signifies that the temperature controller will cool the cabin to the minimum temperature possible.

9. Pulse Oximeter

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

Generally speaking, 98% oxygen saturation (SpO_2) is normal at sea level for a healthy adult.

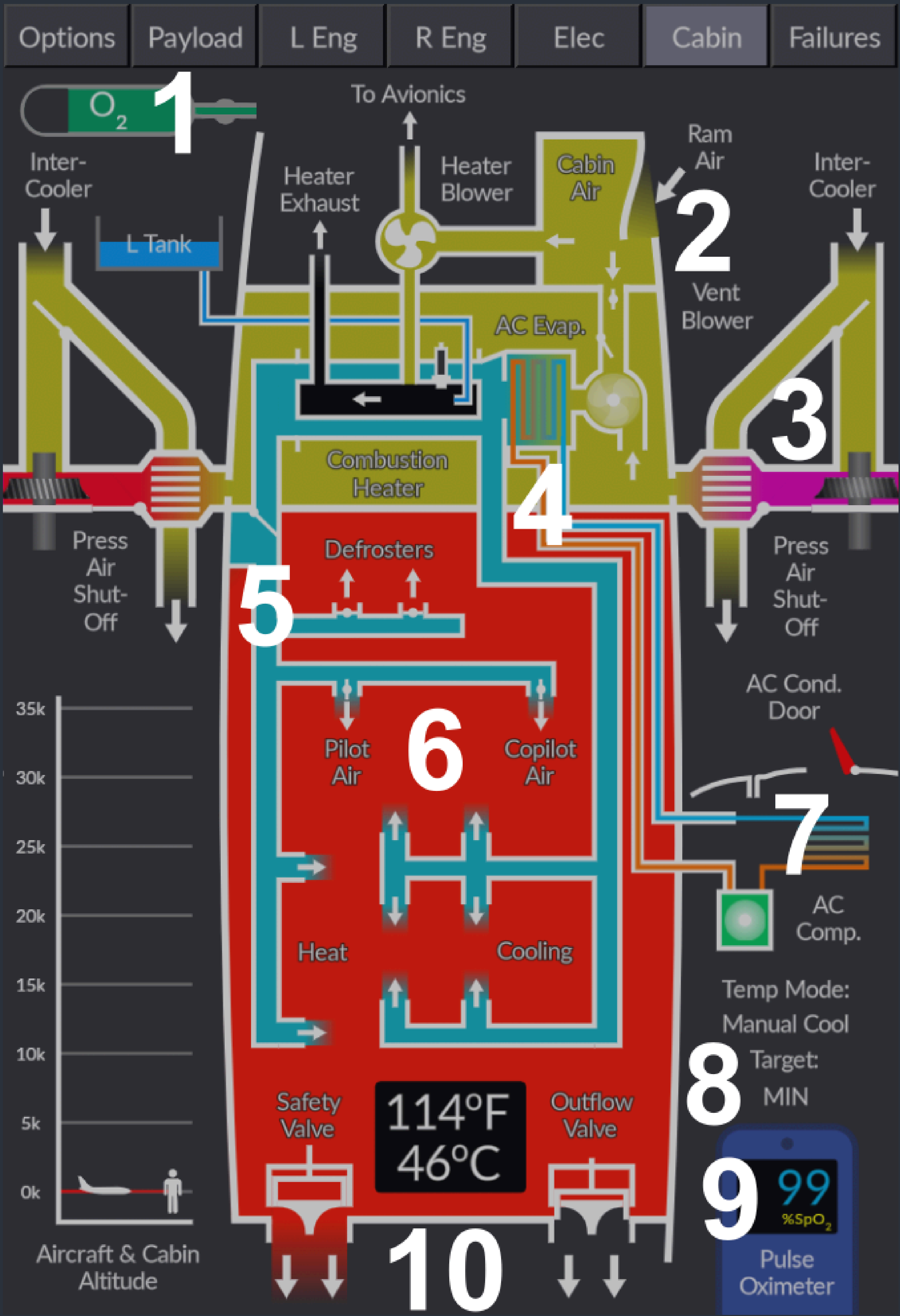
The recommended, and legally required, altitudes for supplemental oxygen use of around 12,000 - 14,000 feet correspond to an SpO_2 of roughly 90-92% for exposure under 60 minutes.

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.

10. Safety & Outflow Valves

Cabin pressurization is controlled primarily by a set of two valves, the safety and outflow valves, on the aft pressure bulkhead of the aircraft. This complex topic is discussed at length in the “Cabin Pressurization System” section of this manual. Here, the outflow valve is closed, and the safety valve is open, because the landing gear weight on wheels sensor is activated. As neither valve is depicted in red, both are functioning properly.


Options
Payload
L Eng
R Eng
Elec
Cabin
Failures
O2
1
To Avionics
Ram Air
Inter-Cooler
Heater Exhaust
Heater Blower
Cabin Air
2
Inter-Cooler
L Tank
Vent Blower
AC Evap.
3
Combustion Heater
4
Press Air Shut-Off
Defrosters
5
Press Air Shut-Off
AC Cond. Door
35k
30k
25k
20k
15k
10k
5k
0k
Pilot Air
6
Copilot Air
7
Heat
Cooling
AC Comp.
Temp Mode:
Manual Cool
Target:
MIN
8
Safety Valve
114°F
46°C
Outflow Valve
99
%SpO2
9
Aircraft & Cabin Altitude
10
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

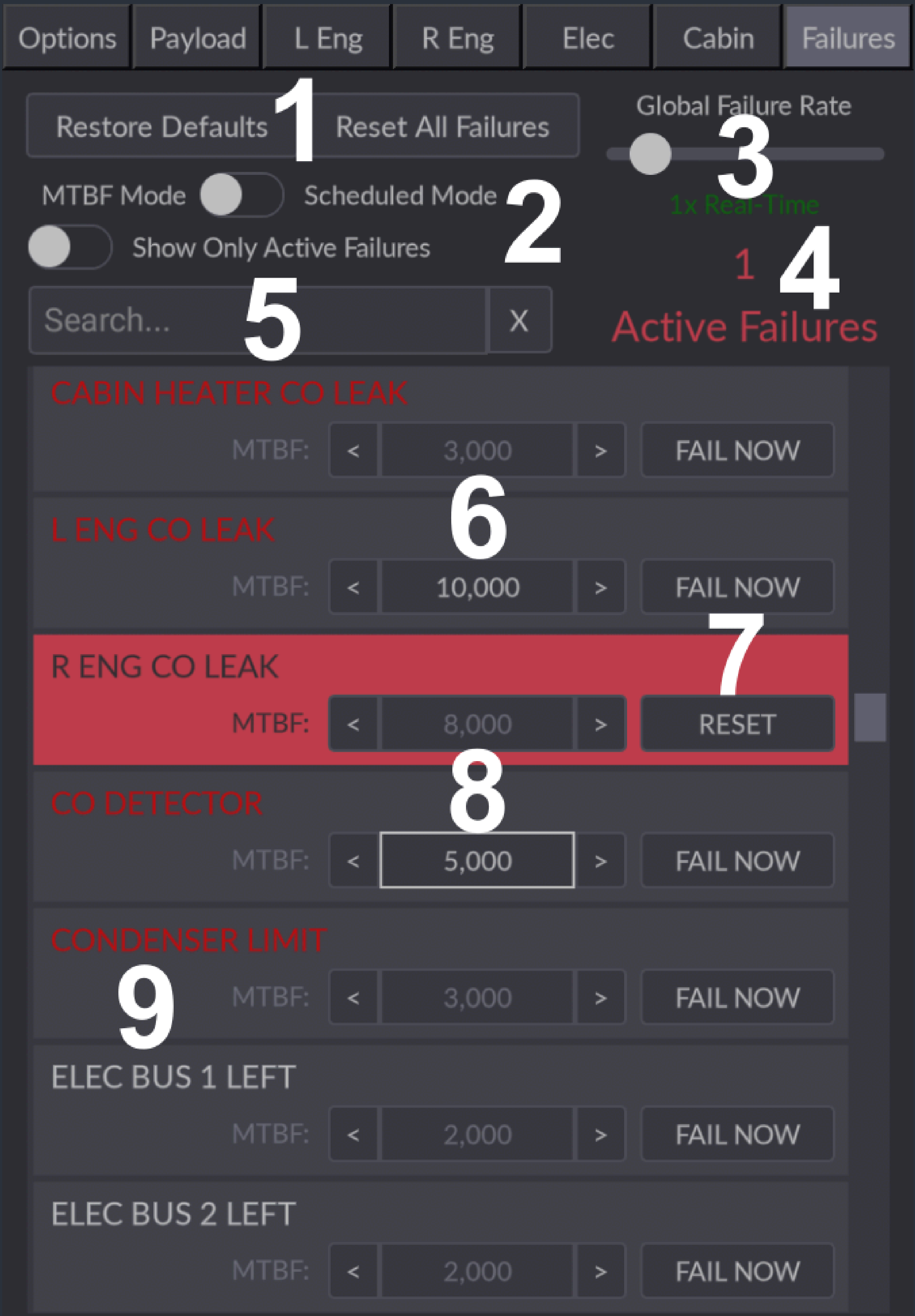
After being triggered by any means, individual failures can be reset by pressing the "RESET" button. Failures can also be triggered manually in this mode by pressing the "FAIL NOW" button.

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
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
AVIONICS BUS RIGHT
BETEWEEN: < 10 > AND < 30 > MIN
ARM?
GEN OVERVOLT DETECT L
6
BETEWEEN: < 1 > AND < 2 > MIN
RESET
7
GEN OVERVOLT DETECT R
BETEWEEN: < 10 > AND < 30 > MIN
ARMED
CABIN TEMP CONTROL
BETEWEEN: < 10 > AND < 30 > MIN
ARM?
CABIN PRESS CONTROL
8
< 10 > AND < 30 > MIN
ARM?
VENT BLOWER
BETEWEEN: < 10 > AND < 30 > MIN
ARM?
AIR CONDITIONING
BETEWEEN: < 10 > AND < 30 > MIN
ARM?

Failure System HTML Interface

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

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

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

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

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

>H:BKSQ_FAILURE_L_FUEL_QTY

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

>H:BKSQ_FAILURE_RESET_ALL_FAILURES

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

List of Possible Failures

Major System Failures

L ENGINE FAILURE
R ENGINE FAILURE
L ENGINE FIRE
R ENGINE FIRE

L ENG L MAGNETO
L ENG R MAGNETO
L ENG L MAGNETO GROUNDING
L ENG R MAGNETO GROUNDING
L IGNITION SWITCH GROUND
L TURBOCHARGER
L UNFEATHERING ACCMLTR
L GENERATOR
L ENG DRIVEN FUEL PUMP
L ENG CO LEAK

R ENG L MAGNETO
R ENG R MAGNETO
R ENG L MAGNETO GROUNDING
R ENG R MAGNETO GROUNDING
R IGNITION SWITCH GROUND
R TURBOCHARGER
R UNFEATHERING ACCMLTR
R GENERATOR
R ENG DRIVEN FUEL PUMP
R ENG CO LEAK

INSTRUMENT AIR
INSTRUMENT AIR PARTIAL
PITOT BLOCKAGE
STATIC BLOCKAGE
L BRAKE
R BRAKE
L FUEL LEAK
R FUEL LEAK
CABIN SAFETY VALVE
CABIN OUTFLOW VALVE
INFLOW CONTROL UNIT
CABIN DOOR LATCH
NOSE DOOR LATCH
DEICE BOOTS INTEG
MAIN INVERTER
STANDBY INVERTER
OXYGEN LEAK
COMBUSTION HEATER
CABIN HEATER CO LEAK
CO DETECTOR
CONDENSER LIMIT
GEAR CRANK HANDLE

Breaker Protected Failures

CABIN TEMP CONTROL
CABIN PRESS CONTROL
VENT BLOWER
AIR CONDITIONING
PITOT HEAT L
PITOT HEAT R
SURFACE DEICE
PROP DEICE
WINDSHIELD HEAT
FLAP MOTOR
GEAR MOTOR
GEAR WARNING
ANNUNCIATOR PANEL
NAV LIGHTS
BEACON AND STROBE
L LDG AND RECOG LTS
PLT AND ENG INST LTS
GLARESHIELD LTS
TAXI AND ICE LTS
AVNCS POWER CONTROL
R LDG AND RECOG LTS
COPLT AND AVNCS LTS
SUBPANEL AND PED LTS
DOME AND READING LTS
CHRONO AND HOBBS
REMOTE COMPASS
VOLT METERS
FLAPS AND GEAR IND
STALL WARNING
LOW THRUST DETECT
ALTITUDE SELECTOR
AUTOPILOT CONTROLLER
AUTOPILOT ACTUATORS
BATTERY MONITOR
PROP SYNC
STARTER MOTORS
FUEL FLOW
L FUEL PUMP
R FUEL PUMP
L FUEL QTY
R FUEL QTY
L FUEL VENT HEAT
R FUEL VENT HEAT
L COWL FLAP
R COWL FLAP
L CYL HEAD TEMP
R CYL HEAD TEMP

COM 1
COM 2
NAV 1
NAV 2
AUDIO PANEL
RADAR ALTIMETER
PILOT ATTITUDE
PILOT HSI
PILOT ALTIMETER
ADF
RNAV
WX RADAR CONTROLLER
WX RADAR TRANSCEIVER
DME
TURN COORDINATORS

ENGINE MONITOR
TRANSPONDER

Power Distribution Failures

L OVERVOLTAGE
R OVERVOLTAGE
ELEC BUS 1 LEFT
ELEC BUS 2 LEFT
ELEC BUS 1 RIGHT
ELEC BUS 2 RIGHT
AVIONICS BUS LEFT
AVIONICS BUS RIGHT
GEN OVERVOLT DETECT L
GEN OVERVOLT DETECT R

Miscellaneous Systems

Audible Warning Tones

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

- Altitude Alerter Tone: A traditional C-Chime will sound when the aircraft is within 1,000 ft of the selected altitude displayed on the PRE-80C Altitude Selector.
- 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 warning buzzer will sound.
- Stall Warning Horn: When the aircraft is within approximately 5-10 knots of stalling speed, a constant tone warning horn will sound.
- Gear Configuration Warning Horn: When both throttle levers are reduced below approximately 20% of their travel, or the flaps are placed in their landing configuration, and the landing gear has not been deployed, a repeating tone will sound.
- Carbon Monoxide Detector: When an engine or the combustion heater becomes compromised, it is possible for poisonous gas to leak into the cabin of the aircraft. When this colorless, odorless, gas is present, a beeping alarm will sound. The alarm will continue to sound as long as the gas is present. Follow the checklists for Carbon Monoxide leaks, and close (pull) the cabin pressurization air shutoff valves immediately.
- Engine Cooling Ticking: The ticking sound an engine makes after shutdown while it cools and contracts is modeled in this simulation. This sound can be used to roughly estimate when temperatures are high enough in the engine cowling to vaporize fuel and contribute to vapor lock.

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

Turbocharger Sound

For users who find the high-pitched whine of turbocharger annoying, the sound can be disabled while retaining the function of the turbocharger via the options page of the tablet interface.

When the throttle is advanced too rapidly, or with cool oil, the wastegate may not react quickly enough to prevent an overboost condition. Should this occur, a pressure relief poppet valve will open, emitting an audible hissing sound.

VOR & ADF Signal Degradation

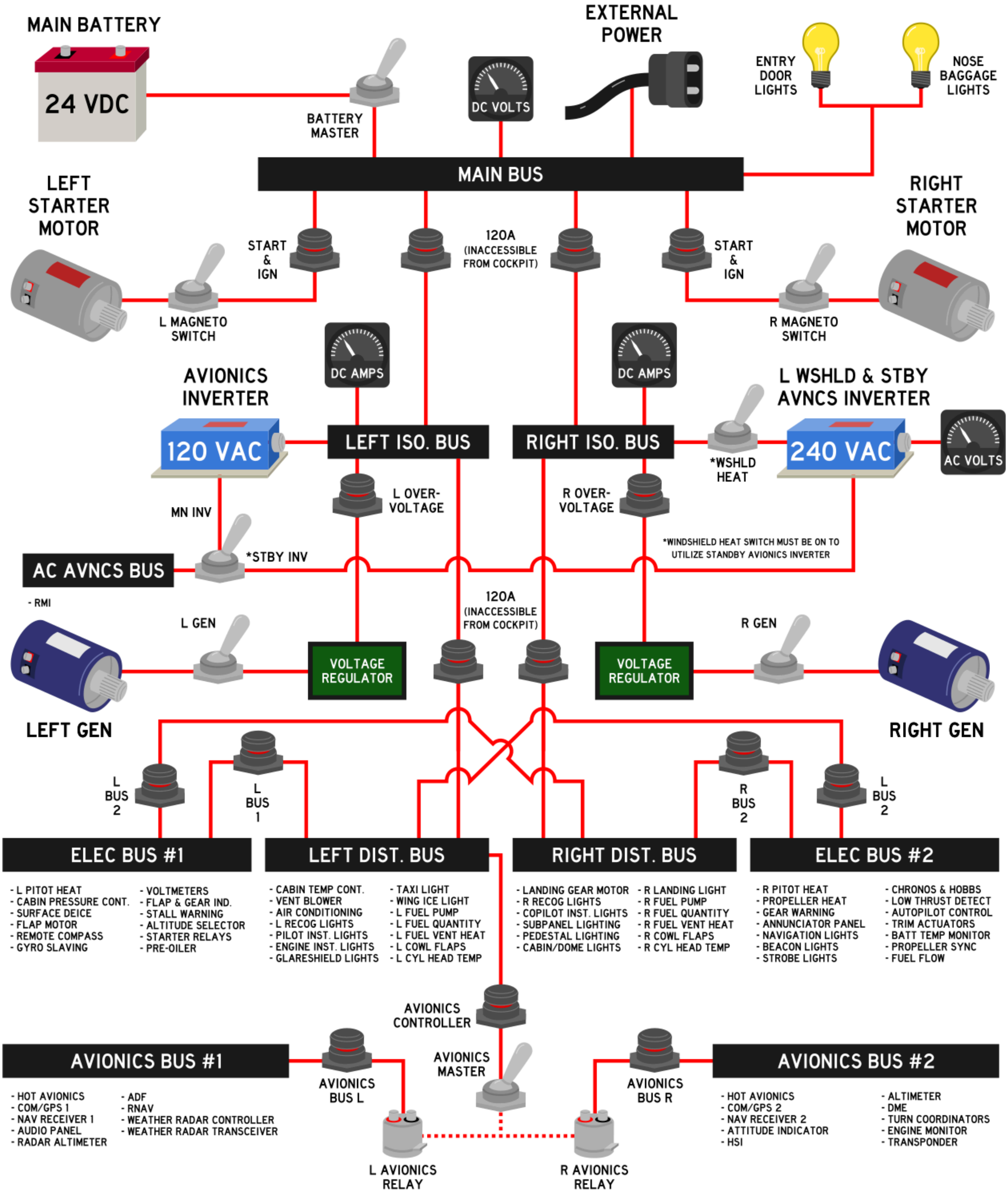
Unlike in the real world, navigation receivers in Microsoft Flight Simulator produce only ideal readings. Signal strength is not affected by distance, altitude, terrain, or atmospheric conditions. When a station is out of range, the signal is abruptly switched off. This is unrealistic, and does not give 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 Piston Duke's electrical system is significantly more complex than other light twin engine aircraft, more closely resembling that of many twin turboprop aircraft. Of particular note is the ability to isolate many loads in the event of a failure, and the automatic isolation of a generator bus in the event of an overvoltage detection. The Piston Duke also possesses two alternating current inverters, one for each isolation bus. The main inverter, labeled "MN INV" on the pilot's upper side panel, provides AC avionics power, while the standby inverter provides power for the heated windshield. The standby inverter can be used to power the AC avionics in an emergency by placing the avionics power inverter switch in the "STBY INV" position, and turning on the "WSHIELD HEAT" switch.

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.


MAIN BATTERY
24 VDC
BATTERY MASTER
DC VOLTS
EXTERNAL POWER
ENTRY DOOR LIGHTS
NOSE BAGGAGE LIGHTS
MAIN BUS
LEFT STARTER MOTOR
RIGHT STARTER MOTOR
START & IGN
120A (INACCESSIBLE FROM COCKPIT)
START & IGN
L MAGNETO SWITCH
R MAGNETO SWITCH
AVIONICS INVERTER
DC AMPS
DC AMPS
L WSHLD & STBY AVNCS INVERTER
120 VAC
LEFT ISO. BUS
RIGHT ISO. BUS
*WSHLD HEAT
240 VAC
AC VOLTS
MN INV
L OVER-VOLTAGE
R OVER-VOLTAGE
*WINDSHIELD HEAT SWITCH MUST BE ON TO UTILIZE STANDBY AVIONICS INVERTER
AC AVNCS BUS
*STBY INV
- RMI
120A (INACCESSIBLE FROM COCKPIT)
L GEN
R GEN
VOLTAGE REGULATOR
VOLTAGE REGULATOR
LEFT GEN
RIGHT GEN
L BUS 2
L BUS 1
R BUS 2
L BUS 2
ELEC BUS #1
LEFT DIST. BUS
RIGHT DIST. BUS
ELEC BUS #2
- L PITOT HEAT
- CABIN PRESSURE CONT.
- SURFACE DEICE
- FLAP MOTOR
- REMOTE COMPASS
- GYRO SLAVING
- VOLTMETERS
- FLAP & GEAR IND.
- STALL WARNING
- ALTITUDE SELECTOR
- STARTER RELAYS
- PRE-OILER
- CABIN TEMP CONT.
- VENT BLOWER
- AIR CONDITIONING
- L RECOG LIGHTS
- PILOT INST. LIGHTS
- ENGINE INST. LIGHTS
- GLARESHIELD LIGHTS
- TAXI LIGHT
- WING ICE LIGHT
- L FUEL PUMP
- L FUEL QUANTITY
- L FUEL VENT HEAT
- L COWL FLAPS
- L CYL HEAD TEMP
- LANDING GEAR MOTOR
- R RECOG LIGHTS
- COPILOT INST. LIGHTS
- SUBPANEL LIGHTING
- PEDESTAL LIGHTING
- CABIN/DOME LIGHTS
- R LANDING LIGHT
- R FUEL PUMP
- R FUEL QUANTITY
- R FUEL VENT HEAT
- R COWL FLAPS
- R CYL HEAD TEMP
- R PITOT HEAT
- PROPELLER HEAT
- GEAR WARNING
- ANNUNCIATOR PANEL
- NAVIGATION LIGHTS
- BEACON LIGHTS
- STROBE LIGHTS
- CHRONOS & HOBBS
- LOW THRUST DETECT
- AUTOPILOT CONTROL
- TRIM ACTUATORS
- BATT TEMP MONITOR
- PROPELLER SYNC
- FUEL FLOW
AVIONICS CONTROLLER
AVIONICS BUS #1
AVIONICS BUS L
AVIONICS MASTER
AVIONICS BUS R
AVIONICS BUS #2
- HOT AVIONICS
- COM/GPS 1
- NAV RECEIVER 1
- AUDIO PANEL
- RADAR ALTIMETER
- ADF
- RNAV
- WEATHER RADAR CONTROLLER
- WEATHER RADAR TRANSCEIVER
- HOT AVIONICS
- COM/GPS 2
- NAV RECEIVER 2
- ATTITUDE INDICATOR
- HSI
- ALTIMETER
- DME
- TURN COORDINATORS
- ENGINE MONITOR
- TRANSPONDER
L AVIONICS RELAY
R AVIONICS RELAY

Using the KNS-81 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 piece of early digital computer technology 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-81 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-81. On the right side of the unit, you will find the “DATA” push button, and the adjacent data entry knob. Along the bottom of the display, “FREQ”, “RAD”, and “DST”, annunciators remind you of the order in which data should be entered, frequency first, then radial, and finally distance. At any given time, one of these annunciators is bracketed 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

On the left of the display, a 7-segment display marked “WPT” indicates the current RNAV waypoint for which data is being shown and edited on the right of the display. The KNS-81 can hold up to ten different combinations of frequency, radial, and distance data at one time. This can be greatly useful while planning a flight on the ground. To cycle through waypoints, rotate the inner knob of the dual concentric rotary encoder on the left of the unit’s face. The active waypoint currently being used by the computer and subsequently displayed on the HSI and DME instruments can be selected by pressing the “USE” button while the desired waypoint is being displayed. Whenever the currently displayed waypoint is different from the currently active waypoint, the number of the currently displayed waypoint will flash continuously.

Distance Measuring Equipment

Most notably different than this unit’s predecessor unit, the KNS-80, is the lack of integrated DME information. The KNS-81 was designed to be used as a secondary, or tertiary navigation radio with an external DME display installed elsewhere on the panel. In this case, a KDI-572R fulfills this role. The KDI-572R is a traditional Distance Measuring Equipment (DME) display, with an extra rotary selector position to display RNAV information. See this manual’s section on the KDI-572 for complete information on operation. 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. The KNS-81 also possesses a “RAD” toggling push button, which will force the DME display to indicate the current radial upon which the aircraft sits, relative to the waypoint.

Modes of Operation

Lastly, on the left side of the display, the KNS-81's many modes are annunciated. The KNS-81's modes fall into two categories; VOR and RNAV, and are activated by rotating the outer dual concentric knob on the left of the unit's face. 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). The 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. In the two RNAV modes, CDI deflection is based on the displaced virtual VOR of the currently active waypoint. There are two RNAV modes, "RNV/ENR" (Enroute), which drives the CDI with linear deflections of +/- 5 nm full-scale, and "RNV/APR" (Approach), which drives the CDI with linear deflections of +/- 1.25 nm full-scale. Lastly, the KNS-81 has a momentary display mode, which can be activated by holding the "CHK" push button. This mode will display the aircraft's current position relative to the tuned physical VOR station. Pressing the "RTN" button will return the data displays to the active waypoint being used for navigation.

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.

RNV: Linear course deviation, 5 nm full-scale deflection, displaced VOR waypoints.
RNV/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-81 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 attitude indicator 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.

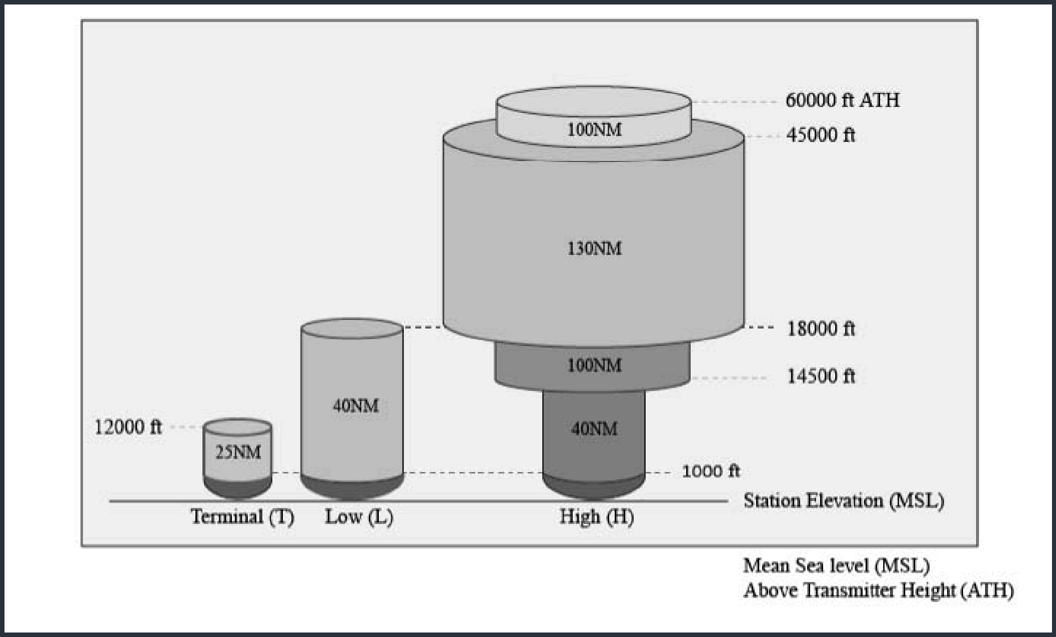
1. Locate the nearest VOR station to your desired destination, and its frequency, radial, and distance from the destination airport. While other station frequencies, radials, and distances can be found on approach, arrival, and departure charts, the easiest place to start is often with a mobile app or 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 Massachustts.

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-81 RNAV computer. Once the KNS-81 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”, and “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 RNV/ENR for enroute operation, unless we need increased precision for some reason. Rotate the outer dual concentric rotary encoder on the left of the unit’s face until only “RNV” is annunciated above the knob. 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 on the external DME instrument. 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 away from the actual VOR station, this system is usually precise enough to place your route of flight inside the airport perimeter fence at your destination.

8. To check your position relative to the actual VOR station you are receiving at any given time, press and hold the “CHK” button. The RAD and DST displays will now indicator your actual distance from the VOR station, and the radial upon which the aircraft sits. Release the “CHK” button to return to viewing RNAV information appropriate to the currently selected mode of operation.

Using the JPI EDM-760 Engine Monitor

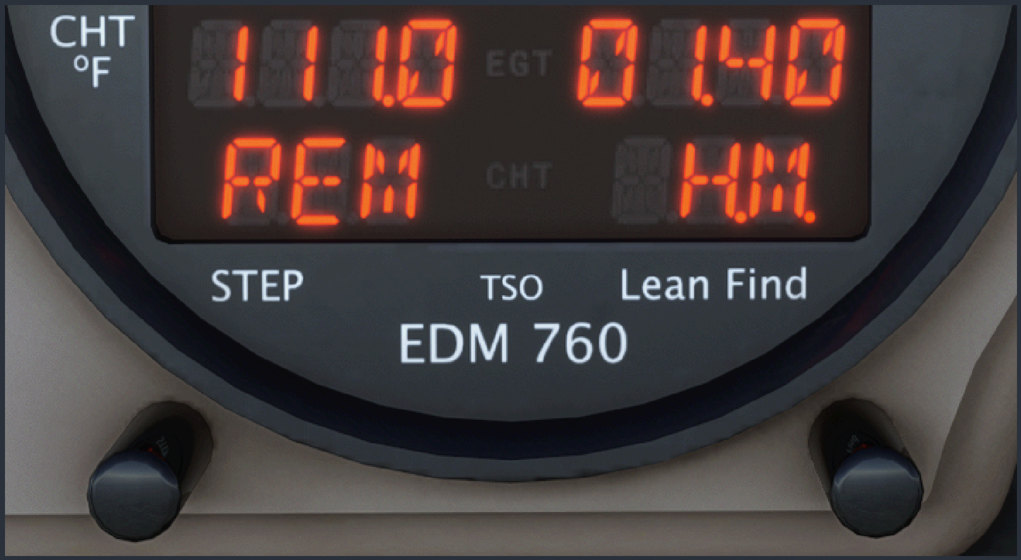
The Piston Duke is equipped with the most complete implementation of the EDM-760 engine monitor to appear in a flight simulator. The EDM-760 is one of the more common pieces of engine monitoring equipment found in general aviation aircraft, and is often underestimated in its power and utility due to its compact size. Aircraft owners would be wise to fully understand the information at their fingertips via the unit's trend monitoring to increase engine longevity and detect changes that may result in a catastrophic failure. In normal operation, the efficient and safe operation of a high performance engine is one of the most important skills that a pilot should learn when advancing from a simple training aircraft to a more complex long-distance cruising aircraft. For a complete understanding of the unit's functionality, please see the "More Information on Operation" section of this manual for training videos and operating manuals. The EDM-760 has two push buttons that provide all control of the unit; however, several functions require pressing both buttons at once. This is accomplished in MSFS via an invisible button at the bottom of the unit's bezel, between both buttons. The twin engine EDM-760 is very similar in appearance and operation to the single engine EDM-800, which is featured in Black Square's Analog Bonanza.

Static Displays

Upon startup, the EDM-760 will perform a self-test and illuminate every segment of the display. At the top of the unit will be “L” and “R” characters, statically displayed, above the left and right engine temperature columns. To the left of this static display will be either a “°C” or “°F” to indicate the temperature units that will be displayed. To toggle between units, press both of the unit’s control buttons at once. Below these static displays are two more static displays with numerals 1-6, for each cylinder of each engine, and a final letter “T”, if the aircraft is turbocharged. These are column headers for each cylinder’s temperature bar, which will be discussed below. Lastly, four 14-segment displays at the bottom of the unit will display many different types of information, units, alarm ID’s, and more.

Data Display

When the unit is powered on, the data display will be in manual mode for 10 minutes, at which time, it will enter automatic mode. In manual mode, the user can cycle through all available data by tapping the “STEP” button. To cycle through data in the opposite order to save oneself the trouble of cycling through all the data again, hold the “STEP” button for three seconds. To enter manual mode, tap “STEP” at any time. To enter automatic mode, tap “LEAN FIND” and then tap “STEP”. When data associated with a particular cylinder is being displayed, a dot below that cylinder’s header number will be displayed. When oil temperature or turbine inlet temperature (TIT) (in turbocharged aircraft only) is being displayed, a dot will be shown above the last column on the right. These conventions also apply in automatic mode, and when an alarm is being displayed. A switch above the copilot’s attitude indicator marked “EGT, ALL, FF”, allows the user to switch between groups of data to be displayed in automatic and manual modes. A summary of these groups, their data, and units follows.



Select Switch	Description	Example		Requirements
EGT, ALL	Main Bus Voltage & Outside Air Temp.	25.7 BAT	75 OAT	None
EGT, ALL	Difference between hottest and coldest CHT.	52 DIF	61 DIF	None
ALL, FF	Fuel Remaining & Time to Empty (endurance in hours.minutes)	78.4 REM	01.28 H.M.	None
ALL, FF	Fuel Required to next GPS waypoint & Fuel Remaining at next GPS waypoint	17.4 REQ	61.0 REM	Compatible GPS
ALL, FF	Nautical Miles per Gallon & Estimated Range	5.2 MPG	407.5 NM	Compatible GPS
ALL, FF	Fuel Flow Rate	24.2 GPH	24.5 GPH	None
ALL, FF	Fuel Used since unit startup each engine	21.8 USD	21.4 USD	None
ALL, FF	Total Fuel Used since unit startup	43.2 GAL	TOTL USD	None
ALL, FF	Approximate Horsepower	285 HP	287 HP	None
EGT, ALL	EGT & CHT (cycles through all cylinders)	1412 392	1437 398	None
EGT, ALL	Turbine Inlet Temp. & Fuel Flow	1465 24.2	1468 24.5	Turbocharger
EGT, ALL	Oil Temp.	161 OIL	168 OIL	None
EGT, ALL	Fastest Cooling Cylinder Head (°/min)	-25 CLD	-28 CLD	None

Temperature Columns

When the unit is in manual or automatic mode, the majority of the display will be occupied by the fourteen temperature columns. The six cylinder columns for each engine have two modes of operation, percent view, and normalized view. The unit defaults to percent view at startup, and normalized view can be activated by holding the “LEAN FIND” button for three seconds, which will illuminate “N” at the top right of the display, rather than a “P” for percent view.. In percent view, each column’s height represents that cylinder’s exhaust gas temperature (EGT) from one-half redline value, to redline value. The same scale applies to the turbine inlet temperature or oil temperature being displayed in the seventh column for each engine. Each of the twelve cylinder columns can also display cylinder head temperature (CHT), on a fixed Fahrenheit scale, inscribed on the bezel of the unit, from 300°F to 525°F. The CHT will be displayed by either a single lit segment in the column when EGT is below CHT, or a single unlit segment when EGT is greater than CHT. When this scale is ambiguous, such as when the CHT and EGT column heights match, the single segment will blink continuously. In the normalized view, each column's height is set to exactly half of the total available column height, and all changes in EGT are displayed relative to the temperature they possessed when you activated the normalized view. Percent view should be used for most normal operation, and normalized view should be used during power level changes in-flight, and when troubleshooting a problem. The seventh column will display the oil temperature on a percent scale only when a turbocharger is not installed, otherwise, TIT will be displayed with the column, and oil temperature will be displayed as the single segment.

Lean Find Mode

Tapping the "LEAN FIND" button will activate Lean Find mode, an intelligent engine leaning optimization feature that will help you optimally lean the engine's mixture for best power, or best economy. When Lean Find mode is activated, "LEAN ROP" will be shown in the data display by default to indicate that the selected leaning method is rich of peak (ROP). To select lean of peak (LOP) leaning, hold both control buttons for three seconds until "LEAN LOP" is shown. This is the only time the leaning method can be toggled.

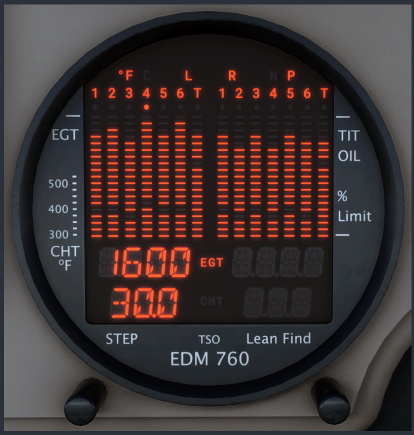
Both methods of leaning begin by "pre-leaning" the engine to approximately 50°F (28°C) EGT rich of peak on any cylinder. After waiting for temperatures to stabilize, begin leaning the engine. When a dot begins flashing above one of the cylinder columns to indicate the hottest cylinder, Lean Find mode is now armed, and an approximately 15°F (8°C) increase of average EGT has been observed.

NOTE: For your convenience while leaning, the friction lock knob located on the right of the throttle quadrant can be used to increase the fidelity of mixture control adjustments via the mouse wheel. Roll the friction lock clockwise (drag up) to make very fine adjustments to the mixture control. Use of this feature, or hall-effect based hardware controls, will be almost necessary for accurate leaning while at high density altitudes.

Leaning Rich of Peak

Leaning “Rich of Peak”, as the name suggests, means operating the engine at mixture settings richer than peak EGT, usually in search of the most power from the engine. This is also known as “leaning for best power”, and can increase power by as much as 15% from peak values.

After completing the pre-leaning procedure above, continue leaning the mixture until one entire column begins flashing, and “PEAK EGT” is shown on the data display. This means that the peak EGT for the first cylinder to peak has been detected. Afterwards, the data display will show degrees relative to peak. Negative numbers indicate a mixture setting richer than peak. This configuration can be further monitored by pressing the “LEAN FIND” button, which will show the EGT of the first cylinder to peak, and the fuel flow relative to peak. Positive fuel flows indicate operating rich of peak.



The final step is to enrich the engine’s mixture setting to the desired EGT for best power cruise. At cruise power settings, this point is approximately 50-100°F (28-56°C) below peak EGT for best power. Keep in mind that this lower EGT results from a higher mixture setting, as opposed to LOP operation. This can be accomplished in either display mode, either by adjusting the raw EGT value, or by the relative EGT offset from peak. For rich of peak operation, the relative EGT should be negative, and the relative fuel flow should be positive. To return to automatic mode, tap “STEP” once.

Leaning Lean of Peak

Leaning “Lean of Peak”, as the name suggests, means operating the engine at mixture settings leaner than peak EGT. This results in significantly lower fuel consumption, and extended range. This is also known as “leaning for best economy”, and can decrease fuel consumption by as much as 30% from peak values, for only a 5-10% loss in airspeed.

After completing the pre-leaning procedure above, continue leaning the mixture until one entire column begins flashing, and “LAST PK” is shown on the data display. This means that the peak EGT for the last cylinder to peak has been detected. The bar graph in LOP mode is shown in the form of a descending histogram to differentiate it from ROP mode. The left side of the data display now will show degrees relative to peak. Positive numbers indicate a mixture setting leaner than peak. This configuration can be further monitored by pressing the “LEAN FIND” button, which will show the EGT of the last cylinder to peak, and the fuel flow relative to peak. Negative fuel flows indicate operating lean of peak.

The final step is to lean the engine’s mixture setting to the desired EGT for best economy cruise. At cruise power settings, this point is approximately 25-50°F (14-28°C) below peak EGT for best power. Keep in mind that this lower EGT results from a lower mixture setting, as opposed to ROP operation. This can be accomplished in either display mode, either by adjusting the raw EGT value, or by the relative EGT offset from peak. For lean of peak operation, the relative EGT should be positive, and the relative fuel flow should be negative. To return to automatic mode, tap “STEP” once.

NOTE: While lean of peak operation is generally accepted as a good method to reduce fuel burn and increase engine longevity, most engine manufacturers only provide guidance for rich of peak operation. This means that the performance data in the aircraft’s operating handbook will most closely be reflected by rich of peak operation. It should also be noted that excessively lean mixtures can cause the engines to run rough, or become damaged. Lastly, it is more important to remember to enrichen the mixture during descent when operating lean of peak, as the mixture may become too lean for combustion otherwise.

Alarms

The EDM-760 is constantly monitoring all available engine and fuel flow parameters, and will activate an alarm to warn the operator of a potentially dangerous situation. When an alarm is activated, regardless of the current operational mode, the data display will show one of the alarm codes and associated values enumerated below, and blink continuously. To cancel the active alarm for ten minutes, tap the “STEP” button. To cancel the active alarm for the duration of the flight until the engine monitor is rebooted, hold the Lean Find button for three seconds. Since many simultaneous alarm conditions may exist at once, each alarm has a priority, allowing the most severe condition to be displayed first. The following list of alarm codes is listed in priority order, with the most severe condition listed first.

Description	Example	Low Limit	High Limit
High Cylinder Head Temp.	552 CHT		450 °F / 230 °C
High Exhaust Gas Temp.	1685 EGT		1650 °F / 900 °C
High Oil Temp.	240 OIL		230 °F / 110 °C
High Turbine Inlet Temp.	1781 TIT		1,650 °F / 900 °C
Low Oil Temp.	86 OIL	90 °F / 32 °C	
High Cylinder Head Cooling Rate	-84 CLD	-60 °F/min / -33 °C/min	
High Exhaust Gas Temp. Difference	587 DIF		500 °F / 280 °C
Battery Voltage (24V system)	23.4 BAT	24.0V	32.0V
Battery Voltage (12V system)	11.6 BAT	12.0V	16.0V
Low Fuel Quantity Remaining	FUEL 17.4 LOW GAL	20 gal	
Low Endurance Remaining	TIME 00.22 LOW H.M.	45 min	

Normal Checklists

Preflight (Cockpit)

Preflight Inspection	Complete
Control Locks	Remove]
Seats & Seatbelts	Secure
Cabin Door	Latched
Nose Baggage Door	Latched
Parking Brake	Set
Landing Gear	Down
Electrical Switches	Off
Engine & Avionics Switches	Off
Oxygen Pressure	1550-1850 psi
Circuit Breakers	All In
Intercooler Air	Off (Push)
Cabin Press Shutoff	Open (Push)
Alternate Static Air	Normal
CO Detector	Test
Environmental Mode	Off
Flaps	Up
Prop Sync	Off
Throttles	Closed
Propellers	High RPM
Mixture	Full Rich
Trims	Centered
Fuel Selectors	On

Before Starting Engine

Beacon Light	On
Battery Master	On
Bus Volts	23V Minimum
Fuel Quantities	Check
Cowl Flaps	Open Fully
Annunciators	Test & Consider
L Boost Pump	On
L Boost Pump	Audible
L Boost Pump	Off
R Boost Pump	On
R Boost Pump	Audible
R Boost Pump	Off

Engine Start (Cold)

Pre-Oiler	R for 30s
R Oil Pressure	Greater than 15 PSI
R Mixture	Full Rich
R Propeller	High RPM
R Throttle	Full Open
R Boost Pump	On for 5-8s
R Fuel Flow	Greater than 50 PPH
R Boost Pump	Off
R Throttle	Open 1/2in
R Starter	Engage
R Throttle	1000-1200 RPM
R Oil Pressure	Green in 30sec
R FUEL PRESS ANNUN	Extinguished
R Generator	On
R Generator Load	Below 0.25 in 2min
Bus Volts	28V
Engine Instruments	Check
Battery Temperature	Below 120F
Pre-Oiler	L for 30s
L Oil Pressure	Greater than 15 PSI
L Mixture	Full Rich
L Propeller	High RPM
L Throttle	Full Open
L Boost Pump	On for 5-8s
L Fuel Flow	Greater than 50 PPH
L Boost Pump	Off
L Throttle	Open 1/2in
L Starter	Engage
L Throttle	1000-1200 RPM
L Oil Pressure	Green in 30sec
L FUEL PRESS ANNUN	Extinguished
L Generator	On
L Generator Load	Below 0.25 in 2min
Bus Volts	28V
Engine Instruments	Check
Pre-Oiler	Off
Battery Temperature	Below 140F

Engine Start (Hot)

R Mixture	Cut-Off
R Propeller	High RPM
R Boost Pump	On for 10-20s
R Boost Pump	Off
R Mixture	Full Rich
R Throttle	Full Open
R Boost Pump	On for 2-3s
R Fuel Flow	Greater than 50 PPH
R Boost Pump	Off
R Throttle	Open 1/2in
R Starter	Engage
If No Start...	Repeat
R Throttle	1000-1200 RPM
R Oil Pressure	Green in 30sec
R FUEL PRESS ANNUN	Extinguished
R Generator	On
R Generator Load	Below 0.25 in 2min
Bus Volts	28V
Engine Instruments	Check
Battery Temperature	Below 120F
L Mixture	Cut-Off
L Propeller	High RPM

L Boost Pump	On for 10-20s
L Boost Pump	Off
L Mixture	Full Rich
L Throttle	Full Open
L Boost Pump	On for 2-3s
L Fuel Flow	Greater than 50 PPH
L Boost Pump	Off
L Throttle	Open 1/2in
L Starter	Engage
If No Start...	Repeat

L Throttle	1000-1200 RPM
L Oil Pressure	Green in 30sec
L FUEL PRESS ANNUN	Extinguished
L Generator	On
L Generator Load	Below 0.25 in 2min
Bus Volts	28V
Engine Instruments	Check

Battery Temperature	Below 140F

Engine Start (Flooded)

R Mixture	Lean
R Propeller	High RPM
R Throttle	Open 1/2in
R Starter	Engage
R Throttle	Advance Until Start
R Throttle	Idle
R Mixture	Full Rich

R Oil Pressure	Green in 30sec
R FUEL PRESS ANNUN	Extinguished
R Generator	On
R Generator Load	Below 0.25 in 2min
Bus Volts	28V
Engine Instruments	Check

Battery Temperature	Below 120F

L Mixture	Lean
L Propeller	High RPM
L Throttle	Open 1/2in
L Starter	Engage
L Throttle	Advance Until Start
L Throttle	Idle
L Mixture	Full Rich

L Oil Pressure	Green in 30sec
L FUEL PRESS ANNUN	Extinguished
L Generator	On
L Generator Load	Below 0.25 in 2min
Bus Volts	28V
Engine Instruments	Check

Battery Temperature	Below 140F

After Starting

Boost Pumps	On if above 90F (32C)
Lights	As Required
Weather Radar	Off/Standby
Avionics	On
Inverter	Main
INVERTER Annun	Extinguished
Cabin Temp & Mode	As Desired
Mixture	Lean for Taxi
Parking Brake	Release
Brakes	Check

Starter Does Not Disengage

Alternators	Off
Battery Master	Off
Mixture	Cut-Off
Magnetos	Off

Runup

Parking Brake	Set
Annunciators	Test & Consider
Remote Compass	Slaved & Aligned
Fuel Selectors	Crossfeed
Boost Pumps	On

Mixture	Full Rich
Throttle	2000 RPM
Exercise Left Propeller	To 300 RPM Drop
Exercise Right Propeller	To 300 RPM Drop
Check Left Magnetos	150 RPM Drop Max
Check Right Magnetos	150 RPM Drop Max
Instrument Air	Green & No Lights
Left Generator	Off
Left Generator Load	Zero
Right Generator	Off
Right Generator Load	Zero
Left Generator	On
Left Generator Load	Above 0.25
Right Generator	On
Right Generator Load	Above 0.10

Throttle	2500 RPM
Cockpit Window	Closed
Cabin Altitude	Field Elevation
Cabin Differential	Zero
Cabin Climb Rate	10 O'Clock
Cabin Altitude Goal	1000ft below field elev.
Cabin Press Mode	Test
Cabin Alt, Diff & Climb	Observe Descent
Cabin Altitude Goal	Set First Assigned Alt
Cabin Press Mode	NORmal

Throttle	1500 RPM
Propeller Heat	On
Prop Heat Gnd Test	Hold
Propeller Amps	14-28A & Cycles
Propeller Heat	Off
Windshield Heat	On
Windshield Volts	220-260V
Ammeters	Increase
Windshield Heat	Off
Left Pitot Heat	On

Ammeters	Increase
Right Pitot Heat	On
Ammeters	Increase
L Fuel Vent Heat	On
Ammeters	Increase
R Fuel Vent Heat	On
Ammeters	Increase
Heating Switches	Off
Surface Deice	Manual
Boot Pressure	15-20 psi
Surface Deice	Single Cycle
Boot Pressure	15-20 psi
Surface Deice	Off

Throttle	1000-1200 RPM
Fuel Selectors	On
Pitch Trim Power	On
Electric Trim	Exercise
Autopilot	Test
Heading Bug	30 Degrees Left
Autopilot Master	Engage
Heading Mode	Engage
Yoke Movement	Observe
Flight Director	Bank Left
Heading Bug	30 Degrees Right
Yoke Movement	Observe
Flight Director	Bank Right
Autopilot Disconnect	Press AP Off
Autopilot Disconnect	Press FD Off
Elevator Trim	Set Takeoff

Flaps	Check Operation
Flaps	Set Takeoff
Window	Closed
CABIN DOOR Annun	Extinguished
Flight Controls	Free & Correct
Altimeter	Set
Departure Altitude	Set
Takeoff Heading	Set
Panel Lights	Dim for Takeoff
Parking Brake	Release

Before Takeoff

Mixture	Max Power
Oil Temperatures	35C Minimum
Battery Temperature	Below 120F
BATTERY CHARGE Annun	Extinguished
Air Conditioning	Off
Lighting	As Desired
Transponder	Alt Mode
Weather Radar	On

Takeoff

Throttles	Full Open
Brakes	Release
Engine Instruments	Check
Landing Gear Up	Positive Rate
Flaps	Retract at 110kts
Autopilot	Engage
Cabin Alt, Diff & Climb	Observe Climb
Landing Lights	Off

Max Continuous Power

Mixture	Max Power
Propellers	2750 RPM
Manifold Pressure	41.5 inHg
Cowl Flaps	Open
Prop Sync	On
Cabin Temp & Mode	As Desired

Enroute Climb

Mixture	Max Power
Propellers	2750 RPM
Manifold Pressure	35.5 inHg
Cowl Flaps	Open
Boost Pumps	Off
Prop Sync	On
Cabin Pressure	Monitor
Cabin Temp & Mode	As Desired
Engine Performance	Monitor

Transition Altitude

Altimeters	Standard
Cabin Pressure	Monitor
Recog Lights	Off

Cruise

Cowl Flaps	As Required
Boost Pumps	Off
Pitot Heat	On if OAT less than 4C
Windshield Heat	As Required
Propeller Heat	As Required
Surface Deice	As Required
Fuel Imbalance	25 gal Max.
Lean Mixture	LOP or ROP
Propellers	2500 RPM
Manifold Pressure	32.0 inHg
Cabin Temp & Mode	As Desired
Cabin Pressure	Monitor
Engine Performance	Monitor

Descent

Cabin Altitude Goal	Set Destination Alt
Cowl Flaps	Close
Throttle	Reduce
Mixture	Enrichen
Engine Performance	Monitor
Cylinder Head Temp	125C Min.
Ice Protection	As Required

Approach

Seats & Seatbelts	Secure
Cabin Alt, Diff & Climb	Check Progress
Fuel Selectors	On
Fuel Imbalance	25 gal Max.
Recog Lights	On
Pitot Heat	On if OAT less than 4C
Windshield Heat	Off
Propeller Heat	Off
Cabin Temp & Mode	Off
Cowl Flaps	As Required
Mixture	Max Power
Flaps	Approach

Landing

Cabin Differential	Zero
Boost Pumps	On
Prop Sync	Off
Propellers	High RPM
Mixture	Max Power
Flaps	As Required
Landing Gear	Down & Locked
Landing Lights	On
Autopilot Disconnect	Press Once

Balked Landing

Mixture	Max Power
Propellers	2750 RPM
Manifold Pressure	41.5 inHg
Engine Instruments	Check
Landing Gear Up	Positive Rate
Flaps	Retract at 110kts
Cowl Flaps	Open

After Landing

Boost Pumps	Off if below 90F (32C)
Cowl Flaps	Open
Flaps	Up
Cabin Alt, Diff & Climb	Verify Zero
Cabin Press Mode	Dump
Weather Radar	Off/Standby
Lights	As Desired
Ice Protection	All Off
Cabin Temp & Mode	As Desired

Shutdown & Securing

Parking Brake	Set
Avionics Switches	Off
Boost Pumps	Off
Electrical Switches	Off
Throttles	Closed
Propellers	High RPM
Mixture	Cut-Off
Magnetos	Off
Generators	Off
Battery Master	Off
Parking Brake	Release
Control Locks	Install

Instrument Markings & Colors

Manifold Pressure:
10.0-41.5 inHg (GREEN)
39.5 inHg (RED)

Propeller RPM:
2350-2900 RPM (GREEN)
2900 RPM (RED)

Fuel Flow:
60-330 PPH (GREEN)
93-110 PPH (55%)
110-131 PPH (65%)
131-142 PPH (75%)
245-312 PPH (Take-Off)

Cylinder Head Temperature:
125-238 °C (GREEN)
238 °C (RED)

Oil Temperature:
35 °C (RED)
35-116 °C (GREEN)
116 °C (RED)

Oil Pressure:
10 psi (RED)
60-90 psi (GREEN)
100 psi (RED)

Turbine Inlet Temperature:
1650°F (RED)

Main Fuel Quantity:
606 lbs / 101 gal (MAXIMUM) (Stock)
696 lbs / 116 gal (MAXIMUM) (Grand)
0-150 lbs / 0-25 gal (YELLOW)

Vacuum Suction:
2.5-3.5 inHg (YELLOW)
3.5-5.5 inHg (GREEN)
5.5-6.5 inHg (YELLOW)

Abnormal & Emergency Checklists

Engine Fire (Ground)

Fuel Selectors	Off
Mixture	Cut-Off
Generators	Off
Battery Master	Off
Magnetos	Off

Engine Fire (Flight)

Inop Eng Fuel Selector	Off
Inop Eng Mixture	Cut-Off
Inop Eng Generator	Off
Inop Eng Magneto	Off
Inop Eng Engine	Do Not Restart
Inop Eng Cabin Press Shutoff	Pull

Engine Failure (Ground Roll)

Throttles	Closed
Braking	Maximum
Fuel Selectors	Off
Generators	Off
Battery Master	Off

Engine Failure (Takeoff)

Landing Gear Up	Up
Flaps	Retract above 95kts
Inoperative Engine	Identify
Inop Eng Throttle	Closed
Inop Eng Propeller	Feather
Airspeed	Maintain 112 kts
Inop Eng Mixture	Cut-Off
Inop Eng Fuel Selector	Off
Inop Eng Boost Pump	Off
Inop Eng Magnetos	Off
Inop Eng Generator	Off
Cowl Flaps	Closed
Generator Load	0.75 Max.
Inop Eng Cabin Press Shutoff	Pull

Engine Failure (In Flight)

Airspeed	112 kts
Inoperative Engine	Identify
Inop Eng Throttle	Closed
Inop Eng Propeller	Feather
Fuel Selector	Inop Eng Crossfeed
Inop Eng Magnetos	Check Both
Inop Eng Boost Pump	On
Inop Eng Mixture	Rich then Lean
Inop Eng Starter	Engage

Inop Eng Engine	If No Restart...
Inop Eng Boost Pump	Off
Inop Eng Mixture	Full Rich
Inop Eng Magnetos	Check Both
Inop Eng Starter	Engage

Inop Eng Engine	If No Restart...
Nearest Airport	Select
Inop Eng Fuel Selector	Off
Inop Eng Boost Pump	Off
Inop Eng Magnetos	Off
Inop Eng Generator	Off
Cowl Flaps	Open
Generator Load	0.75 Max

Rough Running Engine

Boost Pump	On
Mixture	Rich then Lean
Magnetos	Check Both

Left Eng Inop Crossfeed

L Boost Pump	On
L Fuel Selector	Off
R Fuel Selector	Crossfeed
L Boost Pump	Off

Right Eng Inop Crossfeed

R Boost Pump	On
R Fuel Selector	Off
L Fuel Selector	Crossfeed
R Boost Pump	Off

Emergency Descent

Throttles	Close
Propellers	High RPM
Landing Gear	Down
Flaps	Approach
Airspeed	175 kts

Maximum Glide

Landing Gear	Up
Flaps	Up
Cowl Flaps	Close
Propellers	Feathered
Airspeed	110 kts
Cabin Temp & Mode	Off
Nonessential Equipment	Off

Engine & Avionics Switches	Off
Fuel Selectors	Off

Electrical Smoke or Fire

Generators	Off
Battery Master	Off
Window	Open if Unpressurized
Avionics Switches	Off
Cabin Temp & Mode	Off
Electrical Equipment	Off
Cabin Air & Heat	Off
Observe	If No Fire...
Battery Master	On
Restore Essential Power	Circuit by Circuit
Avionics Switches	On
Restore Avionics Power	Circuit by Circuit

High Pressure Differential

Cabin Altitude Goal	Set Higher Altitude
Cabin Climb	If No Descent...
Cabin Press Shutoff	Pull
Cabin Press Mode	Dump
Differential Press	Green
Cabin Press Mode	NORmal
Cabin Press Shutoff	Push

Cabin Depressurization

CABIN ALT Annun	If Illuminated...
Emergency Descent	Begin
Cabin Press Mode	Test
Cabin Climb	If no Descent Observed...
Pressurization Circuit Breakers	Check/Reset
Cabin Press Mode	Test
Cabin Climb	If no Descent Observed...
Cabin Press Shutoff	Pull

Turbocharger Failure

Observe	If No Fire...
Throttles	Advance
Manifold Pressure	If Still Low...
Restart Engine	If Necessary...
Mixture	Lean Max Power
Cabin Press Shutoff	Pull
Land	At Nearest Airport

Carbon Monoxide Detected

Cabin Temp & Mode	Off
Cabin Air & Heat	Off
CO Detector	Reset
CO Alarm	If Persists...
Cabin Press Shutoff	Pull
CO Alarm	If Persists...
Throttle	Closed
Mixture	Cut-Off
Propellers	Feathered
Magnetos	Off
Window	Open if Unpressurized
Cabin Air	On
Nonessential Equipment	Off

Generator Failure

Generator Load	Verify No Load
Inop Eng Generator	Reset
Inop Eng Generator Load	If No Load...
Inop Eng Generator	Off
Generator Load	0.75 Max.
Generator Load	If Dual Failure...
Nonessential Equipment	Off
Land	As Soon as Practical

Dual Instrument Air Failure

Instrument Air	Check Sources
DC Instruments	Check & Reference
Land	As Soon as Practical

Static Air Obstructed

Alternate Static Air	Alternate
Airspeed & Altimeter	Apply Corrections

Severe Icing Encounter

Ice Protection	All On
Wing Light	On
Ice Build-Up	Monitor
Propellers	High RPM
Cowl Flaps	Close
Cabin Temp & Mode	Manual Heat
Cabin Air & Heat	On Maximum

Remote Compass Misalignment

Gyro Slave Circuit Breaker	Pull & Reset
Remote Compass Alignment	If Misaligned...
Remote Compass	Free Mode
Compass Position	Push to Align

Autopilot Failure or Trim Runaway

Autopilot	Disconnect
Pitch Trim Power	Off
Autopilot Circuit Breakers	Pull Off

AC Door Fully Extended in Flight

Cabin Temp & Mode	No AC
Increased Drag	Anticipate

Nose Baggage Door Unlatched

Airspeed	Reduce
Cabin Temp & Mode	No Heat
Increased Drag	Anticipate
Land	As Soon as Practical

CABIN DOOR Annun Illuminated

Emergency Descent	Begin
Cabin Pressure	Monitor
When Below	10,000ft…
Airspeed	Reduce
Cabin Press Shutoff	Pull
Increased Drag	Anticipate
Land	As Soon as Practical

Landing Gear Manual Extension

Airspeed	174 kts or Less
Landing Gear Relay	Pull Off
Landing Gear	Handle Down
Emergency Gear Handle	Engage
Crank Handle	50 Turns
Gear Warning	Push On
Gear Indicators	Three Green

Landing Gear Up after Man Ext

Landing Gear Relay	Push On
Landing Gear	Handle Up

Simulated Engine Out

Propeller	Feather
Manifold Pressure	12.0 inHg

Flap Failure

Flap Breakers	Check On
Bus Volts	23V Minimum
Flaps	As Required
Flap Indicators	Check
Flaps	Visually Check

No Power Landing

Fuel Selectors	Off
Mixture	Cut-Off
Magnetos	Off
Flaps	As Required
Landing Gear	Down & Locked
Generators	Off
Battery Master	Off

Cabin Door Will Not Open

Cabin Door Handle	Pull Firmly
Cabin Alt, Diff & Climb	Verify Zero
Cabin Press Mode	Dump
Cabin Door Handle	If still stuck…
Door Pressure Bypass	Pull
Cabin Door Handle	Pull Firmly

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-81 Navigation System, and the RDR 1150XL, additional resources are available online for the real world counterparts of these units. In particular the **"KNS-81 Pilot's Guide"**, available on Bendix/King's website, and the **"Weather Radar Pilot Training DVD"** on Bendix/King's YouTube channel. There are also comprehensive video tutorials for the EDM-700/800 on Youtube. You will find one complete overview of the instrument under the title of **"JPI EDM 760 Overview, display features, and leanfind mode"**. 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
Throttle Control Locks	L:bksq_throttleLocks	Boolean
Yoke Control Locks	L:bksq_controlLocks	Boolean
Pitot Covers	L:bksq_PitotCovers	Boolean
Engine Covers	L:bksq_EngineCovers	Boolean
Tablet Visibility	L:bksq_TabletVisible	Boolean
Tablet Horizontal Position	L:var_efb_rot_x	-1 - 1
Tablet Vertical Position	L:var_efb_rot_y	-1 - 1
Main Cabin Door	L:bksq_CabinDoor	Boolean
Baggage Compartment Door	L:bksq_NoseDoor	Boolean
Pilot’s Window	L:bksq_stormWindow	Boolean
Cabin Door Pressure Bypass	L:var_doorPressureBypass	Boolean
Cabin Table	L:bksq_CabinTable	Boolean
Pilot’s Sun Visor Position	L:var_Visor_L	0 - 100
Copilot’s Sun Visor Position	L:var_Visor_R	0 - 100

Primary Control Variables

Description	Variable	Range
Left Mixture Lever	K:MIXTURE1_SET - OR - L:BKSQ_MixtureLeverPosition_1	0 - 100
Right Mixture Lever	K:MIXTURE2_SET - OR - L:BKSQ_MixtureLeverPosition_2	0 - 100
Friction Lock (mixture adjust speed)	L:var_FrictionLock	0 - 100
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
Prop Heat Ground Test	L:var_PropHeatGroundTest	Boolean
Windshield Heat	L:var_windshieldHeatSwitch	Boolean
Left Propeller Heat	L:var_PropHeatSwitch_L	Boolean
Right Propeller Heat	L:var_PropHeatSwitch_R	Boolean
Left Fuel Vent Heat	L:var_FuelVentHeatSwitch_L	Boolean
Right Fuel Vent Heat	L:var_FuelVentHeatSwitch_R	Boolean
Surface Deice	L:var_SurfaceDeiceSwitch	0 = AUTO, 2 = MAN
Pitch Trim Power	L:var_PitchTrimPower	Boolean
Annunciator Light Test	L:var_AnnunciatorTestButton	Boolean
Avionics Inverter Select	L:var_InverterSwitch	0 = MAIN, 2 = STBY
Left Ignition Switch	K:MAGNETO1_INCR/DECR - OR - L:BKSQ_IgnitionPosition_1	0 - 5
Right Ignition Switch	K:MAGNETO2_INCR/DECR - OR - L:BKSQ_IgnitionPosition_2	0 - 5
Left Cowl Flaps	L:var_cowlFlapSwitch_L	0 = OPEN, 2 = CLOSE
Right Cowl Flaps	L:var_cowlFlapSwitch_R	0 = OPEN, 2 = CLOSE
Pre-Oiler	L:var_PreoilerSwitch	0 = LEFT, 2 = RIGHT
Annunciator Brightness Dimming	L:var_AnnunciatorDim	Boolean
Carbon Monoxide Detector Test	L:var_CoTest	Boolean

Lighting Control Events & Variables

Description	Variable	Range
Pilot's Yoke Map Light Button	L:OatMapCompassLightButton_1	Boolean
Copilot's Yoke Map Light Button	L:OatMapCompassLightButton_2	Boolean
Nav & Strobe Lights	L:var_NavStrobeLights	0 = NAV, 2 = BOTH
Beacon & Recognition Lights	L:var_BeaconRecogLights	0 = BCN, 2 = BOTH
Wing/Ice Light	B:LIGHTING_WING_1_Toggle (K:TOGGLE_WING_LIGHTS)	
Taxi Light	B:LIGHTING_TAXI_1_Toggle (K:TOGGLE_TAXI_LIGHTS)	
Left Landing Light	B:LIGHTING_LANDING_1_Toggle (1 K:LANDING_LIGHTS_SET)	
Right Landing Light	B:LIGHTING_LANDING_2_Toggle (2 K:LANDING_LIGHTS_SET)	
Master Panel Lighting Switch	L:bksq_MasterPanelLights	Boolean
Left Panel Lights Dimmer	L:var_PanelLights_Left	0 - 100
Right Panel Lights Dimmer	L:var_PanelLights_Right	0 - 100
Engine Panel Lights Dimmer	L:var_PanelLights_Engine	0 - 100
Avionics Lighting Dimmer	L:var_PanelLights_Avionics	0 - 100
Red Flood Light Dimmer	L:var_PanelLights_RedFlood	0 - 100
White Flood Light Dimmer	L:var_PanelLights_WhiteFlood	0 - 100
Subpanel Lighting Dimmer	L:var_PanelLights_Subpanels	0 - 100
Pedestal Lighting Dimmer	L:var_PanelLights_Pedestal	0 - 100
Cockpit Dome Light	L:var_LIGHTING_Push_Cockpit_1	Boolean
Passenger Cabin Reading Light	L:var_LIGHTING_Push_Cockpit_2	Boolean
Passenger Cabin Reading Light	L:var_LIGHTING_Push_Cockpit_3	Boolean
Passenger Cabin Reading Light	L:var_LIGHTING_Push_Cockpit_4	Boolean
Passenger Cabin Reading Light	L:var_LIGHTING_Push_Cockpit_5	Boolean

Environmental Control Variables

Description	Variable	Range
Oxygen Flow Valve	L:var_oxygenOn	Boolean
Pilot Air Valve	L:XMLVAR_Cabin_Air_1_Position	0 - 100
Copilot Air Valve	L:XMLVAR_Cabin_Air_2_Position	0 - 100
Cabin Air Valve	L:XMLVAR_Cabin_Air_3_Position	0 - 100
Left Intercooler Bypass Valve	L:XMLVAR_Cabin_Heat_1_Position	0 - 100
Right Intercooler Bypass Valve	L:XMLVAR_Cabin_Heat_2_Position	0 - 100
Left Pressurization Air Shutoff Valve	L:XMLVAR_Cabin_Heat_3_Position	0 - 100
Right Pressurization Air Shutoff Valve	L:XMLVAR_Cabin_Heat_4_Position	0 - 100
Defroster Valve	L:XMLVAR_Cabin_Heat_5_Position	0 - 100
Environmental Mode Knob	L:var_EnvironmentalModeKnob	0 - 7
Vent Blower Speed Switch	L:var_ventBlowerHigh	Boolean
Cabin Temperature Select Knob	L:var_CabinTemperatureKnob	50 - 100
Pressurization Goal Knob	L:var_pressurizationGoal	-1000 - 15000
Pressurization Rate Knob	L:var_pressurizationClimbRate	150 - 2000
Pressurization Mode Switch	L:bksq_PressurizationMode	0 = TEST, 2 = DUMP

Instrument Variables

Description	Variable	Range
Autopilot Pitch Knob	L:var_AP_PitchKnob	-15 - 15
Altitude Alerter Button	L:var_altitudeAlertLatching	1 = ON, 2 = RESET
Altitude Selector Knob Push/Pull	L:var_AltitudeSelectorKnobPushed	Boolean
RNAV Drives HSI	L:var_rnavDrivesHsi	Boolean
Gyro Slaving Mode	L:var_GyroSlaveModeSwitch	Boolean
Dme Mode	L:var_dmeMode	0 - 4
Left True Airspeed Calculator	L:var_TrueAirspeedKnob_L	4.30 - 69.85

Right True Airspeed Calculator	L:var_TrueAirspeedKnob_R	4.30 - 69.85
RMI Solid Needle Mode	L:var_rmiSolidNeedleAdfMode_L	Boolean
RMI Hollow Needle Mode	L:var_rmiHollowNeedleAdfMode_L	Boolean
Copilot Gyro Compass Heading	L:var_copilotHeading	0 - 360
Pilot Transmitting Radio Selector	L:var_PilotTransmitSelector	0 - 1
Cabin Temperature Display Unit	L:var_CabinTempUnitMode	Boolean
Instrument Air Gauge Source	L:bksq_GyroPressureSource	0 = RIGHT, 1 = LEFT

Primary Control Events Events

Description	Event
Battery Master	B:ELECTRICAL_Battery_1_Toggle
Avionics Master	B:ELECTRICAL_Avionics_Bus_1_Toggle
Left Generator	B:ELECTRICAL_Alternator_1_Toggle
Right Generator	B:ELECTRICAL_Alternator_2_Toggle
Left Fuel Pump	B:FUEL_Pump_1_Toggle
Right Fuel Pump	B:FUEL_Pump_2_Toggle
Left Pitot Heat	K:2:PITOT_HEAT_SET
Right Pitot Heat	K:2:PITOT_HEAT_SET
Alternate Static Air	K:TOGGLE_ALTERNATE_STATIC

Instrument Events

Description	Variable
Autopilot Master	K:AP_MASTER
Flight Director	K:TOGGLE_FLIGHT_DIRECTOR
Transponder Ident	K:XPNDR_IDENT_ON
Propeller Sync	K:TOGGLE_PROPELLER_SYNC
Autopilot Heading Mode	K:AP_PANEL_HEADING_HOLD

Autopilot NAV Mode	K:AP_NAV1_HOLD
Autopilot Approach Mode	K:AP_APR_HOLD
Autopilot Backcourse Mode	K:AP_BC_HOLD
Autopilot Altitude Hold Mode	K:AP_ALT_HOLD
Autopilot Pitch Hold Mode	K:AP_PITCH_LEVELER_ON
Autopilot Go-Around Mode	K:AUTO_THROTTLE_TO_GA
Altitude Selector Increase	K:AP_ALT_VAR_INC
Altitude Selector Decrease	K:AP_ALT_VAR_DEC
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
Emergency Gear Extension	K:GEAR_PUMP

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

KNS81

Description	Variable or Event
Data Knob Outer Increase	H:KNS81_bigInc
Data Knob Outer Decrease	H:KNS81_bigDec
Data Knob Inner Increase	H:KNS81_smallInc
Data Knob Inner Decrease	H:KNS81_smallDec
Mode Knob Increase	H:KNS81_modeInc
Mode Knob Decrease	H:KNS81_modeDec
Waypoint Knob Increase	H:KNS81_wptInc
Waypoint Knob Decrease	H:KNS81_wptDec
Use Button	H:KNS81_useButton
Return Button	H:KNS81_returnButton
Data Button	H:KNS81_dataButton
Data Entry Knob Push/Pull	L:var_rnavKnobPulled
Volume Knob	L:var_RNAV_VOLUME
Radial Button	L:var_RNAV_DMERADIALMODE

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	

EDM 760 Engine Monitor

Description	Variable or Event	Range
Mode Switch	L:var_JpiMode	0 = TEMP, 2 = FF
Left Button Short	H:bksq_JpiButton_1_L_Short	
Left Button Long	H:bksq_JpiButton_1_L_Long	
Right Button Short	H:bksq_JpiButton_1_R_Short	
Right Button Long	H:bksq_JpiButton_1_R_Long	
Short Press Both Buttons (Temp Unit)	L:var_JpiTempUnit	0 = °F, 1 = °C
Long Press Both Buttons	H:bksq_JpiButton_1_B_Long	

Outputs

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

Aircraft & Engine Variables

Description	**Variable**	**Units**
Left Manifold Pressure	L:BKSQ_DUKE_MANIFOLD_PRESSURE_1	inHg
Right Manifold Pressure	L:BKSQ_DUKE_MANIFOLD_PRESSURE_2	inHg
Left Propeller RPM	L:BKSQ_DUKE_PROP_RPM_1	RPM
Right Propeller RPM	L:BKSQ_DUKE_PROP_RPM_2	RPM
Left Fuel Flow	L:BKSQ_DUKE_FuelFlow_1	GPH
Right Fuel Flow	L:BKSQ_DUKE_FuelFlow_2	GPH
Left Oil Pressure	L:BKSQ_DUKE_OilPressure_1	PSI
Right Oil Pressure	L:BKSQ_DUKE_OilPressure_2	PSI
Left Oil Temperature	A:ENG OIL TEMPERATURE:1	CELSIUS
Right Oil Temperature	A:ENG OIL TEMPERATURE:2	CELSIUS
Left Cylinder Head Temperature	A:RECIP ENG CYLINDER HEAD TEMPERATURE:1	CELSIUS
Right Cylinder Head Temperature	A:RECIP ENG CYLINDER HEAD TEMPERATURE:2	CELSIUS
Left Turbine Inlet Temperature	L:BKSQ_DUKE_TIT_TEMPERATURE_1	FAHRENHEIT
Right Turbine Inlet Temperature	L:BKSQ_DUKE_TIT_TEMPERATURE_2	FAHRENHEIT
Left Fuel Quantity	A:FUEL TANK LEFT MAIN QUANTITY	GALLONS
Right Fuel Quantity	A:FUEL TANK RIGHT MAIN QUANTITY	GALLONS
Left Vertical Speed Needle	L:BKSQ_DUKE_VerticalSpeed_1	FPM
Right Vertical Speed Needle	L:BKSQ_DUKE_VerticalSpeed_2	FPM
Turn Coordinator Ball	L:BKSQ_TurnCoordinatorBall	0 - 100
Battery Temperature	L:var_batteryTemperature	FAHRENHEIT

Oxygen Pressure	L:var_oxygenPressure	PSI
Propeller Synchroscope	L:var_propSyncIndicatorPosition	0 - 100
Cabin Climb Rate	L:var_cabinClimbRate	FPM
Cabin Pressurization Altitude	L:var_cabinPressurizationAltitude	FEET
Cabin Differential Pressure	L:var_cabinPressureDifferential	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_DUKE_HSI_LOC	-127 - 127
HSI CDI Flag	L:BKSQ_DUKE_HSI_LOC_FLAG	Boolean
HSI TO Flag	L:BKSQ_DUKE_CDI_1_TO_FLAG	0 - 100
HSI FROM Flag	L:BKSQ_DUKE_CDI_1_FROM_FLAG	0 - 100
HSI Glideslope Needle	L:BKSQ_DUKE_HSI_GLIDE	0 - 100
HSI Glideslope Flag	L:BKSQ_DUKE_HSI_GS_FLAG	0 - 100
Localizer 2 CDI Needle	L:BKSQ_DUKE_LOC_2	-127 - 127
Localizer 2 CDI Flag	L:BKSQ_DUKE_LOC_2_FLAG	Boolean
Localizer 2 TO Flag	L:BKSQ_DUKE_LOC_2_TO_FLAG	0 - 100
Localizer 2 FROM Flag	L:BKSQ_DUKE_LOC_2_FROM_FLAG	0 - 100
Localizer 2 Glideslope Needle	L:BKSQ_DUKE_GLIDE_2	0 - 100
Localizer 2 Glideslope Flag	L:BKSQ_DUKE_LOC_2_GS_FLAG	Boolean
Localizer 3 CDI Needle	L:BKSQ_DUKE_LOC_3	-127 - 127
Localizer 3 CDI Flag	L:BKSQ_DUKE_LOC_3_FLAG	Boolean
Localizer 3 TO Flag	L:BKSQ_DUKE_LOC_3_TO_FLAG	0 - 100
Localizer 3 FROM Flag	L:BKSQ_DUKE_LOC_3_FROM_FLAG	0 - 100
Localizer 3 Glideslope Needle	L:BKSQ_DUKE_GLIDE_3	0 - 100
Localizer 3 Glideslope Flag	L:BKSQ_DUKE_LOC_3_GS_FLAG	Boolean

RMI Solid Needle	L:BKSQ_DUKE_RMI_1_SOLIDNEEDLE	0 - 100
RMI Hollow Needle	L:BKSQ_DUKE_RMI_2_HOLLOWNEEDLE	0 - 100
ADF Needle	L:BKSQ_ADF_BRG_1_Degraded	0 - 360
RNAV CDI Linear Deviation Mode	L:var_rnavCourseLinearFlag	Boolean
RNAV CDI Approach Deviation Mode	L:var_rnavApproachMode	Boolean
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 TurbineDuke_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 cabin altitude annunciator NODE ID is “CabinAltitudeAnnun_EM”, therefore…

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

Frequently Asked Questions

How do I open/close the tablet interface?

Click the back of the tablet **between the pilot's seat and the wall** of the cabin. Click the same area to close the tablet. The tablet can be moved by dragging its frame. If the tablet's bezel does not glow blue and cannot be dragged, switch to the modern control interaction method in the General Settings menu. 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.

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 does the mixture behave strangely in the turbocharged version, and I cannot bind it to hardware controls?

Microsoft Flight Simulator's turbocharger simulation has been significantly flawed for several generations. This aircraft has a custom turbocharger that fixes nearly all of these issues, and is much more realistic, as a result. To make these changes, the new "Input Event" system is used to intercept hardware and key-bindings for the mixture control axis. Please make sure that your hardware bindings are using the Key Events, such as "K:MIXTURE1_DECR_SMALL", or "K:MIXTURE1_SET" to set the mixture, and NOT setting either "A:GENERAL ENG MIXTURE LEVER POSITION:1", or "B:FUEL_Mixture_1_Set". Alternatively, setting **"L:BKSQ_MixtureLeverPosition_1" from 0-100 will also work to set the mixture axis.**

Why can't I start the engines?

The Piston Duke simulates many features of real world fuel injected engine operation that some users may not be familiar with. Understanding the checklists for hot, cold, and flooded engine starts should provide a successful engine start. Recall that fuel injected engines must be primed with an electric fuel pump before starting, and may succumb to vapor lock after recently running. Flooded engines will also be difficult to start, requiring an advanced throttle setting to produce a combustible air-to-fuel ratio. **Check the engine visualizer in the tablet interface** for a graphical representation of these many invisible factors of engine starting.

Why do my engines always fail or lose health?

It is very easy to mismanage high performance reciprocating engines. Be sure to watch the engine instrumentation and EDM-760 engine monitor for alarms. **When a limit is being exceeded, the alarm code will flash on its screen.** see the "Reciprocating Engine & Turbocharger Simulation" section of this manual for more information.

How do I set the vertical speed of the aircraft?

This aircraft is equipped with a Century IV autopilot, which **controls the pitch of the aircraft directly, rather than the vertical speed** of the aircraft. The desired pitch of the aircraft is set with the motorized pitch knob on the Century IV autopilot controller. For more information, see the Century IV Autopilot section of this manual.

Why can't I enable the autopilot?

This aircraft has a toggle switch that controls power to the autopilot servo motors. Make sure the toggle switch to the right of the cockpit lighting dimmers, labeled **"PITCH TRIM" is in the on position**. Additionally, check the "PITCH TRIM" circuit breaker on the copilot's upper side panel to make sure power is available to the autopilot servo motors.

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/

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

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-81 RNAV waypoints?

Yes! This is a new feature in this aircraft. By the nature of how the KNS-81 autopilot has been implemented, it cannot conflict with other GPS sources of navigation; therefore, the KNS-81 can only drive the autopilot’s NAV mode in the no-GPS avionics configuration. For more information, see the “Using the KNS-81 RNAV Navigation System” or the “Bendix/King KNS-81 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 caused by the NanoVG renderer for legacy XML gauges. **Disabling NanoVG from the "Experimental" menu in General Settings** will stop the flickering. Black Square products do not use rendered XML gauges, so there will be no impact on performance.

Does this aircraft use Sim Update 15 ground handling improvements?

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

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

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

Does this aircraft use Sim Update 13 engine improvements?

Sim Update 13 in October of 2023 introduced improved native simulation for turbochargers and superchargers. Luckily, these changes were non-breaking, because Black Square's turbocharger simulation is much more advanced than the native simulation, and enables advanced failures into the turbocharger simulation. In short, the turbocharged Black Square aircraft do not use the new SU13 turbocharger simulation, because **Black Square's turbocharger simulation is equally accurate, and has many more features**.

Why does the flight director not disengage when I press the autopilot disconnect button on my hardware yoke or joystick?

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

Change Log

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

New Features:

- TBD

Bug Fixes:

- TBD

Credits

Piston Duke	Nicholas Cyganski
Publishing	Just Flight
Audio	Boris Audio Works
Liveries	Ryan “ryanbatc” Butterworth
	Tim "TimHH" Scharnhop
Manual	Nicholas Cyganski
Testing	Just Flight Testing Team

Dedication

This product is dedicated to Apollo Astronaut, Frank Borman. Borman commanded Apollo 8 with Jim Lovell as his Command Module Pilot, and Bill Anders as his Lunar Module Pilot. Together, the three men became the first to orbit the moon, delivering unforgettable photos of Earthrise, and broadcasting a reading from the Book of Genesis on Christmas Eve. Borman famously owned the B60 Duke pictured below (though with a different registration), flying it while employed as Vice President of Operations and Chief Executive Officer of Eastern Airlines. Boreman is the author of my personal favorite aviation quotation, and words of advice for all pilots, “A superior pilot uses his superior judgment to avoid situations which require the use of his superior skill.” With the advanced systems and endless possibilities for failure simulated in this product, I hope that a new generation of virtual aviators can take Borman’s message to heart, train for any eventuality, and become the safest pilots they can be. Though you have only recently left us for those starry heavens you once explored, your memory and inspiration will live forever in all those young men and women who seek to equal your superior judgment and superior skill.

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