



“Virtual Aircraft. Real Engineering.”

Black Square TBM 850 User Guide

Please note that Microsoft Flight Simulator must be correctly installed on your PC prior to the installation and use of this TBM 850 aircraft simulation.

Contents

Introduction	8
Feature Overview	9
Systems	9
Checklists	9
Sounds	9
Model	10
Cockpit	10
Flight Dynamics	10
Aircraft Specifications	11
Aircraft Performance	12
V-Speeds	12
Engine Limitations	13
Other Operating Limitations	13
Starter Limitations	13
Paint Schemes	13
Instrumentation/Equipment List	14
Main Panel	14
Avionics	14
Electrical/Miscellaneous	14
Installation, Updates & Support	15
Installation	15
Installing the PMS GTN 750/650	15
Installing The Working Title GNS 530/430	16
TDS GTNxi 750/650 Integration	16
Accessing the Aircraft	17
Uninstalling	17
Updates and Technical Support	17
Regular News	17
Liveries & Custom Dynamic Tail Numbers	18

Cockpit & System Guide	20
Main Panel	20
Master Warning/Caution	20
Annunciator Panel	20
Airspeed Indicator	22
EFIS Control Panel	23
Bendix/King EFS 40 EADI	24
Bendix/King EFS 40 EHSI	26
Honeywell AM-250 Altimeter	28
Vertical Speed Indicator	29
Standby Electric Artificial Horizon	29
Bendix/King KI 206 Localizer	30
Bendix/King KI 229 Radio Magnetic Indicator (RMI)	31
Engine Instrumentation	32
Fuel Control Panel	33
Duplicate Copilot Instrumentation	34
Bendix/King KI 525A Horizontal Situation Indicator (HSI)	35
Collins ALI-55 Radar Altimeter	36
Avionics	37
Garmin GMA 340 Audio Panel	37
Garmin GTN 750 (Com1)	38
Garmin GNS 530/430 (Com1/Com2)	39
Bendix/King KX-155B (Com1/Com2)	40
Bendix/King KNS-80 RNAV Navigation System	40
Bendix/King KR 87 ADF	40
Bendix/King KDI 572R DME	41
Bendix/King KFC 325 Autopilot (KMC 321 Mode Controller)	42
Bendix/King KAS 297B Altitude Selector	43
Bendix RDR 1150XL Color Weather Radar	44
ETM Engine Trend Monitor	47
Garmin GTX 327 Transponder	47
Electrical/Miscellaneous	48
Circuit Breakers	48
Voltmeter & Ammeters	49
Bendix/King KA 51B Remote Compass Synchroscope	49
Gyro Suction Indicator	50
Terrain Warning System	51
Oxygen Pressure Gauge	51
LC-2 Digital Chronometer	53
Tach Timers	53
Davtron Outside Air Temperature Display	53
Lighting Controls	54

Cabin Lighting	54
Cockpit Lighting	55
Panel Lighting	55
Voltage-Based Light Dimming	56
State Saving	56
Environmental Simulation & Controls	57
Cabin Temperature Monitoring	57
Environmental Control Panel	58
Turboprop Engine Operation	60
Inertial Separator	60
Turbine Engine Ignition	61
Torque Limiter & 850 Mode	61
Turbine Engine Fuel Control Failures	61
Propeller Governor	61
Engine Visual Model	62
Residual Heat & Dry Motoring	62
P2.5 Bleed Air Valves	62
External Power	63
Engine Power Settings	64
Take-Off Power - Standard Day (ISA) No Wind	64
Maximum Cruise Power - Standard Day (ISA)	64
Normal Cruise Power - Standard Day (ISA)	64
Long Range Cruise Power - Standard Day (ISA)	65
Climb Performance 130 KTS - Standard Day (ISA)	65
Descent Performance 230 KTS -2,000 FPM - Standard Day (ISA)	65
Gyroscope Physics Simulation	66
Gyroscope Physics	66
Pneumatic Gyroscopes	66
Electric Gyroscopes	67
Tips on Operation within MSFS	68
Turboprop Engine Simulation	68
Engine Limits and Failures	68
Beta Range	68
Electrical Systems	69
Third Party Navigation and GPS Systems	69
Deicing and Anti-Icing Systems	70
Foreign Object Debris Damage	70
St. Elmo's Fire & Electrostatic Discharge	71
Realistic Strobe Light Bounce	71
Headphone Isolation	72
Magnetic Compass Effects	72
Tablet Interface	73

Options Page	74
Payload Page	76
Engine Visualizer Page	78
Cold Engine	78
Starting Engine	82
Running Engine	85
Live Schematic Page	88
Cabin Climate Visualizer Page	91
Heating Cabin	91
Cooling Cabin	94
Failures Page	97
MTBF Failures	97
Scheduled Failures	100
Failure System HTML Interface	103
List of Possible Failures	104
Major System Failures	104
Breaker Protected Failures	104
Miscellaneous Systems	105
Audible Warning Tones	105
VOR & ADF Signal Degradation	106
Overview Electrical Schematic	106
Using the KNS-80 RNAV Navigation System	108
The Concept	108
How it Works	108
“Moving” a VOR	108
Data Entry	109
Data Storage Bins	109
Distance Measuring Equipment	109
Modes of Operation	110
Other Possible Uses	110
Flying an RNAV Course with the Autopilot	111
Recommended Skills	111
Direct Flight to Airport Tutorial	111
Using the ETM Engine Trend Monitor	115
Alarms	120
Stopwatch	120
Normal Checklists	121
Preflight (Cockpit)	121
Before Starting Engine	121
Engine Start (Battery)	121
Engine Start (GPU)	122
After Starting Engine	122

Before Takeoff	122
Takeoff	122
Climb	123
Transition Altitude	123
Cruise	123
Descent	123
Before Landing	123
Landing	123
Go Around	123
Touch & Go	123
After Landing	123
Shutdown & Securing	123
Instrument Markings & Colors	124
Abnormal & Emergency Checklists	125
Rejected Takeoff	125
Engine Failure After Rotation	125
Engine Airstart	125
Engine Motoring	125
Engine Fire (Ground)	125
Cabin Fire (Ground)	125
Engine Fire (Flight)	125
Electrical Fire or Smoke	125
Oil Pressure Drop	126
Loss of Power Regulation	126
Loss of Propeller Control	126
Propeller Overspeed	126
Maximum Rate Descent	126
Maximum Range Descent	126
Engine Out Landing	126
Gear Up Landing	127
Engine Does Not Shutdown	127
Low Fuel Pressure	127
Main Generator Failure	127
Low Volts (On Main Gen.)	127
Low Volts (On Stby. Gen.)	127
CABIN PRESS Illuminated	127
BLEED OFF Illuminated	127
BLEED TEMP Illuminated	127
DOOR Illuminated In Flight	128
Cabin Pressurized After Landing	128
Vacuum Suction Low	128
Starter Does Not Disengage	128

CHIP Illuminated	128
Remote Compass Misalignment	128
Flap Failure	128
Autopilot Failure or Trim Runaway	128
Airspeed Failure	128
Severe Icing Encounter	128
Severe Precip. Encounter	128
Landing Gear Manual Extension	128
Landing Gear Up after Man Ext	128
More Information on Operation	129
Hardware Inputs & Outputs	130
Inputs	130
Exterior & Cabin Element Variables	130
Primary Control Variables	131
Lighting Control Events & Variables	132
Environmental Control Variables	133
Instrument Variables	134
Instrument Events	135
EFS 40 Events	137
Avionics Variables & Events	138
PMS50 GTN	138
TDS GTNxi	138
Working Title GNS 530	139
KNS80	140
KX155B	141
KR87 ADF	141
GTX 327 Transponder	142
Weather Radar	143
ETM Engine Trend Monitor	143
KAS 297B	144
Outputs	145
Aircraft & Engine Variables	145
Radio Navigation Variables	146
Annunciator Lights	147
Frequently Asked Questions	148
How do I open/close or move the tablet interface?	148
How do I change which avionics/radios are installed?	148
How do I choose between the TDS and PMS GTN 750?	148
Why does the aircraft crash if I open the cockpit door?	148
Is beta range simulated?	148
Do I have to use the tablet interface to set fuel & payload?	148
Why is the autopilot behaving strangely, not changing modes, showing HDG/NAV	

simultaneously, or not capturing altitudes?	149
Why do my engines always fail or lose health?	149
Why does it take so much power to get the aircraft moving?	149
Why is the GTN 750 GPS screen black?	149
Can the autopilot track KNS-81 RNAV waypoints?	149
Why is the state of my aircraft and radios not saved/recalled?	150
Why does the engine not fail when limits are clearly exceeded?	150
Do the doors open?	150
I have the TDS or PMS GTN 750 installed. Why do they not automatically show up on the panel?	150
Is beta range simulated?	150
Why do my engines always fail or lose health?	150
Why is the autopilot behaving strangely, not changing modes (HDG/NAV), or not capturing altitudes?	151
Why can't I enable the autopilot?	151
Why do the localizer cards rotate with the EHSI course needle?	151
Why do screens flicker at night when adjusting lighting intensity?	151
How do you open the baggage door and engine cowlings?	152
Does this aircraft use Sim Update 15 ground handling improvements?	152
Why does the aircraft tip over or veer sideways during takeoff?	152
Why does the flight director not disengage when I press the autopilot disconnect button on my hardware yoke or joystick?	152
Why does pitch control seem overly sensitive in MSFS 2024?	152
Change Log	153
v1.0 - Initial Release	153
v1.1 - Aerodynamics, Beta & Requested Features	154
v1.2 - Major Update: Tablet, Exterior Elements & RNAV Autopilot	157
v1.3 - Marketplace Update	160
v1.4 - MSFS 2024 Compatibility & Altitude Selector Update	160
Credits	162
Dedication	162
Copyright	162

Introduction

In the 1980's, a growing economic divide in aviation became clear. Cabin-class twins were becoming antiquated, and business jets were becoming ever more expensive to operate, leaving an unfulfilled middle market for economical executive transport. The TBM 700 was designed to capture this market by combining the speed of a modern airframe with the economical operation of a single engine turboprop. The result was a six seat, pressurized aircraft with excellent utility, which has routinely been recognized as the fastest single engine turboprop in the world. This particular model of TBM depicts the 2006 TBM 850, which incorporated an additional 150 horsepower over the TBM 700, accessible during takeoff and cruise flight. The TBM 850 saw much greater adoption in international markets, and has proven to be one of the most reliable and economical executive transports in the world. As of today, there are now over 1,000 TBM aircraft in operation.

Black Square's TBM 850 brings you one of the most technically advanced aircraft simulations for Microsoft Flight Simulator, with over 100 possible failures, including new turbine engine failures, hot-swappable radio configurations, and the most advanced 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, many with multiple different failure modes. Experience real world failures from popular YouTube videos, including generator failure, propeller governor failure, fuel control failure, and compressor surging. The 3D gauges are modeled and coded to meticulously match their real world counterparts, with reference to real world manuals. 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 aircraft's history, so users can fly without GPS via a Bendix KNS-80 RNAV system, or with the convenience of a Garmin GTN 750 (PMS50 or TDS). Other radio equipment includes EFS 40 EADI & EHSI, KX-155 NAV/COM radios, dual GNS 530, KR 87 ADF, KDI 572 DME, GTX 327 Transponder, and a Bendix RDR1150XL Weather Radar. A 160+ page manual provides instruction on all equipment, and 55 in-game checklists with control/instrument highlighting are included for normal and emergency procedures.

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

Systems

This Black Square's aircraft will challenge you with unapologetically realistic systems, like...

- **Tablet Interface** for configuring options, payload settings, failure management, and real time visualizers for engines, electrical schematics, and environmental systems.
- Improved turbine dynamics (ITT, TRQ, Ng, Fuel Flow, Inertial Separator), and hot starts, with the unique "850 Mode" torque limiter, and new beta range implementation.
- Turbine engine failures, such as compressor stall and surging, and fuel control failures. Engine limit excursions that decrease engine health and will eventually lead to failure
- Gyroscope physics simulation for electric and pneumatic gyroscopes with precession, partial failures, based on a coupled quadrature oscillator
- Magnetic compass effects, including fields from onboard circuits
- Turbine bleed air driven pressurization system and cabin climate system
- Completely intractable electrical system with 15 buses and 85+ circuits
- EFS 40 EADI & EHSI Electronic Flight Instrumentation System & Engine Trend Monitor
- State saving for fuel, radio selection, radio frequency memory, cabin aesthetics, etc.
- 100 system failures, set via in-cockpit interface. Either random based on settable MTBF, or schedulable, with optional time acceleration.
- Cabin environmental control 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.
- Crew/Passenger oxygen system that depletes according to pressure altitude, passenger occupancy, and their weight.
- Mathematically accurate VOR & ADF signal attenuation and noise, and remote compass
- FOD ingestion damage demands use of inertial separators & ice protection systems

Checklists

Over 600 checklist items are provided for 55 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 TBM 850 features a highly customized version of the MSFS-native (Wwise) 3D TBM 930 sound package, with many new handmade sounds added for warnings, environmental control systems, electronics, and more. The default sounds have been carefully assigned to all interactable cockpit elements for an authentic 3D spatial audio experience, and engine sounds have been integrated with Black Square's turbine engine and propeller simulation.

Model

- Accurately modeled TBM 850 created from hundreds of reference photos and technical documentation with the help of real TBM 850 operators and maintenance technicians.
- Engine visual model, opening cabin and passenger doors, and baggage compartment.
- 100% MSFS native animation code for the smoothest animations and cockpit interactions using either legacy or new cockpit interaction modes
- 4096x4096 (4K) PBR (Physically Based Rendering) materials with real-time environment reflections for superb quality and realism, and vector-graphic-like decal quality.
- Detailed normal mapping for leather, fabric, plastic, stitches, scratches, carpet, and tooling marks, resulting in a texture resolution of 10,000 pixels per square inch (90.0kB)

Cockpit

- Faithfully recreated interior and cockpit with Black Square's hyper-realistic art style.
- Custom coded steam gauges with lowpass filtering, needle bounce, and physics provide ultra-realistic and silky smooth animations like you've never seen before. New gyroscopic simulation makes analog instruments more realistic than ever!
- Carefully modeled components match the depth and character of the real instrumentation, based on reference photos, schematics, and real world measurements. Unlike other expensive Flight Sim aircraft, every piece of equipment that appears in a Black Square aircraft is modeled after a real piece of aircraft equipment, and will behave the same way in its primary functionality.
- Every knob, switch, and button is interactable and implemented, along with its respective electrical circuitry. Turn systems on and off or pull circuit breakers to see the impact it has on your generators and battery via the analog meters. Alternating current inverters and bus ties are correctly simulated. Many pieces of equipment respond correctly to electrical configurations with warning messages and diagnostic codes.
- Fully 3D cockpit lighting technology for every gauge and panel, with ambient bounce lighting, and all lights dim with battery voltage and load, an immediately recognizable effect to nighttime pilots. Strobe lights now cause disorienting light bounce in clouds.
- Experience the rare St. Elmo's Fire effect while flying through intense thunderstorms!
- Hideable yokes, adjustable sun visors, and other cockpit aesthetics

Flight Dynamics

Black Square's TBM 850 features a flight model with performance to match the real world aircraft based on real TBM 850 in-flight data. The flight model uses the most up to date features available in MSFS, such as CFD propeller and stall physics, and improved ground handling. Takeoff, climb, and cruise performance matches POH values within 2%.

Aircraft Specifications

Length Overall	34'11"
Height	14'4"
Wheel Base	9'6"
Track Width	12'9"
Wingspan	41'7"
Wing Area	193.75 sqft.
Flight Load Factors	+3.8/-1.5 G's (+2.0/-0.0 G's with Flaps Down)
Design Load Factor	150%
Cabin W/L/H	48" x 13'3" x 48"
Baggage Capacity	330 lbs (110 lbs in nose compartment, 220 lbs in aft cabin)
Oil Capacity	3.2 U.S. Gallons
Seating	6
Wing Loading	38.16 lbs/sqft
Power Loading	7.8 lbs/hp
Engines	850 SHP (634 kW) Pratt & Whitney PT6A-66D Free-Turbine
Propellers	4-Blade Hartzell, Constant Speed, Fully Reversible, Aluminum, Hydraulically Actuated, 90.5 inch propeller. Fully fine blade angle of 21°, feathering angle of 86°, reverse angle of -11°.
Approved Fuel Grades	JET A (ASTM-D1655) JET A-1 (ASTM-D1655) JET B (ASTM-D1655) JP-4 (MIL-DTL-5624) JP-5 (MIL-DTL-5624) JP-8 (MIL-DTL-83133)
Fuel Capacity	Total Capacity: 290.6 U.S. Gallons Total Usable: 281.6 U.S. Gallons Capacity Each Tank: 145.3 U.S. Gallons Usable Each Tank: 140.8 U.S. Gallons
Electrical System	
Voltage:	28 VDC
Batteries:	24V, 42 amp-hour, sealed lead acid battery
Main Generator:	28V, 200 amp @ 2,000 RPM
Standby Generator:	28V, 70 amp @ 2,000 RPM
Pressurization System	6.2 PSI Maximum Pressure Differential Pressurization Rate Controller 150 ft/min to 2,000 ft/min Minimum/Maximum attainable altitude Sea Level / 14,390 ft

Aircraft Performance

Maximum Cruising Speed	320 ktas
Normal Cruising Speed	286 ktas
Long Range Cruising Speed	252 ktas
Takeoff Distance	2,840 ft
Takeoff Ground Roll	2,035 ft
Landing Distance	2,430 ft
Landing Ground Roll	1,840 ft
Normal Range (30 min. reserve)	1,450 nm
Maximum Range (30 min. reserve)	1,520 nm
Rate of Climb	2,005 ft/min
Service Ceiling	31,000 ft
Empty Weight	4,806 lbs
Max Ramp Weight	7,430 lbs
Max Takeoff Weight	7,394 lbs
Max Landing Weight	7,024 lbs
Useful Load	2,588 lbs
Usable Fuel Weight	1,690 lbs
Full Fuel Payload	898 lbs
Maximum Operating Temp.	+37°C
Minimum Operating Temp.	-40°C

Maximum Demonstrated Crosswind Component: 20 kts

V-Speeds

V _r	85 kts	(Rotation Speed)
V _s	81 kts	(Clean Stalling Speed)
V _{so}	65 kts	(Dirty Stalling Speed)
V _x	95 kts	(Best Angle of Climb Speed)
V _y	123 kts	(Best Rate of Climb Speed)
V _a	158 kts	(Maneuvering Speed)
V _g	120 kts	(Best Glide Speed)
V _{fe}	122 kts	(Maximum Full Flap Extension Speed)
V _{fa}	178 kts	(Maximum Approach Flap Extension Speed)
V _{le}	178 kts	(Maximum Landing Gear Extension Speed)
V _{le}	128 kts	(Maximum Landing Gear Retraction Speed)
V _{is}	200 kts	(Maximum Inertial Separator Operating Speed)
V _{ne}	266 kts	(Do Not Exceed Speed)

Engine Limitations

Engine Speed	2,000 RPM
Torque ("850 Mode" OFF)	100.0%
Torque ("850 Mode" ON)	121.4%
ITT	850°C (T/O) 840°C (Climb/Cruise) 1090°C (Starting)
Gas Generator	104.1% (Continuous)
Oil Temperature	-40°C (Starting) (min.) 110°C (max.)
Oil Pressure	60 PSI (min.) 135 PSI (max.)
Fuel Pressure	10-50 PSI (normal)

Other Operating Limitations

- When ITT exceeds 840°C, time at this power setting should be limited to 5 minutes.
- Reverse thrust operation limited to durations of one minute.
- Aircraft shall not be operated when outside takeoff temperature exceeds 100°F (38°C).
- Maximum slip duration: 30 seconds.
- Use of flaps not authorized above 15,000 ft
- Use of "850 Mode" prohibited for takeoff and landing
- Use of reverse and beta propeller modes prohibited in flight

Starter Limitations

Using Airplane Battery:

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

Using External Power:

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

Paint Schemes

The Black Square TBM 850 comes with seven paint schemes, including one blank white scheme for livery makers to modify. This product makes use of Black Square's highly customizable dynamic tail number system, which can also be configured by livery makers. See the "Custom Dynamic Tail Numbers" section of this manual for more information. There are also two interior schemes that can be incorporated into any livery mod: black, and tan.

Instrumentation/Equipment List

Main Panel

- Master Warning/Caution
- Annunciator Panel
- Airspeed Indicator
- EFIS Control Panel
- Bendix/King EFS 40 EADI
- Bendix/King EFS 40 EHSI
- Honeywell AM-250 Altimeter
- Vertical Speed Indicator
- Bendix/King KI 206 Localizer
- Bendix/King KI 229 Radio Magnetic Indicator (RMI)
- Engine Instrumentation
- Fuel Control Panel
- Duplicate Copilot Instrumentation
- Bendix/King KI 525A Horizontal Situation Indicator (HSI)
- Collins ALI-55 Radar Altimeter

Avionics

- Garmin GMA 340 Audio Panel
- Garmin GTN 750 (Com1/Com2)
- Garmin GNS 530/430 (Com1/Com2)
- Bendix/King KX-155B (Com1/Com2)
- Bendix/King KNS-80 RNAV Navigation System
- Bendix/King KR 87 ADF
- Bendix/King KDI 572R DME
- Bendix/King KFC 325 Autopilot (KMC 321 Mode Controller)
- Bendix/King KAS 297B Altitude Selector
- ETM Engine Trend Monitor
- Bendix RDR 1150XL Color Weather Radar
- Garmin GTX 327 Transponder

Electrical/Miscellaneous

- Voltmeter & Ammeters
- Bendix/King KA 51B Remote Compass Synchroscope
- Gyro Suction Indicator
- Terrain Warning System
- Oxygen Pressure Gauge
- LC-2 Digital Chronometer & Tach Timers
- Davtron Outside Air Temperature Display

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

No additional downloads are required for the Working Title GNS 530/430 and all previous modifications should be removed from your community folder. Some older aircraft may still require a “link” to the new GPS, which can be downloaded from the in-game marketplace for free. This package is not required for the Black Square TBM 850, or any subsequently updated Black Square aircraft.

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.

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 'Black Square TBM 850'.
4. After selecting the aircraft, use the 'Liveries' menu to choose your livery.

Uninstalling

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

Control Panel -> Programs and Features

or

Settings -> Apps -> Apps & features

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

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

Updates and Technical Support

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

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

Regular News

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

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

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

Liveries & Custom Dynamic Tail Numbers

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



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

```
font_color=red&stroke_size=30&stroke_color=black&sv=1&sx=18&sy=41&sr=0&sk=20&ss=250  
&tv=1&tx=16&ty=8&tr=0&tk=20&ts=225
```


Each position ("s" = side and "t" = tail) 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

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

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

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

Cockpit & System Guide

Main Panel

Master Warning/Caution

This aircraft is equipped with Master Caution, and Master Warning annunciators with integrated push buttons above the pilot's airspeed indicator. The Master Caution annunciator illuminates in amber behind "MASTER CAUTION" text, and the Master Warning annunciator illuminates in red behind "MASTER WARNING" text. Both are latching annunciators, meaning that they illuminate when triggered by a specific aircraft condition, and remain illuminated until canceled by a crew member by pressing the annunciator's integrated push button.



A Master Warning is triggered by any condition that illuminates on the annunciator panel in RED. These conditions require immediate pilot action to rectify. A Master Caution is triggered by any condition that illuminates on the annunciator panel in AMBER. These conditions likely require pilot action to rectify, might lead to a more severe condition if not rectified soon, or represent an atypical configuration for some phases of flight.

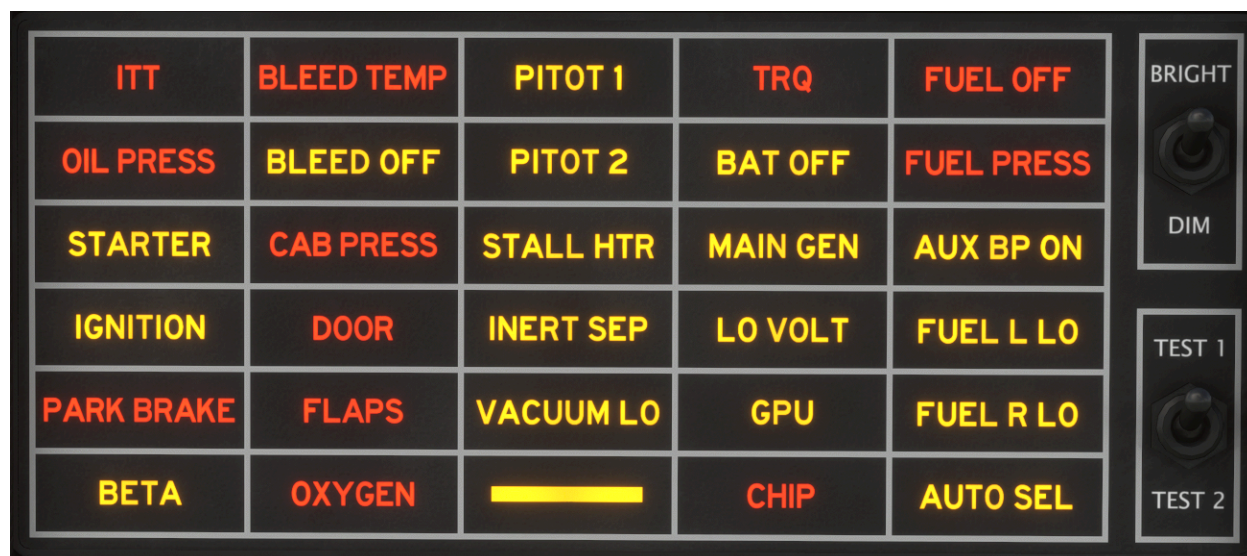
Annunciator Panel

The annunciator panel consists of 30 indicator lamps located above the center panel avionics stack. The annunciator panel brightness can be dimmed for nighttime conditions with the associated toggle switch. The indicator lamps are supplied by two separate circuits for redundancy. Each circuit may be isolated for testing with the associated momentary switch.

The annunciator text color indicates the severity of the condition. RED conditions are flight critical, and require immediate pilot action to rectify. AMBER conditions will likely result in a more severe condition if pilot action is not taken to rectify the condition soon, or represent an atypical configuration for some phases of flight.

The following text illuminates to indicate the associated condition:

ITT (RED)	Interstage turbine temperature exceeds 850°C
TRQ (RED)	Torque exceeds 121.4%
CHIP (RED)	Metal particulate detected in the engine oil
FUEL OFF (RED)	Fuel tank selector is in "OFF" position
FUEL PRESS (RED)	Fuel pressure < 10 PSI
OIL PRESS (RED)	Oil pressure < 60 PSI
PARK BRAKE (RED)	Parking brake applied
BLEED TEMP (RED)	Air conditioning outlet temperature > 317°C
CABIN PRESS (RED)	Cabin altitude > 10,000 FT, or cabin differential > 6.2 PSI
DOOR (RED)	Passenger or pilot access door unlatched
FLAPS (RED)	Asymmetric flap deployment
OXYGEN (RED)	Oxygen cylinder valve closed
STARTER (AMBER) (FLASHING)	Starter engaged
IGNITION (AMBER)	Turbine ignition activated
BLEED OFF (AMBER)	Bleed air regulator off
PITOT 1 (AMBER)	Pitot heat 1 off
PITOT 2 (AMBER)	Pitot heat 2 off
STALL HTR (AMBER)	Pitot heat 2 off
INERT SEP (AMBER)	Inertial separator deployed
VACUUM LO (AMBER)	Vacuum suction < 3.75 inHg
BAT OFF (AMBER)	Battery disconnected while generator supplying power
MAIN GEN (AMBER)	Main generator not supplying power
LO VOLT (AMBER)	Battery voltage < 26V
GPU (AMBER)	GPU receptacle door open
AUX BP ON (AMBER)	Auxiliary boost pump running
FUEL L LO (AMBER)	Left fuel quantity < 9.1 gallons
FUEL R LO (AMBER)	Right fuel quantity < 9.1 gallons
AUTO SEL (AMBER)	Automatic fuel selector off
BETA (AMBER) [OPTIONAL]	Power lever is in beta range



Airspeed Indicator

The airspeed indicator displays indicated airspeed in knots, and select reference speeds with white arcs. As opposed to nearly all airspeed indicators on American built aircraft, the TBM's airspeed indicator rests at zero airspeed in the 6 o'clock position, as opposed to the 12 o'clock position. This can be rather disorienting for pilots solely used to more conventional airspeed indicators, as it positions the critical arc of approach and landing speeds on the opposite side of the instrument with the needle moving across the arc in the opposite direction vertically than they are used to seeing. The bottom of the white arc represents the dirty configuration stalling speed. The top of the white arc represents the maximum full flap deployment speed. The discontinuity between arc thicknesses represents the clean configuration stalling speed. The red marking corresponds to the never-exceed speed of 266 kts.



EFIS Control Panel

The Bendix/King EFS 40 Electronic Flight Instrumentation System (EFIS) is a comprehensive flight display system consisting of two displays for a conventional attitude indicator and horizontal situation indicator (HSI). In this aircraft, the EFS 40 is controlled via the EFIS control panel, above the EADI. This panel features a master EFIS power switch, test button to trigger the EADI's self test function, the EADI brightness control, decision height controls, DME selector knob, and composite display mode push button (labeled "CMPST").



Pressing the "CMPST" composite display mode button will drive both the EADI and EHSI display units with the same graphical signal, which can provide redundancy in the event of a single display failure. This display integrates most aspects of both an attitude indicator and HSI, including a horizontal compass heading tape, heading bug, course needle, navigation source annunciator, crosstrack deviation indicator, and glideslope indicator. In composite mode, the turn rate indicator is replaced by numerical representations of heading bug and course needle positions. DME information is shown to the left of the crosstrack deviation display, above where marker beacon annunciators are displayed.

NOTE: The EFS 40 display system consists of two cathode ray tube (CRT) displays, which can take a considerable time to warm up during cold conditions. If the cabin of the aircraft is not warmed up before starting the aircraft on a particularly cold day, it may take several minutes for the displays to reach full brightness.

Bendix/King EFS 40 EADI

The EFS 40 ADI normally displays a large aspect conventional attitude display with an overlaid turn rate indicator at the bottom of the display. Marker beacon symbols will be overlaid at the bottom left of the attitude indicator. At the top of the display, a row of autopilot mode information is displayed. At the far left, master autopilot modes are displayed, including autopilot master (AP), yaw damper (YD), soft-ride (SR), and half-bank (HB). The remaining display shows lateral autopilot modes on the left, and vertical autopilot modes on the right. Currently active modes will be shown in green, while armed modes are shown in white.

When an approach navigation source with vertical guidance is detected, the attitude indicator will receive a black border, in which crosstrack deviation and glideslope information will be displayed. Crosstrack deviation is displayed in the bottom margins with an indication of the navigation source type to the right. During approach lateral guidance, such as GPS LNAV only, this course deviation indicator will be green in color. When vertical guidance is present, glideslope information will be shown in the right margins of the display, and the course deviation needle will be replaced by a green rising runway. The rising runway moves laterally like a course deviation indicator, and will descend towards the course deviation scale while growing in size from 250ft to touchdown.



At the far right of the top display is the radar altimeter display, which will be flagged with dashes when radar altitude is over 2,500ft. A knob on the EFIS control panel is used to set decision height. To the left of this knob, a three position switch controls the decision height mode. In normal mode, the decision height is displayed at the bottom right of the display whenever the radar altitude is less than 2,500ft, and greater than 5ft. In test mode, the radar altimeter should output 25ft, allowing the user to adjust the decision height above 25ft to ensure that the associated annunciators are functioning. In “DH SET” mode, the decision height will be displayed regardless of present radar altitude so that it may be set before descent below 2,500ft. The decision height annunciators may be disabled by rotating the decision height test knob counterclockwise until “OFF” is displayed in “DH SET” mode.



Composite Display Mode

NOTE: Major software updates since the EFS 40 system was released in 1990 have changed the appearance of many aspects of the displays. Keep in mind that your reference material for this unit may not be a perfect match for the software version represented.

Bendix/King EFS 40 EHSI

The EHSI screen brightness is controlled with a knob on the bottom of the screen's bezel. The EHSI's self test mode can be initiated by holding the "TST REF" button.

The EFS 40 EHSI resembles a conventional light aircraft horizontal situation display with the addition of two colocated bearing pointers. A knob on the face of the instrument marked "HDG" controls the position of the orange heading bug. The current position of this heading bug is displayed numerically at the bottom right of the display in orange. A knob on the face of the instrument marked "CRS" controls the course arrow in the center of the display. The current position of this course arrow is displayed numerically at the top left of the display. Each knob has an integrated push button. The heading push button will align the heading bug with the current heading of the aircraft. The course push button will align the course needle with the bearing to the current station or waypoint. Directly below the course numerical display in white is a wind indicator display consisting of a direction arrow and velocity in knots.

To the left of the HSI compass display, the currently selected primary navigation source is displayed in vertical text. This navigation source is selected using the "NAV" push button on the left of the display's bezel. Pushing this button will cycle through the following primary navigation sources: VOR1, VOR2, GPS, RNAV, MLS (Microwave Landing System), and ADF. Each of these navigation sources has a color associated with it on the pilot's display. These colors are consistent with the navigation source text, current course numerals, course needle, and range/DME information. Pressing the "1 2" push button will cycle between redundant navigation sources, in the case of this aircraft, only VOR1 and VOR2. Cross-side navigation information is displayed in yellow.

Cyan	Same-side Enroute Navigation (Ex. GPS, VOR1, RNAV, MLS, ADF)
Green	Same-side Approach Navigation (Ex. GPS, LOC1, RNAV, MLS)
Yellow	Cross-side Navigation (Ex. VOR2, LOC2)

At the top right of the display range and DME information is shown for the primary navigation source. From top to bottom, this block of text will display the current distance to the next GPS waypoint or DME station, the current groundspeed or DME speed of the aircraft, and the time to go until reaching the waypoint or station. When the DME mode selector knob on the EFIS control panel is in hold mode, the currently held DME frequency will also be displayed, followed by the letter "H". Cross-side DME information is displayed in yellow.

Two additional bearing pointers can be displayed simultaneously on the HSI compass for situational awareness. These pointers are toggled on and off with the two buttons on the bottom of the screen's bezel. Pressing these buttons will cycle through the available navigation sources for the two pointers. The solid pointer is displayed in blue, while the hollow pointer is displayed in magenta. If available, distance information is shown under the pointer navigation source text on the screen, above the pointer buttons. For the solid pointer, the available navigation sources include: VOR1, GPS, and RNAV. For the hollow pointer, the available navigation sources include: VOR2 and ADF. Whenever a primary navigation source with vertical guidance is detected, a glideslope indicator will be positioned at the right of the display.



NOTE: The EFS 40 EHSI can be purchased with an optional “symbol generator” unit, which is a Line Replaceable Unit (LRU) avionics component mounted remotely in the aircraft. This piece of equipment augments the existing features of the EHSI with rudimentary map rendering capabilities for improved situational awareness. Included with this upgrade is a compass arc display mode, and overlaid weather radar imagery. These modes are controlled with the “HSI”, “ARC”, and zoom in/out buttons on the bezel. The symbol generator functionality of the EFS 40 is not currently simulated in this aircraft, but may be at a future date. See the “Regular News” section of this manual for information on product updates and news information.

NOTE: Major software updates since the EFS 40 system was released in 1990 have changed the appearance of many aspects of the displays. Keep in mind that your reference material for this unit may not be a perfect match for the software version represented.

NOTE: Both EHSI VOR sources can be used to drive the autopilot. Switching between sources with the “NAV” or “1 2” push buttons will automatically select the currently selected EHSI source as the source for autopilot navigation.

Honeywell AM-250 Altimeter

The Honeywell AM-250 is a single needle type altitude indicator with digital altitude and barometric setting readout. The barometric setting is controlled via an adjustment knob on the face of the unit. The “STD” button on the face of the altimeter is used to set the altimeter to standard barometric pressure when passing transition altitude. The altimeter has an integrated altitude capture alerting system in the form of an amber indicator on the right of the instrument’s face. The altimeter also possesses a small white reference altitude indicator, which can be rotated around the face of the instrument. The pilot’s altimeter is the encoding altimeter used for the Mode-C transponder output, and to drive the altitude hold function of the KFC 325 autopilot. This model of altimeter is approved for RVSM operations.



Vertical Speed Indicator

A vertical speed indicator displaying a maximum of +/- 6,000 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.



Standby Electric Artificial Horizon

To the left of the pilot's localizer is a DC electric standby attitude indicator.

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

Bendix/King 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, or the GNS530. 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.



Bendix/King KI 229 Radio Magnetic Indicator (RMI)

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



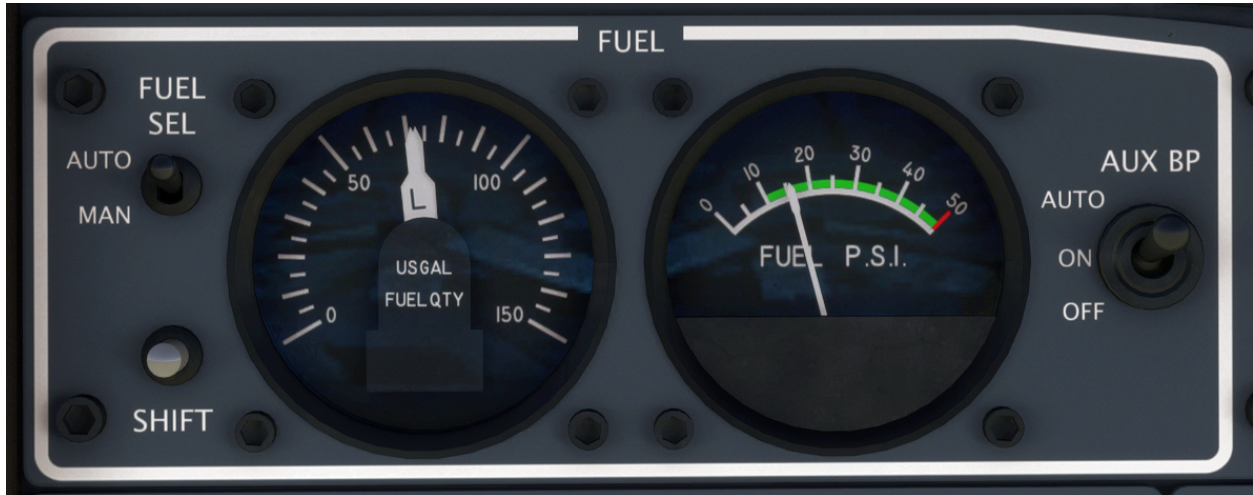
Engine Instrumentation

A column of five engine instruments resides to the right of the pilot's main instrument panel. From top to bottom, the instruments are: Torque (FT-LBS), Propeller RPM, Gas Generator RPM (Ng%) (% rated RPM), Interstage Turbine Temperature (ITT) (°C), and engine oil parameters, including oil temperature (°C), and oil pressure (PSI). The interstage turbine temperature gauge possesses an integrated 7-segment display. The ITT needle, display, ITT annunciator, and associated master warning can be tested before engine start by holding the "ITT TEST" button on the main instrument panel.



Fuel Control Panel

To the right of the annunciator panel, on the copilot's main instrument panel, resides the fuel control panel, including fuel quantity indicator, and fuel pressure indicator. The fuel quantity indicator consists of one coaxial needle for each fuel tank on a scale graduated in gallons. The fuel pressure needle indicates fuel pressure downstream of the auxiliary fuel boost pump.



To the left of the fuel quantity indicator are the controls for the automatic fuel selector control. The TBM is equipped with an automatic fuel selector, which eliminates the need for the pilot to change fuel tanks during most flights. When the automatic fuel selector is in operation, the selected fuel tank will change every 75 seconds when the aircraft is on the ground. When in flight, the fuel tank is changed every 10 minutes. If a low fuel condition is detected in flight, the opposite tank is selected immediately. The fuel selector will not change again until the selected tank also enters a low fuel condition, after which, the fuel selector will be changed every 75 seconds. While the automatic fuel selector is in operation, the tank may always be changed manually, including to the off position. The tank may also be changed manually by pressing the "SHIFT" button on the fuel control panel.

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.

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, vacuum powered artificial horizon, three pointer altimeter, Bendix/King KI 525A Horizontal Situation Indicator (HSI), vertical speed indicator, and Collins ALI-55 Radar Altimeter. To best serve as backup instrumentation in case of a vacuum failure, the artificial horizon is electrically powered.



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

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

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



Collins ALI-55 Radar Altimeter

The ALI-55 Radar Altimeter displays the height of the belly-mounted radar transducer with respect to the terrain below the aircraft. The orange indicating needle rests in a vertical position when the unit is not receiving power, a valid signal, or when the indicated altitude is below 10 feet. A yellow 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 “DH” annunciator on the co-pilot’s main panel. Be aware that the indicating scale is non-linear.



Avionics

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

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

Garmin GMA 340 Audio Panel

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



Garmin GTN 750 (Com1)

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 and TDS GTNxi 750 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 KX-155B (Com1/Com2)

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

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



Bendix/King KNS-80 RNAV Navigation System

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

NOTE: The autopilot in this aircraft is capable of receiving navigation input from the KNS-80, but will only do so when the no-GPS avionics configuration is selected from the tablet interface. When operating without a GPS, press the "NAV" source button on the EHSI to select RNAV. The autopilot will automatically use the RNAV course deviation information in this mode. For more details, see the "Flying an RNAV Course with the Autopilot" section of this manual.

Bendix/King KR 87 ADF

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



Bendix/King KDI 572R DME

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



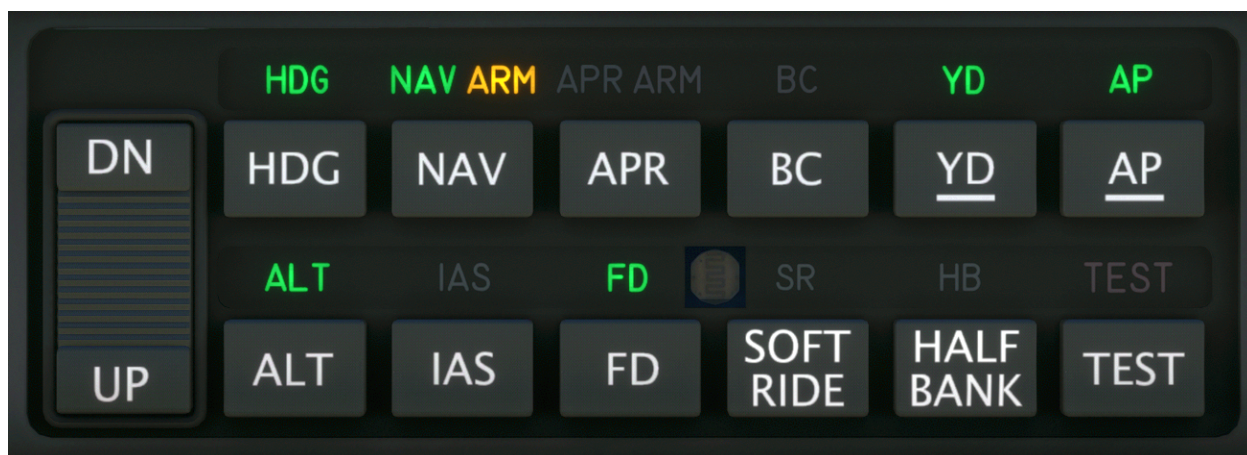
Selecting “HLD” mode will hold the current DME frequency and information on the unit, while allowing the user to change the tuned NAV frequencies on the NAV1 or NAV2 radios. This can be useful for some specific instrument approaches. This unit’s state will be automatically saved and reloaded at the start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

Bendix/King KFC 325 Autopilot (KMC 321 Mode Controller)

The KFC 325 Autopilot is a collection of components that comprise a sophisticated automatic flight system, rather than just a line replaceable autopilot head unit, as is common in smaller aircraft. All the operators need to concern themselves with, however, is the KMC 321 autopilot mode controller, mounted in the glareshield of this aircraft. This autopilot receives vertical speed and target altitude information from the KAS 297B Altitude Selector.

The UP/DN rocker switch can be used to adjust the target altitude, target vertical speed, or the target holding airspeed, depending on the autopilot’s active vertical navigation mode. In altitude holding mode, each press of the switch will adjust the target altitude by 500 ft. In vertical speed hold, each press will adjust the vertical speed by 100 ft/min, and the new vertical speed will be displayed momentarily on the KAS 297B. In IAS hold mode, each press will adjust the target airspeed by one knot.

NOTE: The AP/TRIMS MASTER switch, located to the left of the panel lighting dimmers and above the throttle quadrant, must be in the full on position (not “AP OFF”) for the autopilot to function and servos to control the aircraft.



When power is first supplied to the autopilot, a self test function is performed. This self test can be initiated by pressing the test button should problems be suspected. While the rest is being performed, the red “TEST” annunciator light will be illuminated, and the autopilot will not be capable of controlling the aircraft. Annunciator lights are also provided for soft-ride (“SR”) and half-bank (“HB”) modes. Soft-ride mode attempts to smooth control inputs to minimize cabin jostling during turbulence. Half-bank mode limits the maximum autopilot bank angle to 15°.

The EFS 40’s integrated flight director can be toggled by pressing the “FD” button. 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.

NOTE: Both EHSI VOR sources can be used to drive the autopilot. Switching between sources with the “NAV” or “1 2” push buttons will automatically select the currently selected EHSI source as the source for autopilot navigation.

Bendix/King KAS 297B Altitude Selector

The KAS 297B resides on the main instrument panel, above the pilot’s altimeter. The altitude selector is an integral part of the KFC 325 autopilot system, allowing the pilot to select target and alert altitudes, as well as vertical speeds. The unit’s dual concentric rotary encoder can be used to select target and alert altitudes by default, and can be used to select vertical speeds when the inner knob is pulled out. The outer knob will adjust both quantities in 1,000 ft/(min) increments, and the inner knob will adjust both quantities in 100 ft/(min) increments. When the knob is pulled, “FT/MIN” will illuminate on the display, as opposed to just “FT” when in altitude selection mode. When adjusting vertical speed, two small arrows to the left of the set rate indicate whether the desired vertical speed is a climb or a descent.

When the autopilot is transitioning between vertical speed hold mode and altitude hold mode to capture the desired altitude, “CAPT” will illuminate on the display. When approaching the desired altitude within 1,000 feet, or departing the set altitude beyond 300 feet, “ALERT” will illuminate on the display, and an audible tone will be heard. Pressing the altitude hold mode button on the KFC 325 will cancel any currently set altitudes in the KAS 297B, insert the current barometric altitude, and begin to level the aircraft to hold the shown altitude. Whenever a change in vertical speed occurs by means other than the concentric adjustment knobs, such as via the KFC 325 rocker switch, or when using external hardware, the vertical speed will be displayed momentarily for two seconds if the unit is otherwise displaying the selected altitude.



When adjusting vertical speed, the aircraft will remain level at the currently captured altitude until vertical speed mode is activated. Pressing the “VS ENG” button when the vertical speed is displayed will begin a climb or descent at the currently selected vertical speed. Pressing “VS ENG” when the selected altitude is displayed will synchronize the target vertical speed with the aircraft’s current vertical speed and begin a climb or descent. If the climb or descent is in the direction of the selected altitude, altitude capture will automatically be armed. Alternatively, pressing the “ALT ARM” button when either value is displayed will toggle altitude capture arming mode. When altitude capture is armed, pressing “VS ENG” when either value is displayed will begin a climb or descent with the selected vertical speed.

NOTE: In order to use the new vertical speed arming capabilities of this unit, external hardware must be configured to use the HTML events: “kas297b_VsButton”, “kas297b_ArmButton”, “kas297b_1000_INC”, “kas297b_1000_DEC”, “kas297b_100_INC”, and “kas297b_100_DEC”. If you do not wish to use these events, the original functionality of the KAS 297B in this aircraft without vertical speed arming has been maintained for use with the native vertical speed hardware events, such as “AP_VS_VAR_INC” or “AP_VS_VAR_SET_ENGLISH”.

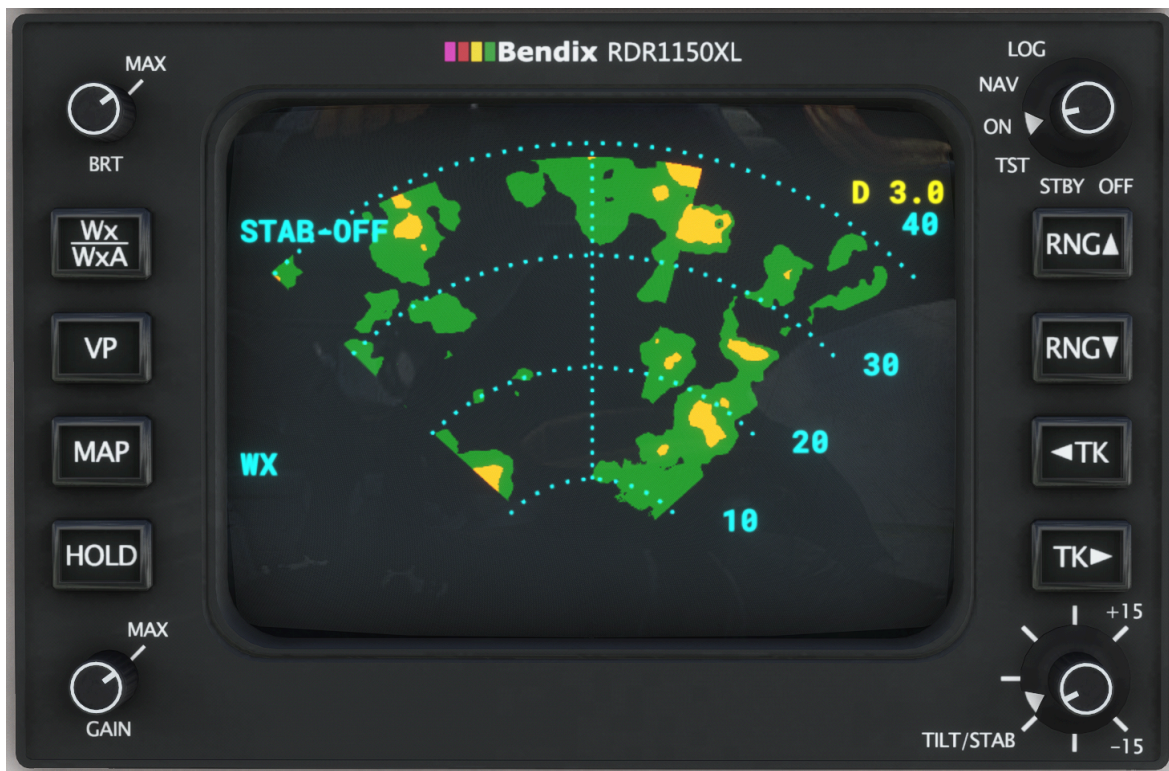
Bendix RDR 1150XL Color Weather Radar

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.

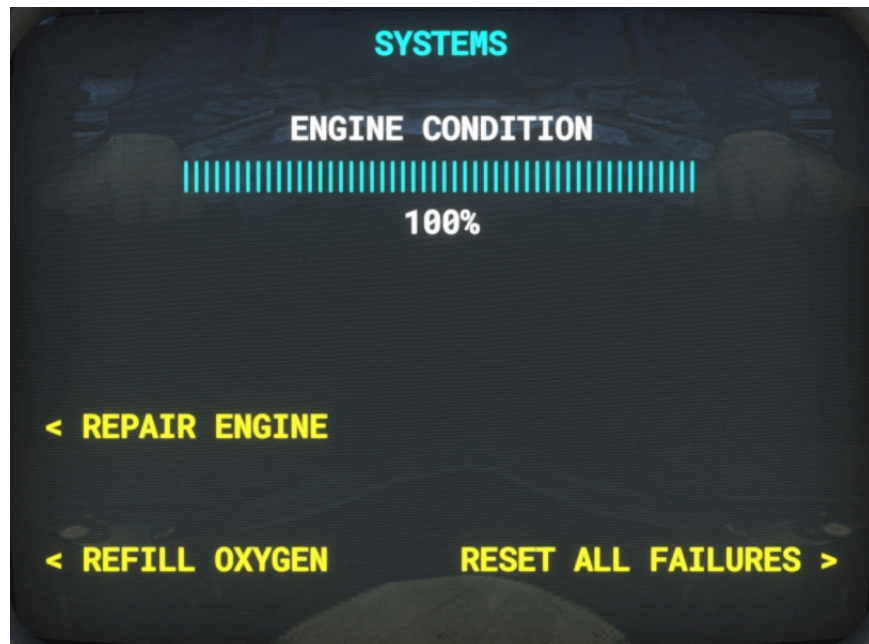
In “TST” mode, the unit will continuously display a sweeping test signal from the radar unit, which should subtend the full horizontal radar arc, and contain concentric arcs of magenta, red, yellow and green. The “RT FAILURE” flag will also display in cyan.

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.



ETM Engine Trend Monitor

This engine trend monitor is a powerful tool for monitoring turbine engines and aircraft performance, 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 ETM, below.

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 Black Square TBM 850's circuit breaker panel is located on the right wall of the cockpit when the aircraft is equipped with the optional pilot access door. The panel features two types of breakers, ones that cannot be manually disengaged, and ones that can be. The breakers which can be manually disengaged are labeled with their maximum continuous current, and highlighted on a white background. For more information on the design philosophy of the electrical system, see the "Overview Electrical Schematic" section of this manual.



All 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 power, or an alternator failure, all non-essential electrical systems should be switched off, workload permitting.

Voltmeter & Ammeters

On the overhead panel are a voltmeter and ammeter. The voltmeter indicates the voltage sensed at the main distribution bus. Colored arcs on the instrument's scale provide an indication of what voltage range is expected for starting and when the generator is providing power to the aircraft. The ammeter provides an indication of the charge or discharge rate of the battery. Positive values indicate that the battery is charging, while negative values indicate that the battery is discharging. This aircraft has accurately simulated battery charging current which can affect the health of the aircraft. After discharging the battery, such as during starting, or while obtaining clearance, the battery charge current may be excessive once the generator is brought online. Observe the +50A limit specified in the checklists to avoid damage.



Bendix/King KA 51B Remote Compass Synchroscope

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

“FREE” position. In this mode, the input of the magnetometer will be ignored, and the unit will behave like a normal directional gyroscope. The position of the remote compass can be advanced in one direction or another by holding the remaining switch on the remote compass control in either the clockwise (“CW”) direction, or the counter-clockwise (“CCW”) direction. In this mode, the synchroscope will show the set compass position’s deviation from the detected magnetic heading.



Gyro Suction Indicator

The gyro suction indicator shows the vacuum suction generated by the engine-driven vacuum pump. 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, when the engine is running near cruising power. As the outside air becomes less dense with altitude, the vacuum suction will begin to decline.



Terrain Warning System

This aircraft is equipped with a terrain warning system, which is capable of providing the pilot with basic aural alerts based on sensed information from the radar altimeter. The system may be inhibited during non-hazardous low altitude operation by pressing the “TERR INHB” button. The system and aural warnings can be tested by pressing the “TEST” button. The unit’s indicator lamps can be tested with the “ANNUN TEST” button located below the terrain warning panel. The system will use the cautionary phrase “SINK RATE”, or the warning phrase “DON’T SINK”, whenever vertical speed falls into either the caution or warning regimes, which are calculated based on radar altitude. The system will also announce when the aircraft is descending below 500 feet above the surrounding terrain with the phrase “FIVE HUNDRED”.



Oxygen Pressure Gauge

On the ceiling, above the overhead panel, 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 arm the oxygen system, the overhead “OXYGEN” switch should be positioned in the on position. No oxygen will flow with this switch in the on position alone, unless that cabin altitude is above 14,000ft. Additionally, the amber “OXYGEN” annunciator light on the main annunciator panel must be extinguished. This annunciator indicates that a valve has been left closed while recharging the oxygen cylinders that is only accessible from the exterior of the aircraft.

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 “SYSTEMS” page on the weather radar. When the passenger oxygen system is activated, the sound of pressurized gas flowing through pipes will be audible.

To activate passenger oxygen masks, either the “PASSENGERS OXYGEN” switch must be placed in the on position, or the cabin altitude must be above 14,000ft for automatic deployment. The “OXYGEN” master switch must also be in the on position. Crew oxygen is supplied via the quick-donning oxygen masks above the crew seats.



To activate the crew oxygen masks, depress the red “PRESS FOR CREW OXY” tabs. When the crew oxygen masks are activated, the sound of breathing through a diluter-demand oxygen mask will be heard. Keep in mind that the crew’s oxygen masks are located on the opposite side of the aircraft from where they are sitting for best accessibility in a small cabin.

LC-2 Digital Chronometer

To the left of the pilot's yoke is a digital chronometer. This chronometer is capable of displaying zulu time in 24-hour format, the current month and day, and an elapsed time stopwatch. A decimal place on the clock display is located above either the word "CLOCK", "TIMER", or neither to indicate which mode is active. Clock and timer modes are toggled between by pressing the "MODE" button. The month/date mode is accessed by pressing the "DT/AV" button. In timer mode, the rightmost button is used to start and stop ("ST/SP") the timer, and the leftmost button is used to reset the timer ("RST").

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.



Davtron Outside Air Temperature Display

At the bottom left of the pilot's instrument panel is a simple outside air temperature LCD display, labeled "Outside Air Temp.", which indicates the current outside air temperature in degrees Fahrenheit, or Celsius. To switch between display modes, press the blue push button.



Lighting Controls

The lighting controls in the Black Square TBM 850 can appear redundant if the operator is not aware of the intended use for each system and control, which are designed for convenience.

Cabin Lighting

The overhead cabin lighting consists of individual reading and baggage lights, and access lighting. The reading and baggage lights are toggled with one push-button toggle switch per light on the decorative overhead panel. The multiple access lights throughout the cabin are toggled by pressing any of the access lighting momentary push-buttons, including the one on the cockpit lighting panel above the throttle quadrant, labeled “ACCESS”. The reading lights can be disabled or enabled with the master “CABIN” toggle switch on the same panel.

The purpose of this lighting scheme is to allow the pilot to ensure a dark cabin for critical phases of flight by disabling the cabin reading lights, yet allow for easy access lighting control when needed, regardless of the master cabin lighting switch.

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 crew member has a swiveling overhead reading light, activated by small rocker switches on the cockpit walls. Each yoke also possesses a dimmable reading light focused on the integrated clipboards.



Panel Lighting

Two types of panel lighting are controlled via the dimmer knobs on the lighting control panel, from off to full brightness. The “INSTR” dimmer knob controls the intensity of integrated and integral lighting in all cockpit instrumentation. The “PANEL” dimmer knob controls glareshield flood lighting that illuminates the entire instrument panel.



In addition to these dimming lights, there are also two dimmable lights on the ceiling of the cockpit that are connected directly to the hot battery bus. These lights, referred to as emergency panel lights, are activated and dimmed with the “PANEL EMER” knob, located above the crew seats on the center ceiling panel.

Voltage-Based Light Dimming

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

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

State Saving

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

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 environmental controls are located on the copilot's main instrument panel to the left of the yoke.

Without the need for any aircraft power, the cabin temperature can be partially equalized with the outside air temperature by opening the pilot or main cabin access 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. The rate at which temperature equalization, active heating, or active cooling can be achieved can be increased by placing the "FAN FLOW" switch in the "AUTO" position when the climate control system is in use, and the cabin is far from the desired temperature. During high altitude flight, the "AUTO" bleed air setting may be insufficient to heat the cabin to a comfortable level. If this occurs, the bleed air switch may be placed in the "HI" position for additional heating.

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 to the right of the copilot's yoke, will display temperatures from -99° to 999° Celsius, or Fahrenheit, toggleable with the small blue push button. Backlighting for this instrument is dimmed via the "INSTR" light dimmer, along with the other avionics backlighting. In addition to this LCD display, two small LED's are located near 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 alternately when the cabin pressurization altitude exceeds approximately 15,000 ft without supplemental oxygen to indicate a hypoxic cabin.



Environmental Control Panel



Cabin pressurization and temperature are controlled via the environmental control panel on the copilot's main instrument panel. The cabin altitude 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 window over the altitude scale. The upper scale (labeled "CABIN ALT") is used to set the desired cabin altitude from -500 ft to 10,000 ft. The lower scale (labeled "AIRCRAFT ALT") 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 2,000 ft at the white diamond index mark, the inner scale will read 17,800 ft. This means that the pressurization controller will be able to maintain a cabin pressure equivalent to 2,000 feet pressure altitude until the aircraft reaches 17,800 feet pressure altitude. If the aircraft continues climbing without an adjustment being made to the pressurization controller, the cabin

altitude will begin climbing beyond the desired 2,000 feet. If the cabin pressure differential becomes negative, or increases beyond 6.2 psi, the electric dump valve will activate, rapidly dropping the pressure differential.

To the right of the cabin pressurization controller dial and instruments is a three position locking toggle switch used to control bleed air. Hot exhaust gasses from the turbine engine are used to heat and pressurize the cabin. The bleed air switch should remain in the AUTO, or HI positions during all phases of flight, except when directed otherwise by a checklist, as the aircraft will depressurize without the bleed air system operating. Below this switch, another three position switch controls the air conditioning system. The “ON” position will automatically heat or cool the cabin. The FAN ONLY position of this switch can be used to cool the cabin with ambient air only, and also heat the cabin. In the off position, there will be no automatic temperature control. The adjacent FAN FLOW switch is used to select fan speed control modes. The air conditioning compressor will not operate when solely on battery power, when starting, when sourcing power from the standby generator or when airframe or propeller deicing systems are activated.

The red, guarded “DUMP” switch manually triggers the electrically actuated pressurization dump valve to rapidly release cabin pressure. Dumping the cabin pressure can be painful for passengers and crew. This switch should only be used during an emergency, or to ensure that the cabin pressure is equalized with the ambient pressure before opening doors. 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.



Below the copilot's yoke, two pull handles control the alternate static air supply, and the emergency ram air supply to the cabin. Pulling the ram air handle outwards admits ambient air into the cabin, which defeats the pressurization system; therefore, it should only be used during emergencies when fresh air is needed in the cabin. Leaving the handle pulled out will not allow the cabin to pressurize after takeoff.

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

Turboprop Engine Operation



Inertial Separator

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

The inertial separator is controlled via a switch on the deicing panel located to the left of the pilot's yoke, labeled "INERT SEP". The inertial separator should be used whenever operating on unimproved or marginal surfaces, and whenever entering visible moisture. It takes 20-30 seconds for the inertial separator louvers to reposition, so anticipation of sky conditions as far as five miles ahead of the aircraft may be required to ensure proper use. The inertial separator is

not fully positioned in the bypass position until the amber “INERT SEP” annunciator light illuminates.

Turbine Engine Ignition

This turboprop engine is equipped with a continuous ignition system that can be toggled on and off manually, or automatically with a three position switch on the overhead panel. In the “ON” position, the igniters arc continuously. This position should be used during extreme weather conditions to prevent engine flameout, such as heavy precipitation. In the “AUTO” position the igniters will only be energized only when the starter switch is in the on position. The automatic position should be used for normal flight and starting procedures.

Torque Limiter & 850 Mode

The flap control lever of this aircraft is equipped with a gated fourth position, referred to as “850 Mode”, which is only available when the flaps are fully retracted. In this position, climb and cruise flight may be conducted above the 100% torque value, as indicated on the torquemeter. When 850 Mode is not engaged, a torque limiter prevents the pilot from torquing the engine beyond approximately 105% torque at sea level; however the torque limiter should not be relied upon during takeoff, and power should be set as if there were no torque limiter present, as the torque limiter is not very precise, and the actual torque limit varies with atmospheric conditions. Operators should be aware that the red “TQ” annunciator does not illuminate for torque exceedances above 100% regardless of 850 Mode, only for torques exceeding 121.4%.

Turbine Engine Fuel Control Failures

This aircraft implements two types of partial engine failures that are unique to turbine engines. The first is a fuel control failure, resulting in the engine’s power lever having minimal or zero control over the engine’s fuel flow. This failure can occur during any phase of flight. In the case of the Black Square TBM 850, this failure may not necessitate an engine shutdown, as the fuel control manual override lever may be used to restore throttle control. Should this occur, follow the loss of engine power checklist, and advance the manual override lever slowly out of its detent. Operators should take extreme caution when applying power changes through the manual override control, as the mechanical control system of the primary fuel control unit is not present when operating through the backup control.

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

Propeller Governor

The propeller governor is an essential component of a high performance aircraft that controls the pitch of the propeller blades, usually by metering oil pressure to the propeller hub. In single

engine aircraft, the propeller blade pitch system is usually configured to drive the blades into their fully fine position automatically when oil pressure is lost. For this reason, a decrease in indicated oil pressure is expected while exercising propeller pitch on the ground. To ensure that these systems are functioning properly, a governor test button is provided for use during the runup procedure. Holding the “PROP O’ SPEED TEST” button, located above the flap control lever, will offset the overspeed propeller governor to a lower RPM, limiting the propeller to around 1800 RPM. Should the governor fail to maintain the expected RPM in flight, or on the ground, the flight should be discontinued as soon as practical.

Engine Visual Model

The Black Square TBM 850 is equipped with a visual model of the Pratt & Whitney PT6A-66D engine. Both sides of the engine cowling can be opened by depressing the rudder pedal adjustment levers in the cockpit. These are the two black levers inset into the cabin side walls, just under the main instrument panel on both the pilot and copilot’s side of the aircraft. For best performance, the engine visual model is not rendered when both cowlings are closed; thus, the high polygon engine model should have no impact on your framerate while flying.

Residual Heat & Dry Motoring

With the latest update to this aircraft, the ITT may remain sufficiently hot after shutdown to require dry motoring of the engine to reduce temperatures to safe levels before attempting a start. This limitation may present itself during quick turnarounds in high ambient temperatures with little wind to provide cooling. Should the ITT remain above around 150°C, cranking the engine with the electric starter motor will promote airflow through the compressor section, more quickly cooling the engine. Repositioning the aircraft into the wind will also help cool the engine before attempting a restart.

P2.5 Bleed Air Valves

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

External Power

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



Engine Power Settings

Shaded areas denote operation at max. torque or max. ITT. All figures at max. gross weight.

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

Press. Alt. (ft)	Torque	Prop RPM	Fuel Flow (GPH)	T/O Ground Roll (ft)	50ft Obstacle T/O Dist. (ft)	Rate of Climb (ft/min)
SL	100%	2,000	82	2,035	2,840	1,570
2,000	100%	2,000	82	2,280	3,150	1,540
4,000	100%	2,000	82	2,545	3,510	1,510
6,000	100%	2,000	81	2,890	3,955	1,480
8,000	100%	2,000	81	3,315	4,445	1,445

Maximum Cruise Power - Standard Day (ISA)

Pressure Alt. (ft)	Torque	Prop RPM	Fuel Flow (GPH)	Indicated Airspeed	True Airspeed	Range (nm)
SL	121%	2,000	89	241	244	745
10,000	121%	2,000	76	229	269	944
20,000	121%	2,000	69	217	298	1,122
25,000	120%	2,000	67	211	313	1,202
30,000	105%	2,000	58	193	311	1,333

Normal Cruise Power - Standard Day (ISA)

Pressure Alt. (ft)	Torque	Prop RPM	Fuel Flow (GPH)	Indicated Airspeed	True Airspeed	Range (nm)
SL	121%	2,000	89	241	244	745
10,000	121%	2,000	76	229	269	944
20,000	121%	2,000	69	217	298	1,122
25,000	113%	2,000	67	210	312	1,177
30,000	95%	2,000	55	189	305	1,378

Long Range Cruise Power - Standard Day (ISA)

Pressure Alt. (ft)	Torque	Prop RPM	Fuel Flow (GPH)	Indicated Airspeed	True Airspeed	Range (nm)
24,000	55%	2,000	40	144	212	1,341
26,000	61%	2,000	41	151	229	1,413
28,000	65%	2,000	42	154	243	1,451
30,000	66%	2,000	42	153	249	1,472
31,000	67%	2,000	41	152	252	1,521

Climb Performance 130 KTS - Standard Day (ISA)

Target Alt. (ft)	Torque	Prop RPM	Fuel Flow (GPH)	Time to Climb (min)	Fuel to Climb (gal)	Dist. to Climb (nm)
5,000	121%	2,000	87	1	3	5
10,000	121%	2,000	79	5	7	12
15,000	121%	2,000	76	8	11	20
20,000	121%	2,000	74	11	14	28
25,000	120%	2,000	71	14	18	37
30,000	105%	2,000	67	19	22	53

Descent Performance 230 KTS -2,000 FPM - Standard Day (ISA)

Target Alt. (ft)	Fuel Flow (GPH)	Time to Descend (min)	Fuel to Descend (gal)	Dist. to Descend (nm)
30,000	54	15	13	72
25,000	52	13	10	58
20,000	49	10	9	44
15,000	48	8	6	32
10,000	46	5	4	21
5,000	44	1	2	6

Gyroscope Physics Simulation

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

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

Gyroscope Physics

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

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

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

Pneumatic Gyroscopes

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

The speed of a pneumatic gyroscope is controlled by the air pressure (positive or negative) available to it from the source (usually a pump in modern aircraft). The pressure the pump can

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

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

Electric Gyroscopes

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

Tips on Operation within MSFS

Turboprop Engine Simulation

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

Engine Limits and Failures

When you operate an engine beyond its limits, damage to the aircraft is accumulated according to the severity of the limit exceedance, and the type of limit exceeded. For instance, exceeding starting ITT limits will destroy an engine in seconds, while a slight exceedance of the maximum governed propeller RPM would not cause an engine failure for quite some time. When engine health is reduced to 25% of its initialized value, the CHIP DETECT annunciator light will illuminate. If engine parameters are not brought back within limits soon, the engine will fail.

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

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

Beta Range

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

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

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

Electrical Systems

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

Third Party Navigation and GPS Systems

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

While existing Black Square aircraft have required an update to be fully compatible with some of these new products, the Black Square TBM 850 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.

Regarding this specific aircraft, the ETM Engine Trend Monitor includes many more navigation and fuel planning features than the EDM800/760 for reciprocating engine Black Square Aircraft. One of these features has proven difficult to integrate with 3rd party GPS units, because they do not all use the native flight planner. Specifically, Estimated Time of Arrival (ETA) to waypoints and the destination may not possess the correct timezone offset in all conditions. 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.

Deicing and Anti-Icing Systems

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

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

Lastly, the aircraft is also equipped with deicing boots that use regulated bleed air to inflate to shed ice from the leading edges of the aircraft. The airframe deicing switch has two green LED’s above it, which indicate which zones of the aircraft are being deiced at any time. The left LED corresponds to the wings, while the right LED corresponds to the tail surfaces.



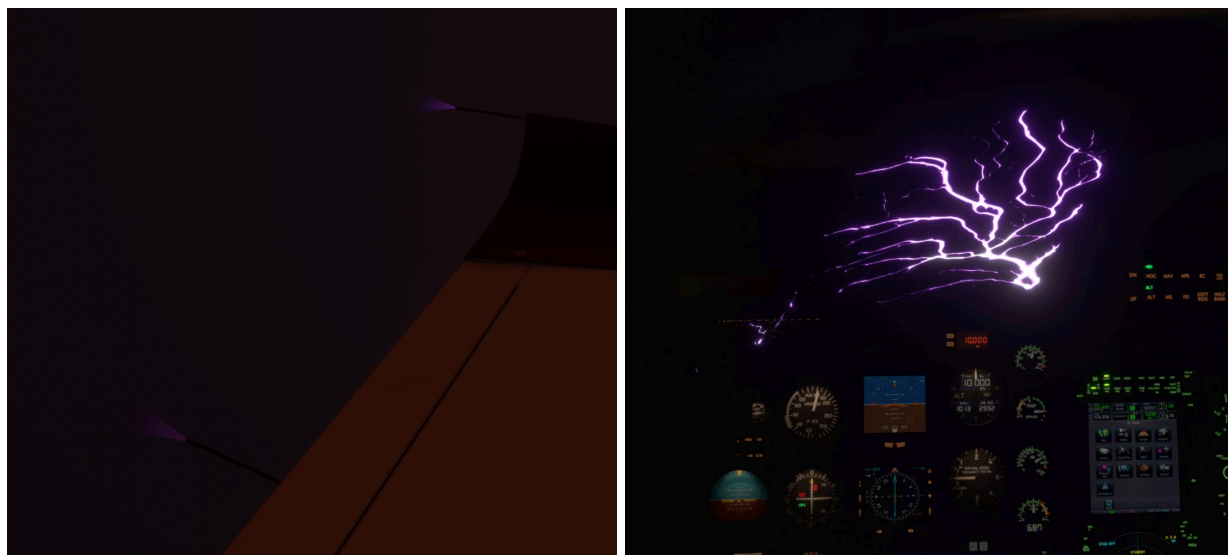
Foreign Object Debris Damage

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

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.

Realistic Strobe Light Bounce

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

Headphone Isolation

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



NOTE: Headphone isolation is not yet implemented in this Black Square aircraft.

Magnetic Compass Effects

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

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

Tablet Interface

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



To show or hide the tablet, click on the tablet or cabin side wall, beside the pilot's seat. The tablet can be moved around the cockpit by dragging the frame of the tablet.

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

Options Page

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

1. Primary Avionics Selection

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

2. Secondary Avionics Selection

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

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

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

3. PMS50 GTN / TDS GTNxi Switch

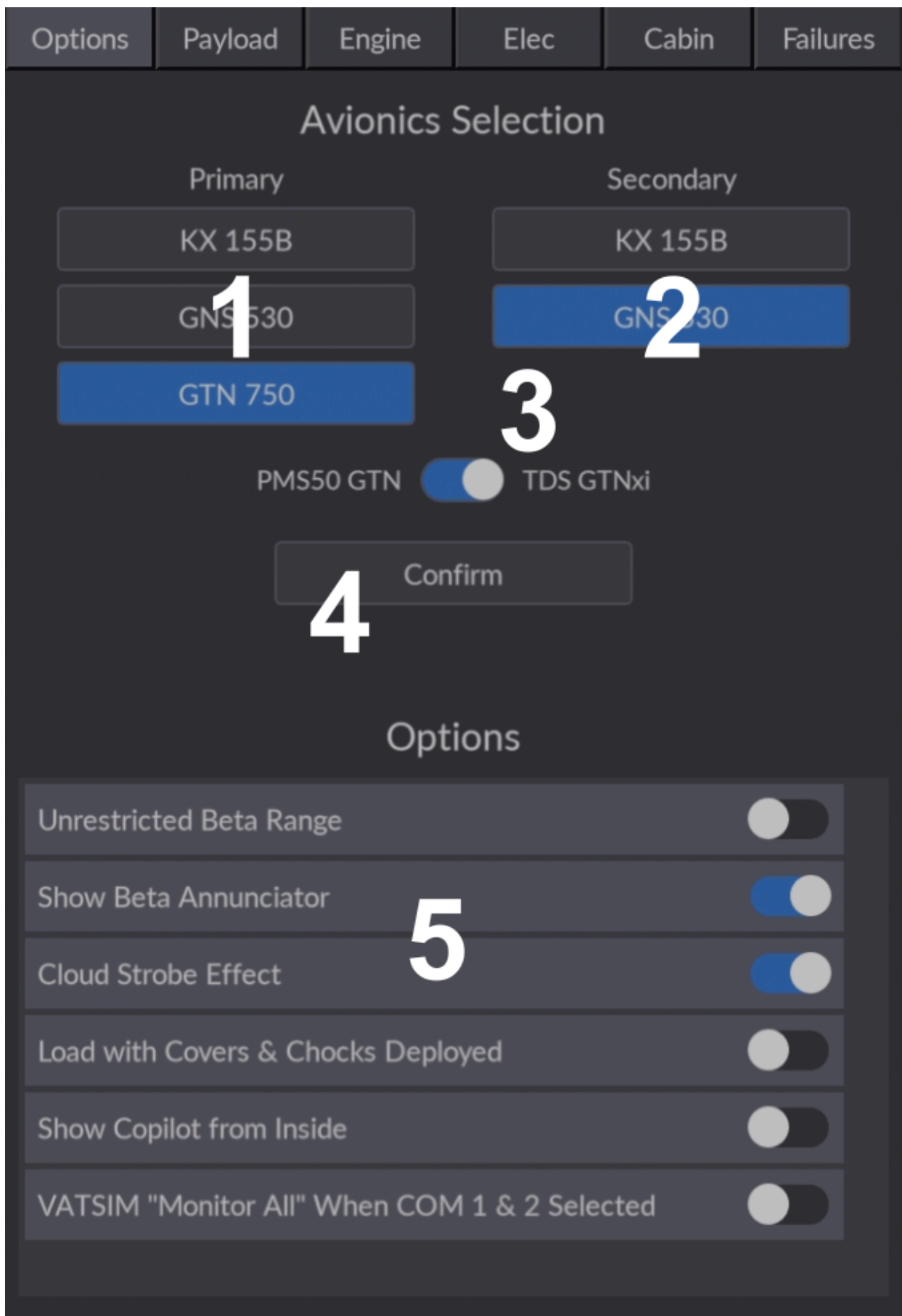
To switch between the PMS50 and TDS offerings of GTN GPS units, toggle this switch. This selection will be saved and recalled at the start of your next flight.

4. Confirm Avionics Selection

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

5. Options List

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



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

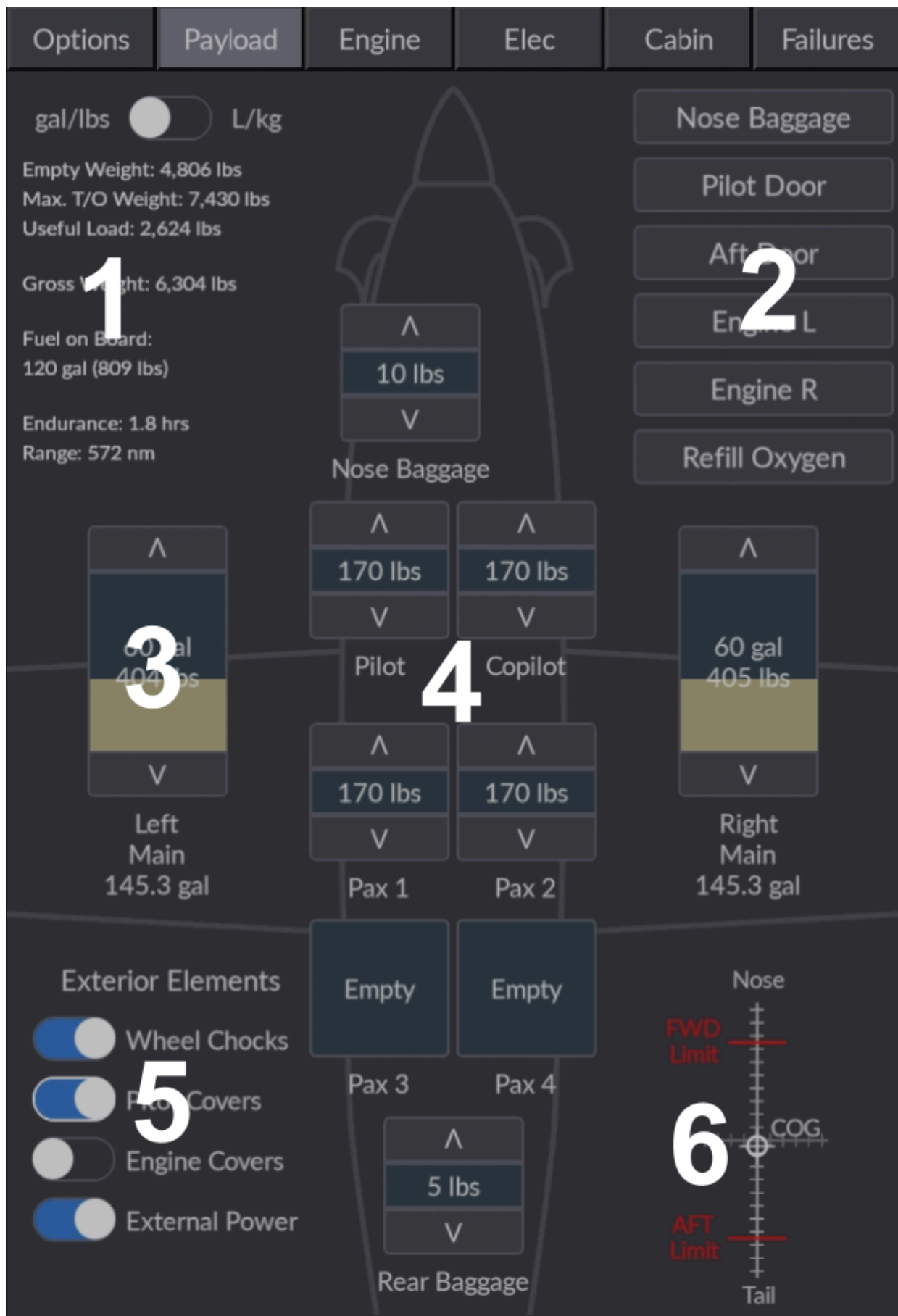
Each payload station in the aircraft is represented by a payload block. When occupied by passengers or cargo, each block shows the current weight of the station in its center. Clicking in the center of the block will toggle the payload between empty, and the default station weight. The weight of the 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.



Engine Visualizer Page

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

Cold Engine

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

1. Repair Engine

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

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

2. Engine Condition Reset Buttons

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

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

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

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

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

3. Fuel & Oil Lines

This aircraft has an electric fuel boost pump and an engine driven pump, an inline primary fuel filter which can become clogged, and an oil-to-fuel heat exchanger.

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

4. Output Shaft

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

5. Planetary Reduction Gearbox

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

6. Power Turbine

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

7. Gas Generator

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

8. Accessory Gearbox

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

9. Induction & Bleed Air Controls

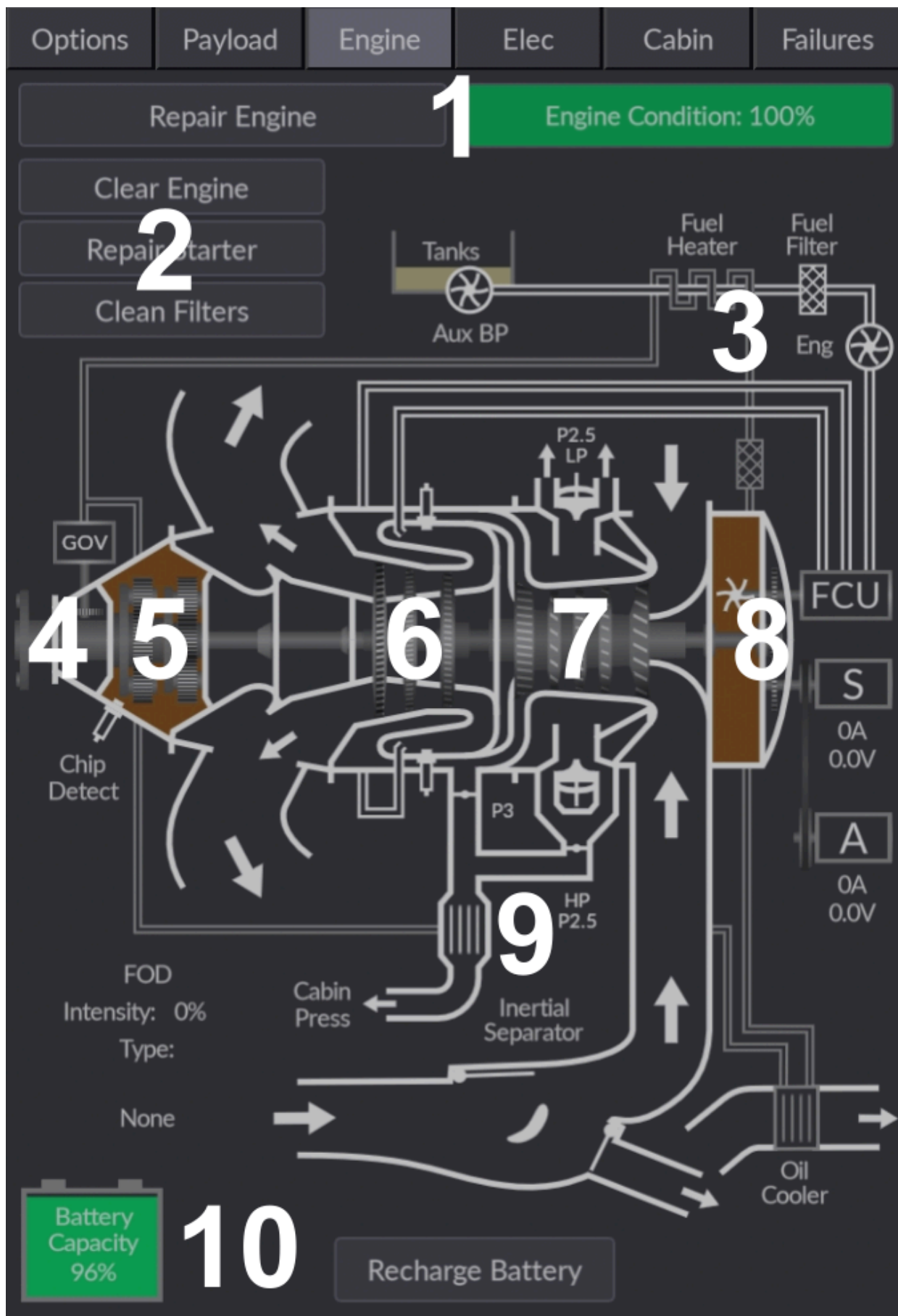
Control of the engine's intake and bleed air relies on a series of valves and louvers. Ambient air enters the induction system through the air inlet under the engine, at the bottom of the visualizer. This air is always at the same temperature and pressure as the air surrounding the aircraft.

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

When ambient pressure and temperature ram air reaches the gas generator, it is pressurized before entering the combustion chamber. This air is metered by the bleed air controller, before being passed through the cooling turbine and intercooler, and then sent into the cabin air ducts. Should the bleed air become contaminated, such as by a carbon monoxide leak, the bleed air valves can be closed by moving the bleed air control switch to the off position. See the "Cabin Environmental Controls" section of this manual for more information on the pressurization and bleed air controls.

10. Active & Inactive Batteries

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



Starting Engine

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

1. Fuel Pumps

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

2. Ignitors

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

3. Fuel Control Unit & Starter Motor

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

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

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

4. Intake Air

The gasses in the intake manifold are color-coded not for temperature, but pressure. Fully saturated, bright blue indicates sea level pressure. Darker blues indicate higher pressures, and greens and yellows indicate lower than sea level pressures. Seen here, the intake air is at the same pressure as the ambient air, but the air in the combustion chamber has been compressed by the gas generator. Before the engine is sustaining combustion the P2.5 bleed air valves will

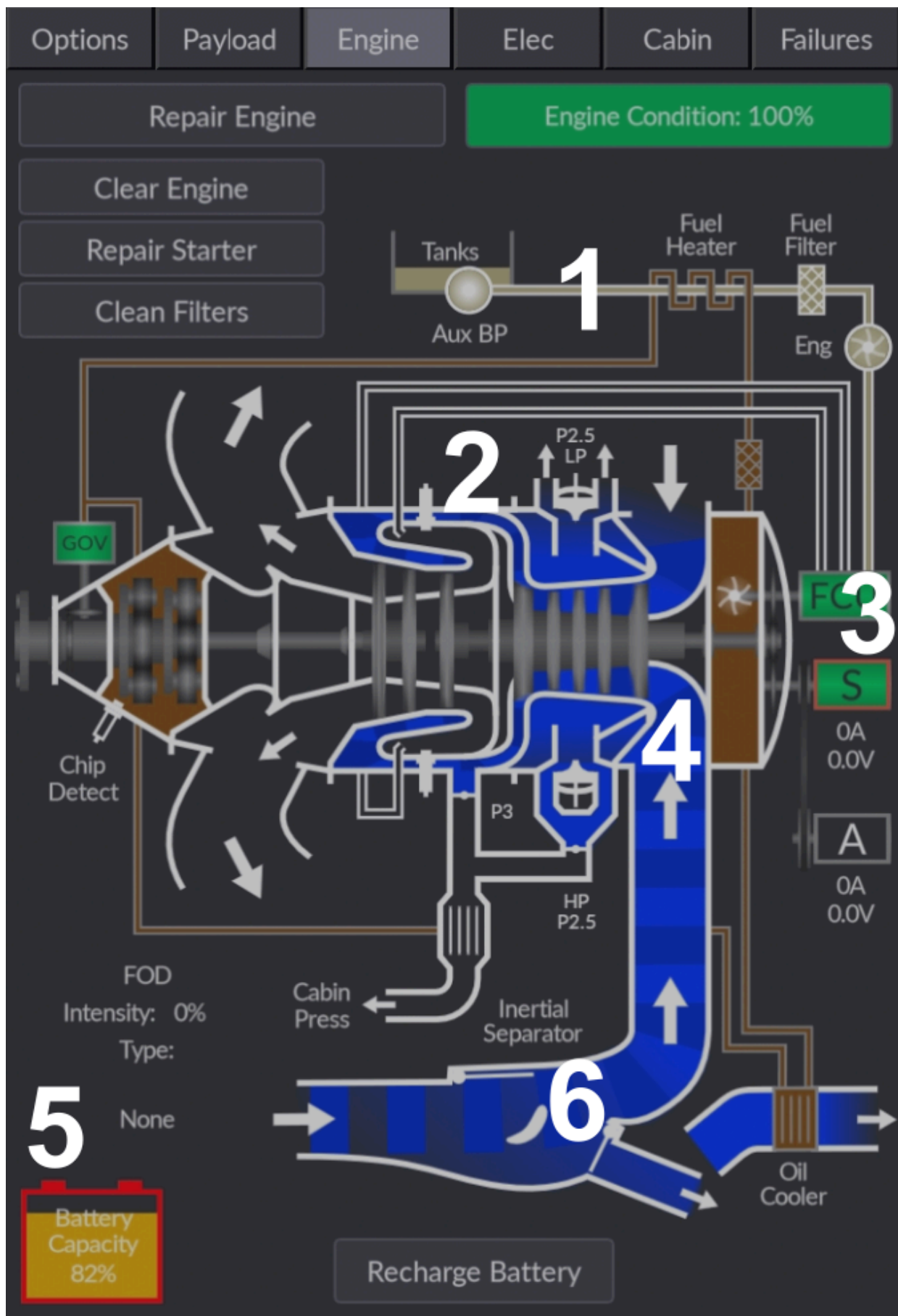
be open, as there is no P3 bleed air pressure to close them. For more information on P2.5 bleed valve operation and failures, see the “P2.5 Bleed Air Valves” section of this manual.

5. Battery Temperature

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

6. Inertial Separator Stowed

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



Running Engine

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

1. Propeller Governor

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

2. Exhaust Gasses

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

3. Combustion Chamber

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

4. Bleed Air Valves

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

5. Oil Pumps, sumps & Lines

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

6. Chip Detector

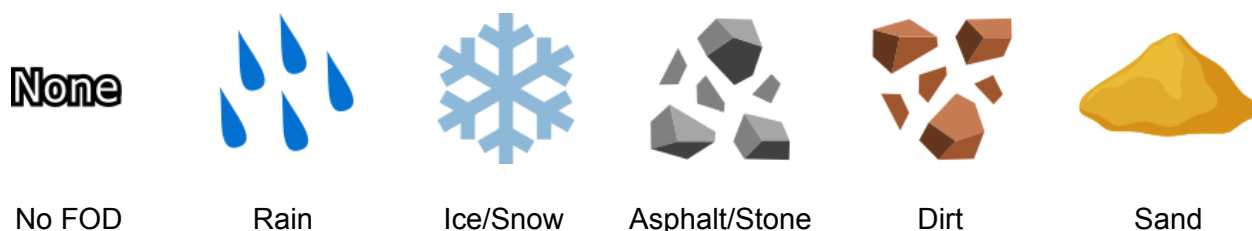
The chip detector is a magnetic pair of electrodes at the bottom of the planetary reduction gearbox oil sump. This is the most likely location in the engine for metallic particles to collect due to wear. The magnet attracts the particulate, and the electrodes allow for a complete circuit to be created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

7. Standby Generator

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

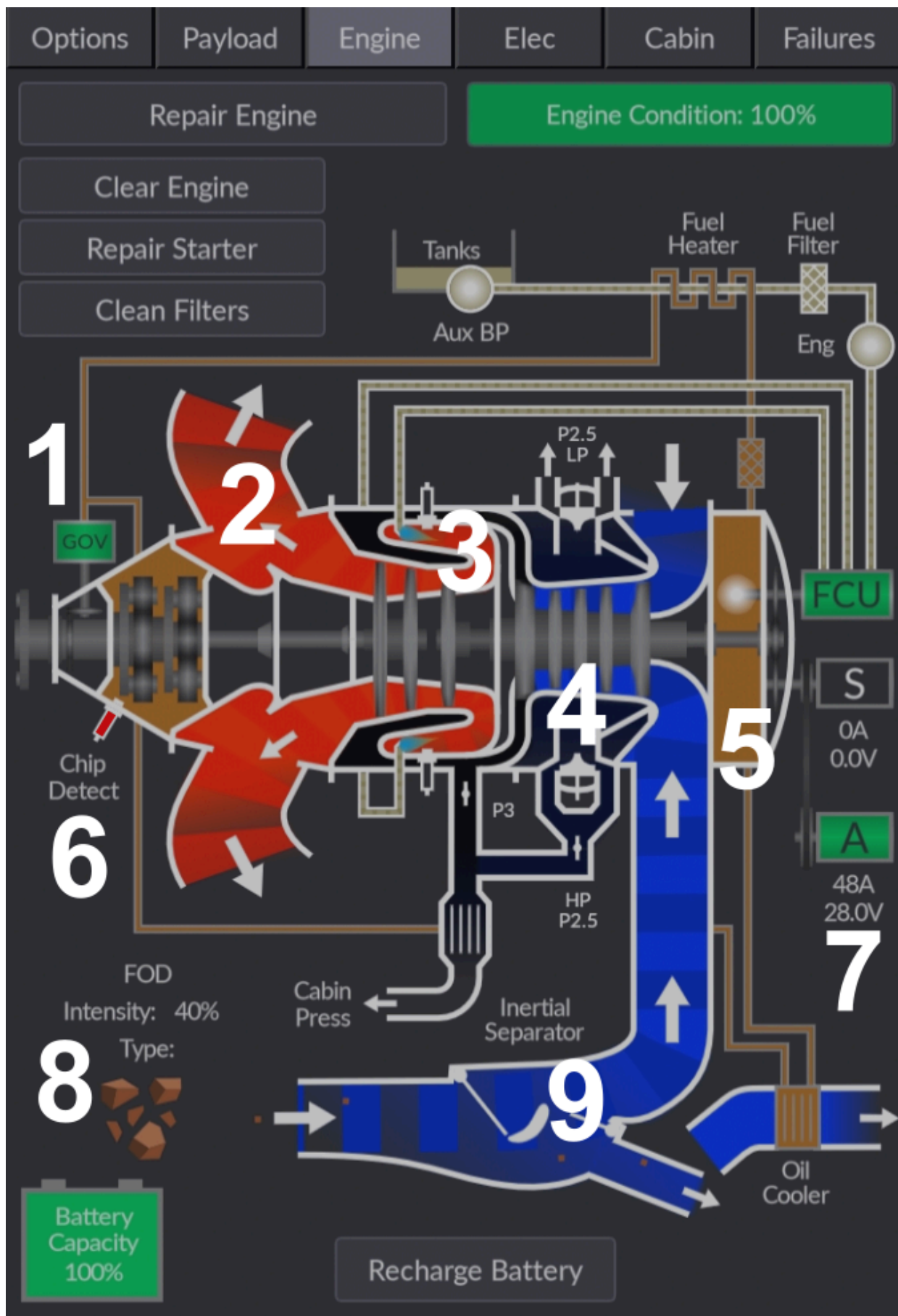
8. Foreign Object Debris (FOD)

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



9. Inertial Separator Deployed

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



Live Schematic Page

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

1. Voltmeter

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

2. Active & Inactive Equipment

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

3. Buses & Circuit Connections

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

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

Logic or signal connections, which do not carry any meaningful current, are depicted as dashed lines. For example, in this aircraft, the 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. In this aircraft, the only ammeter is positioned in-line with the battery, so that the operator can determine whether the battery is being charged or discharged.

6. Circuits

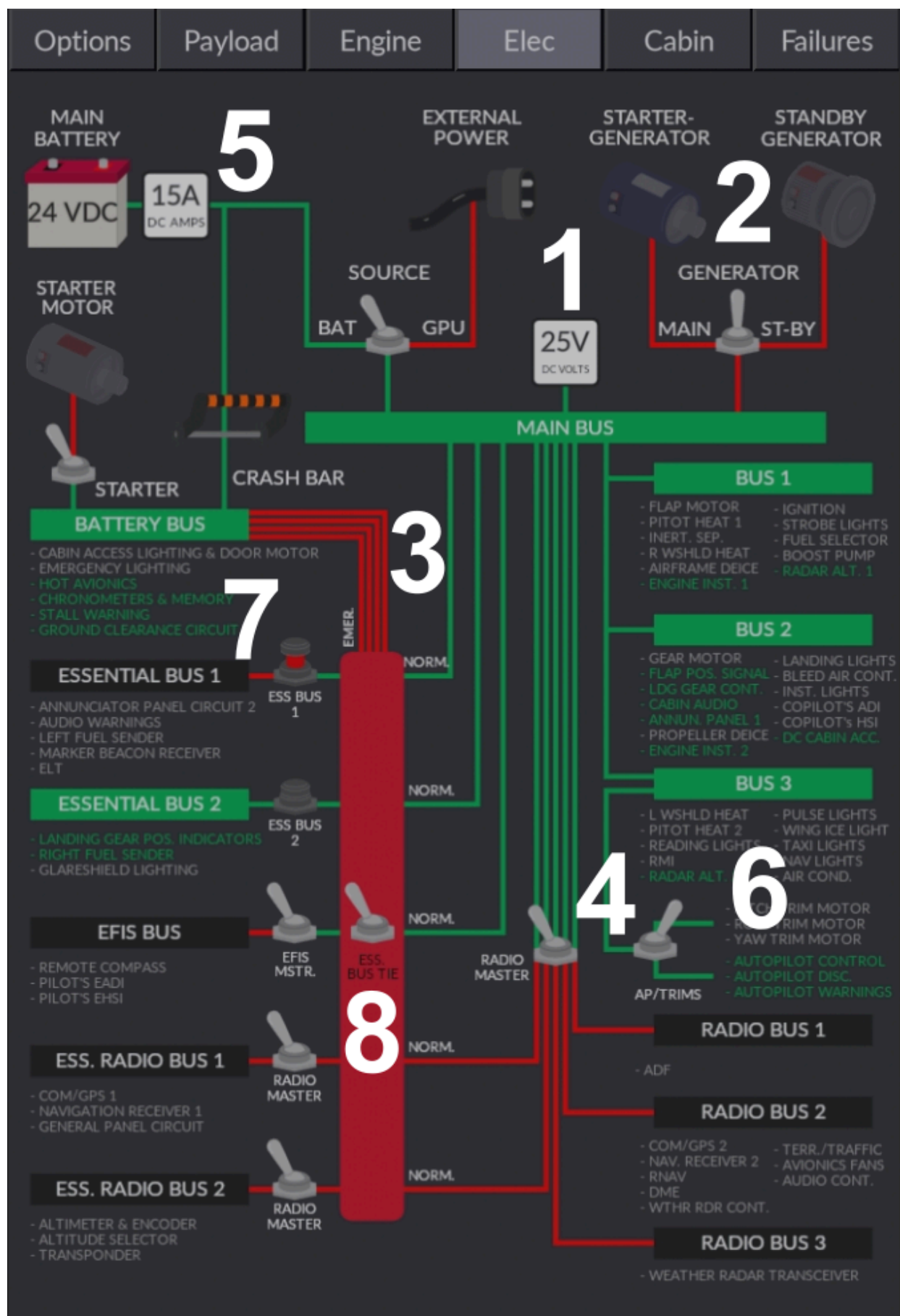
Each circuit for an individual piece of equipment in the aircraft is represented on this schematic. When the circuit is in use and powered, its name will be highlighted in green. Otherwise, the name will be grayed out.

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.

8. Essential Bus

This aircraft possesses load shedding and electrical redundancy features usually common to larger aircraft. In the event of a power distribution failure, power can be restored to only the most essential equipment in the aircraft by way of the "Essential Bus". A covered toggle switch on the top of the circuit breaker panel allows the operator to source power for these essential items directly from the battery. For more information on the essential bus, see the "Overview Electrical Schematic" section of this manual.



Black Square - TBM 850 User Guide (2024)

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 the pressurized P2.5 or P3 bleed air. The bleed air is heated by compression, and by proximity to the engine's combustion chamber. For more information on the environmental control systems, see the "Environmental Simulation & Controls" section of this manual.

1. Engine Bleed Air Supply

The heating and pressurization system in this aircraft derives hot pressurized air primarily from the P2.5 bleed valve on the engine. Hotter and more pressurized air can also be sourced from the P3 bleed air valve for high altitude operation when the bleed air switch is set to the "HI" position, which may become necessary at very cold ambient temperatures. Here, two valves can be seen, which are used to control the flow of the P2.5 and P3 bleed air.

2. Ram Air Intake

When the bleed air leaves the engine, it is very hot, and is used to melt ice around the engine's induction air intake. To cool the bleed air before it enters the cabin, ram air is passed over an intercooler. Ram air enters through a large NACA duct on the right side of the engine cowl. Before passing over the intercooler, an emergency ram air valve can be positioned to divert ram air into the cabin in case of an emergency, such as smoke in the cockpit. This valve is controlled via the locking pull handle in the cockpit, below the copilot's yoke.

3. Cooling Turbine

When the aircraft is operating on the ground and there is no ram air pressure, airflow for the bleed air intercooler is supplied by a cooling turbine, which operates similarly to a turbocharger in a reciprocating engine aircraft. Bleed air exiting the engine spins a turbine, which pulls air in through the right-side NACA duct.

4. Air Vents & Air Flow Selector

The vents positioned throughout the cabin carry either hot pressurization air, or recirculated cabin air, which has been cooled by the evaporator coils above the baggage compartment in the aft of the aircraft. Positive pressurization airflow is generated by the bleed air pressure and ram air pressure on the cooling turbine. Positive cooling airflow is generated by the AC evaporator cooling fan in the aft of the aircraft, which can be run without the air conditioning in the by placing "Air Cond" switch in the "Fan Only" position. The fan above the nose baggage compartment of the aircraft only provides airflow over the condenser coils of the vapor cycle cooling system. The airflow selector valve controls how much hot bleed air is diverted towards

the windshield and cockpit side windows, as opposed to directed into the cabin. The valve can be positioned at any intermediate position.

5. 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.

6. 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.

7. Ear Discomfort Index

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

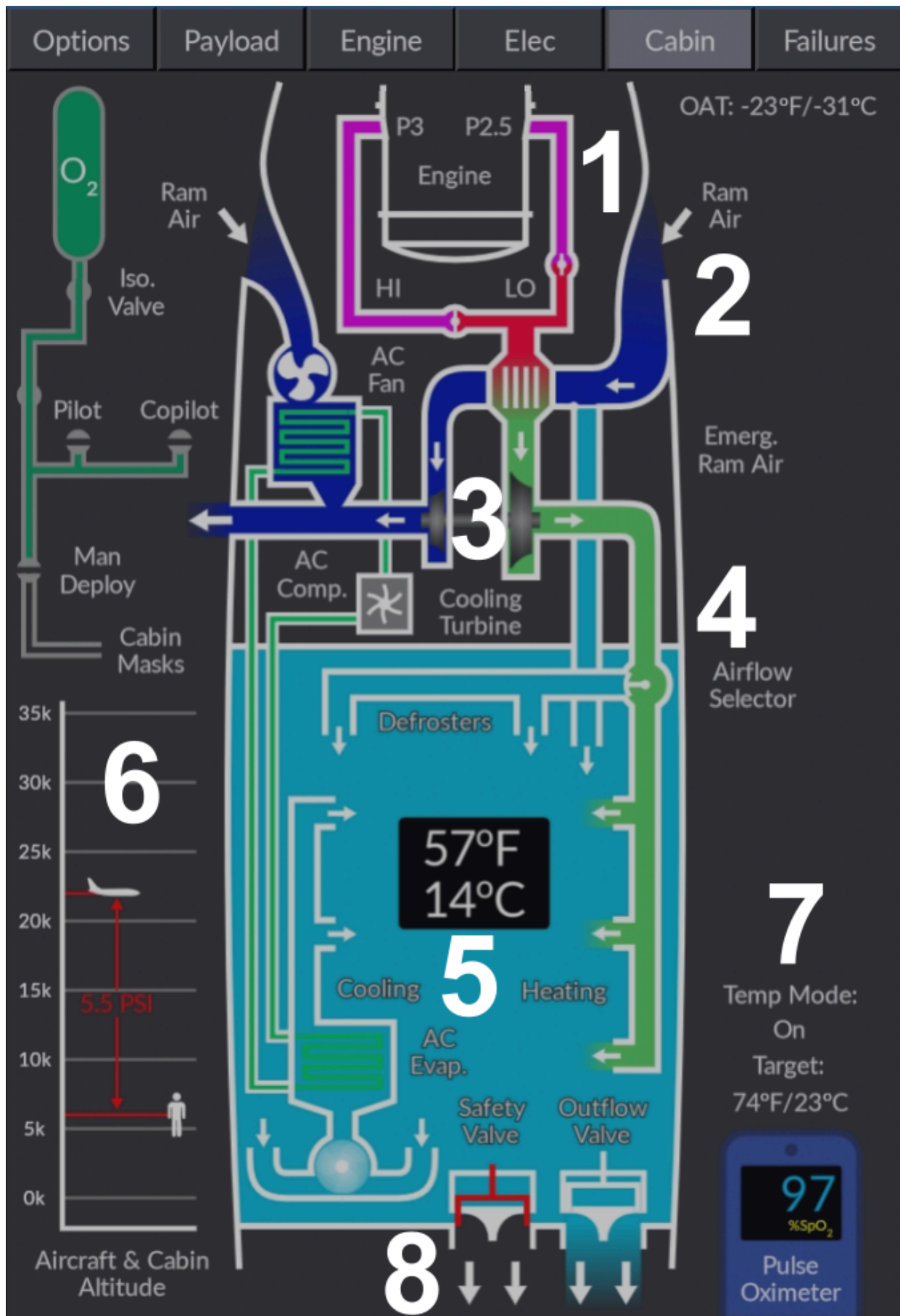
8. Climate Control Modes & Target

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 display the numeric set point of the "CABIN TEMP" rotary selector knob, when the automatic climate control system is receiving power. Otherwise, the target will appear as "None". When the target temperature is not attainable in the current ambient conditions, the target value will appear in red. This should be the operator's cue to set the bleed air switch to the "HI" position while climbing, or that the air conditioner is operating at maximum capacity.

9. 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.



Cooling Cabin

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

1. Oxygen System

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

2. Emergency 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 emergency ram air valve is in the open position, allowing ram air to flow into the cabin.

3. Evaporator Fan & Air Conditioning Evaporator

The air conditioning fan and evaporator coils are located above the aft baggage compartment, and deliver air to the occupants through the overhead ducts. The fan will run any time the “Air Cond” switch is in the “Fan Only” or “On” position. When the air conditioning compressor is operating, chilled refrigerant will be passed through the evaporator coils. The speed of the air conditioning fan can be controlled via the “Fan Flow” switch.

4. Air Vents & Air Flow Selector

The air vents and air flow selector valve operate as discussed in the cabin heating section, above. Here, the air conditioning is operating to cool the cabin, while the cooled bleed air is maintained at ambient temperature, and only used to pressurize the cabin.

5. 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.

6. Air Conditioning Compressor & Condenser

The air conditioning system (also known as the vapor cycle cooling system), is driven by an electric motor, as opposed to many aircraft where it is driven directly from the engine. This allows the cabin to be cooled before the engine is running. When the compressor motor is running, 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 above the nose baggage compartment, which requires cooler ambient air to operate. A small screened inlet forward of the copilot's windshield directs ambient air towards the condenser coils. For more information on the air conditioning operation, see the "Environmental Simulation & Controls" section of this manual.

7. Climate Control Modes & Target

The display of operating modes and target temperatures is discussed in the cabin heating section, above. Here, the automatic cooling target temperature is displayed in red, indicating that the air conditioner cannot cool the cabin to the desired temperature, because the outside ambient temperature is too warm.

8. Pulse Oximeter

Loss of consciousness 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.

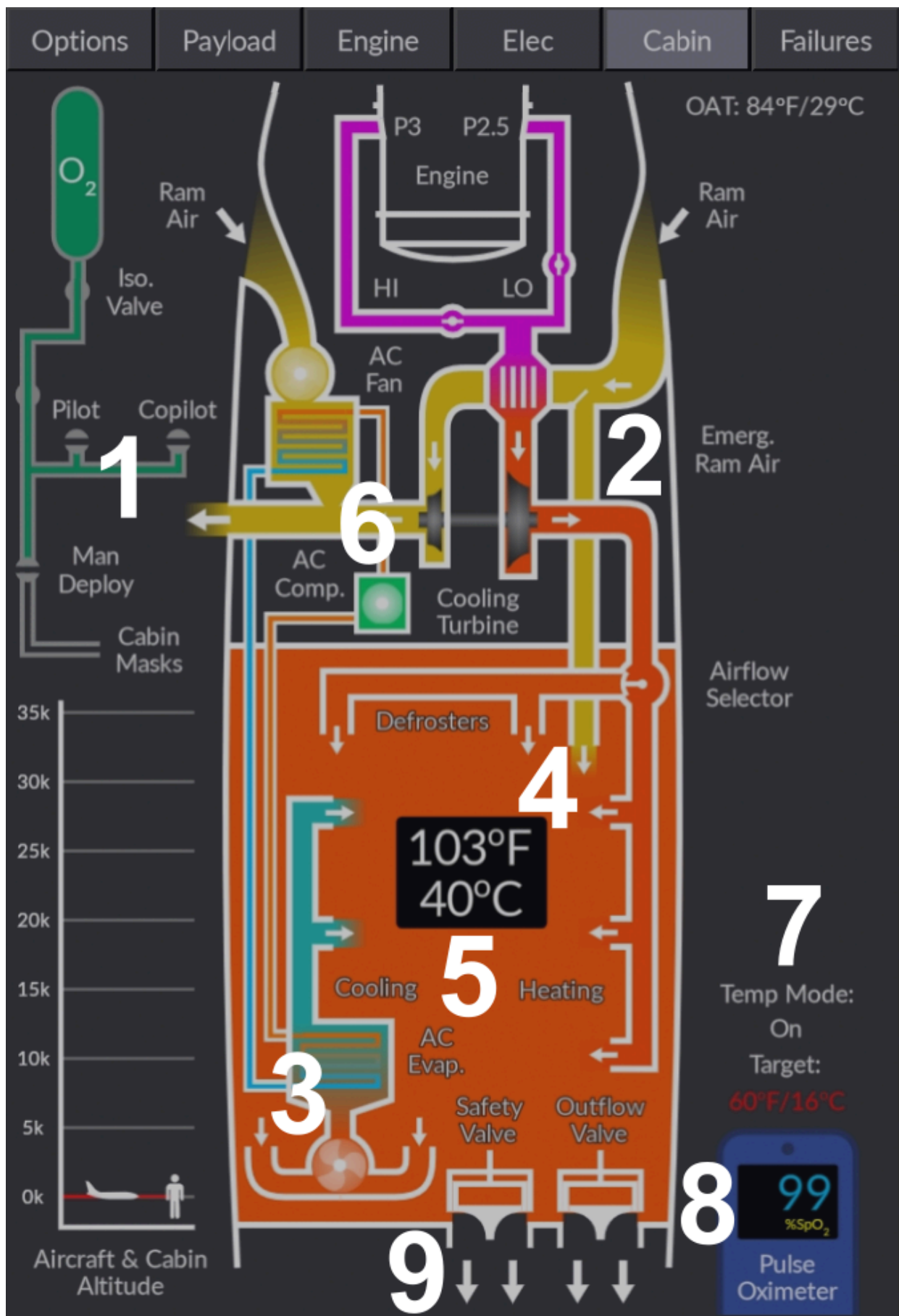
The recommended, and legally required, altitudes for supplemental oxygen use of around 12,000 - 14,000 feet correspond to an SpO_2 of roughly 90-92% for exposure under 60 minutes.

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.

9. 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.



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

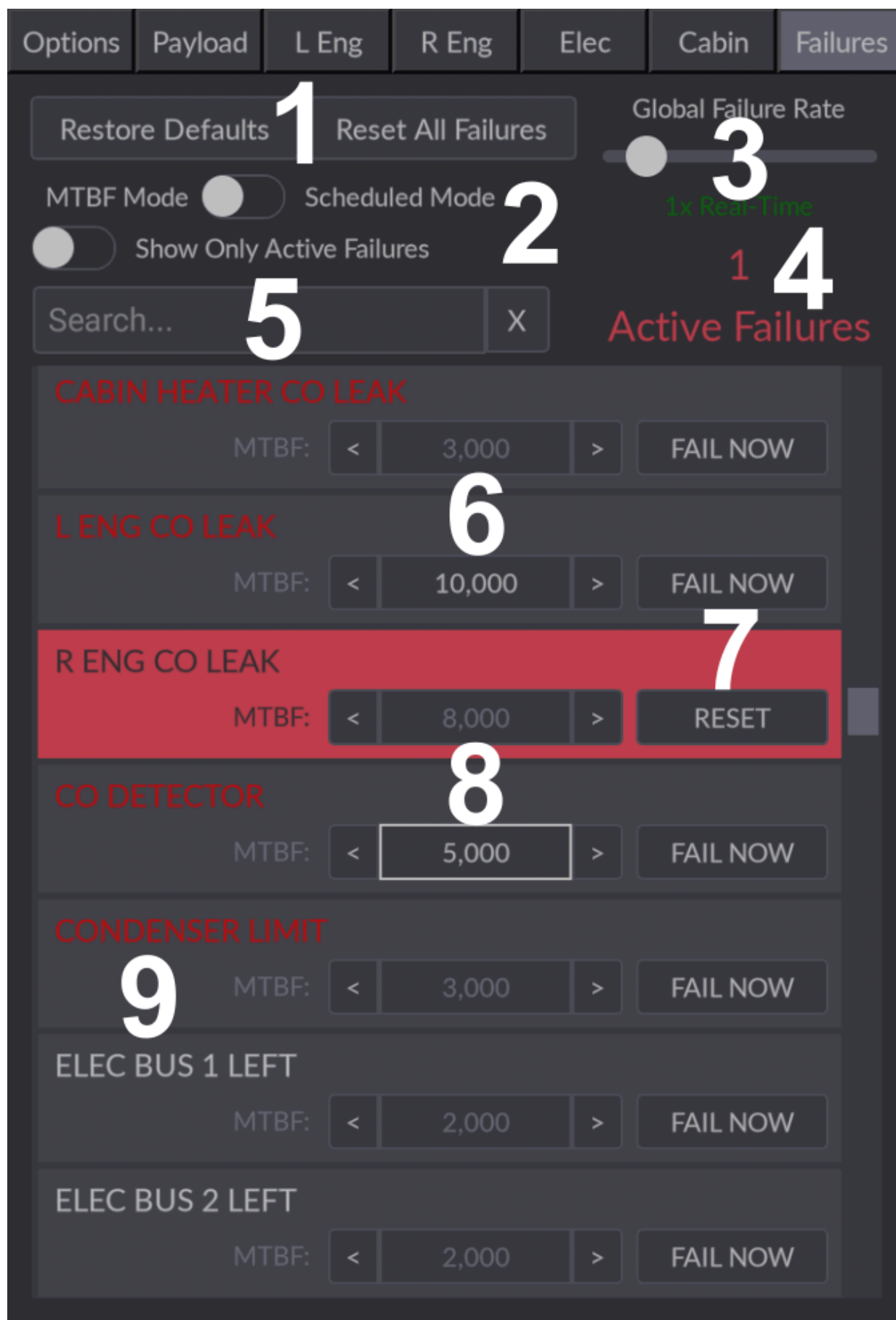
After being triggered by any means, individual failures can be reset by pressing the “RESET” button. Failures can also be triggered manually in this mode by pressing the “FAIL NOW” button.

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.



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.



Failure System HTML Interface

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

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

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

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

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

```
>H:BKSQ_FAILURE_L_FUEL_QTY
```

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

```
>H:BKSQ_FAILURE_RESET_ALL_FAILURES
```

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

List of Possible Failures

Major System Failures

ENGINE FAILURE
ENGINE FIRE
MAIN GENERATOR
STANDBY GENERATOR
PROPELLER GOVERNOR
FUEL CONTROLLER
ENGINE SURGE
PRIMARY INJECTORS
SECONDARY INJECTORS
FUEL FILTER
ENG DRIVEN FUEL PUMP
LP BLEED
HP BLEED
TORQUE LIMITER
VACUUM PUMP
PARTIAL VACUUM
PITOT BLOCKAGE
STATIC BLOCKAGE
L BRAKE
R BRAKE
L FUEL LEAK
R FUEL LEAK
ENVIRONMENTAL FAULT
CABIN SAFETY VALVE
CABIN OUTFLOW VALVE
INFLOW CONTROL UNIT
AIRFRAME DEICE
PILOT DOOR LATCH
AFT DOOR LATCH
OXYGEN LEAK
OXYGEN ISOLATION VALVE
BLEED OVERTEMP

Breaker Protected Failures

STARTER MOTOR
GEAR MOTOR
FLAP MOTOR
PITCH TRIMS
AILERON TRIMS
RUDDER TRIMS
AUTOPILOT
FLAP SIGNAL
GEAR CONTROLLER
GEAR SIGNAL
CABIN CD AUDIO
PITOT HEAT 1
PITOT 2 & STALL HEAT
INERTIAL SEPARATOR
ANNUNCIATORS 1
ANNUNCIATORS 2
AUDIO WARNINGS

AUTOPILOT DISC
AUTOPILOT WARN
ALTITUDE SELECTOR
L WINDSHIELD HEAT
R WINDSHIELD HEAT
PROPELLER DEICE
AIRFRAME DEICE
ENG INSTRUMENTS 1
ENG INSTRUMENTS 2
IGNITION
PULSE LIGHTS
ICE LIGHT
STROBE LIGHTS
L LANDING LIGHT
R LANDING LIGHT
TAXI LIGHT
NAV LIGHTS
BLEED AIR
AIR CONDITIONER
L FUEL SENDER
R FUEL SENDER
AUTO FUEL SELECTOR
AUX BOOST PUMP
INSTRUMENT LIGHTS
PANEL LIGHTS
EMER PANEL LIGHTS
COCKPIT READING LIGHTS
CABIN LIGHTING
EMER LOC TRANSMITTER
EHSI
EADI
GYRO
RMI
ADI2
HSI2
RADAR ALT 2
ACCESS LIGHTING
MEMORY & CHRONO
RADAR ALT 1
CABIN ACCESSORIES
MARKER BEACON
GPS/COM 1
GPS/COM 2
GROUND CLEARANCE
ALTIMETER & ENCODER
TRANSPONDER
NAV RECEIVER 1
NAV RECEIVER 2
RNAV
ADF
DME
TERR & TCAS
WX RADAR CONTROLLER
WX RADAR TRANSCEIVER
AVNCS COOLING FANS

Miscellaneous Systems

Audible Warning Tones

This aircraft is 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 soft beep will sound five times when the aircraft is within 1,000 ft of the selected altitude displayed on the KAS 297B 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. This is notably lower pitch than the gear configuration warning horn.
- **Gear Configuration Warning Horn:** When the power lever is reduced to flight idle, or the flaps are placed in their landing configuration, and the landing gear has not been deployed, a constant tone will sound. This is notably higher pitch than the stall warning horn.
- **Overspeed Horn:** When the aircraft exceeds the VNE (red line) airspeed on the airspeed indicator, a repeating beeping tone warning will sound until the speed of the aircraft is reduced to below VNE. This is the highest pitch tone of the three above.
- **Terrain Warning System:** See the "Terrain Warning System" of this manual for more information on these aural warning messages, and their associated annunciator lights.

The stall and gear configuration warning horns can be tested by pressing the "HORN TEST" button on the center ceiling panel. When both horns are sounding, the high and low pitch tones will alternate. This typically also occurs during power off stall training with the gear retracted.

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.

VOR & ADF Signal Degradation

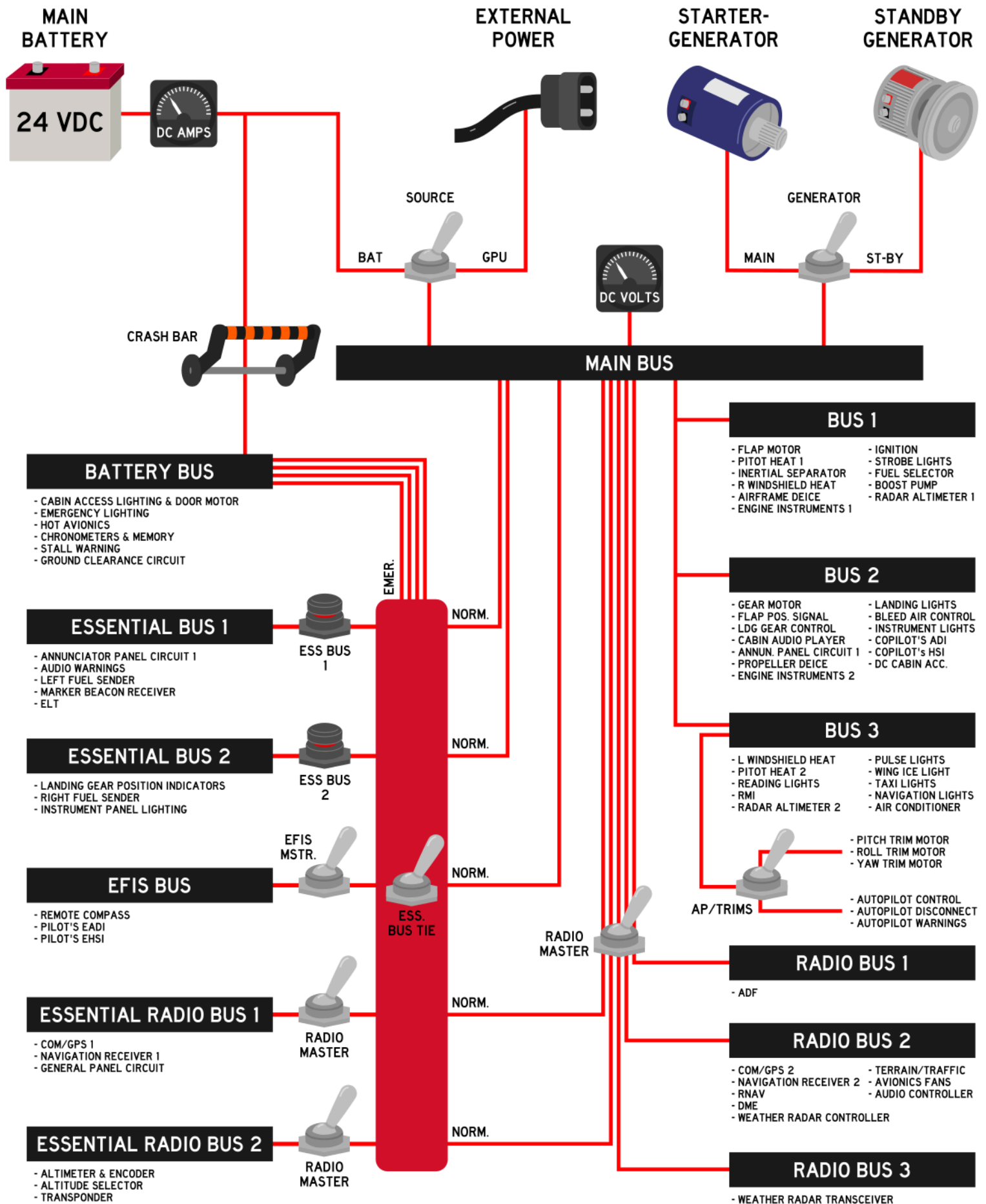
Unlike in the real world, navigation receivers in Microsoft Flight Simulator produce only ideal readings. Signal strength is not affected by distance, altitude, terrain, or atmospheric conditions. When a station is out of range, the signal is abruptly switched off. This is unrealistic, and does not give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

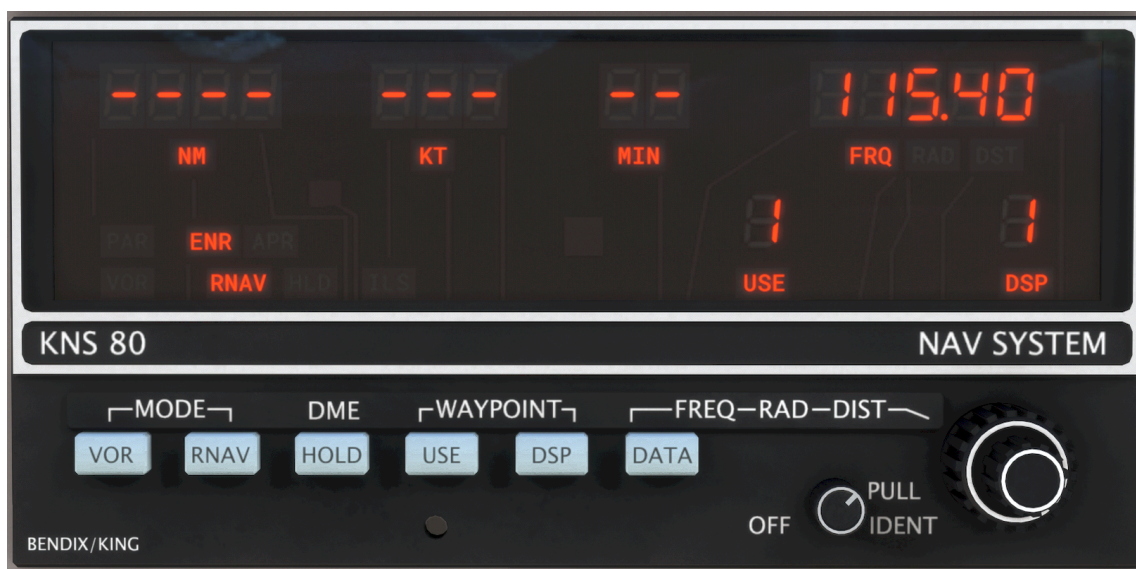
Overview Electrical Schematic

The Black Square TBM 850 electrical system and controls may be slightly confusing to pilot's familiar with older style single engine aircraft. For starters, the orange and black striped "crash bar" above the two main electrical switches on the overhead panel is not merely a convenient way to disable both sources of electrical power. The crash bar is a switch unto itself, which completes the connection between the battery and the battery bus when it is lifted up.

Of particular note, the aircraft's electrical system is designed with a load shedding mechanism by way of an essential bus. A guarded switch on the top of the circuit breaker panel allows the operator to select the battery bus as the source for electrical power, rather than the main distribution bus. In addition to bypassing the main bus which might be the source of a malfunction, switching to the essential bus also sheds the aircraft's electrical system of many nonessential loads. This switch should be positioned in the emergency position whenever called for by the checklists, or when an immediate reduction of electrical load is necessary.



Using the KNS-80 RNAV Navigation System



The Concept

When most pilots hear the acronym “RNAV”, they probably think of the modern RNAV, or GPS approach type, or precision enroute navigation for airliners; however, long before this type of navigation, there was the onboard RNAV computer. This 1980’s era 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-80 Navigation System allows the user to “move” a virtual VOR antenna anywhere they like within the service volume (area of reliable reception) of an existing VOR antenna.

“Moving” a VOR

To “move” a VOR antenna to somewhere useful, we must know how far from the tuned VOR station we would like to move it, and in what direction. These quantities are defined by a

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

Data Entry

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

Data Storage Bins

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

Distance Measuring Equipment

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

the user to change the tuned NAV frequency. This can be useful for some specific instrument approaches. This feature cannot be used in RNAV modes of operation.

Modes of Operation

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

Modes in Summary:

VOR: Angular course deviation, 10° full-scale deflection, just like a third NAV radio.

VOR/PAR: Linear course deviation, 5 nm full-scale deflection, useful for existing airways.

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

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

Other Possible Uses

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

Flying an RNAV Course with the Autopilot

The autopilot will only use the KNS-80 as a navigation source when the no-GPS avionics configuration is selected from the tablet interface. Press the “NAV” source button on the EHSI to select RNAV crosstrack deviation as the active autopilot lateral navigation source. Then, select the desired course with the HSI’s course select knob.

Recommended Skills

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

Direct Flight to Airport Tutorial

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

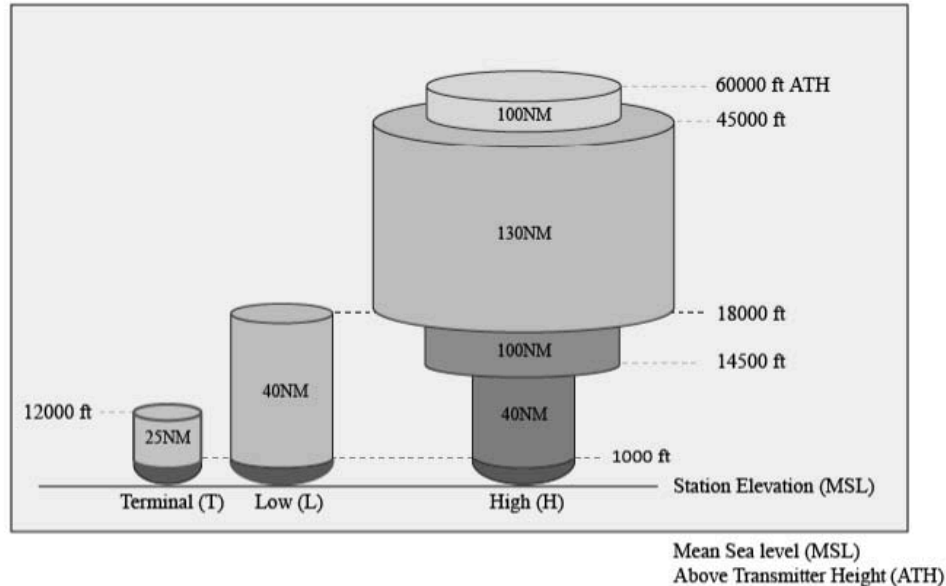
1. Locate the nearest VOR station to your desired destination, and its frequency, radial, and distance from the destination airport. While other station frequencies, radials, and distances can be found on approach, arrival, and departure charts, the easiest place to start is often with a mobile app or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

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

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

For this example, we will choose the nearest VOR at Lawrence Airport, (LWM). This

VOR has a frequency of 112.50 Mhz, a radial to Beverly Airport of 154°, and a distance of 12.3 nm. These are all three pieces of data that we need to fly directly to Beverly.



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



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



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



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

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



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

NOTE: Unlike other Black Square aircraft that implement Bendix/King RNAV systems, the crosstrack deviation information provided by the KNS-80 in this aircraft is viewed through the EFS 40 electronic flight instrumentation system. The RNAV navigation source is selected via the “NAV” button on the EHSI bezel, rather than with a dedicated toggle switch.

Using the ETM Engine Trend Monitor



The Black Square TBM 850 is equipped with the first and most complete implementation of the ETM engine trend monitor to appear in a flight simulator. The ETM is a common piece of engine monitoring equipment found in general aviation turbine engine 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. Due to the cost and relative fragility of turboprop engines, operators keep a close watch on recorded engine parameters. Exceedance alarms alert pilots to dangerous conditions, and realtime information on engine performance provides a means to increase fuel efficiency and reduce wear. For a complete understanding of the unit's functionality, please see the "More Information on Operation" section of this manual for real world operating resources.

The ETM's interface is divided into four "Files" with an arbitrary number of "Pages" in each file. The files are selected with the rotary knob, and pages with the "PAGE UP/DOWN" toggle switch. Some pages have additional subpages, which are selected from with the "INCR/DECR" toggle switch. When power is applied to the unit, a self-test is initiated while the current software version, data version, aircraft model number, and company information is shown.

ETM File - Engine Trend Monitor

Page Name	Example	Description
NG & ITT	NG% 98.4 ITT 746	Gas Generator RPM % Interstage Turbine Temperature °C
TQ & ITT	TQ 1124 ITT 728	Propeller Torque in FT-LBS Interstage Turbine Temperature °C
Prop & NG	NG% 98.4 NP 746	Gas Generator RPM % Propeller RPM
SHP	SHAFT HP : 955	Derived Shaft Horsepower $HP = Tq * RPM / 5252$
Specific Fuel	SFC : 0.452	Pounds of fuel consumed to produce one shaft horsepower - engine efficiency
Key Status	Key 21.4%used Status: Init	Amount of data used on USB data stick
Log of Totals, Title Page	LOG OF TOTALS	Use INCR/DECR toggle switch to select sub-page.
Total Cycles, Total Flight Time	AF TC/TT 825/1285:15	Total takeoff/landing cycles of the airframe/ Total hours and minutes of flight time
Engine Total Starts, Engine Total Time	Eng TS/TT 858/1498:58	Total engine start/shutdown cycles/ Total hours and minutes of engine run time
Lowest Voltage Highest ITT	LoV Hi ITT 18.8 821	Lowest voltage and highest ITT during start Symbols: - = stopped, / = starting, = running
Next Inspection	Inspection Due 72:34:12	Time until regular inspection Interval set by maintenance technician



NAV File - Navigation Data

Page Name	Example	Description
Current GPS Position	Pos N 45°23.2 W081°10.8	*Current GPS longitude and latitude
ETE Next Waypoint	To BOSOX ETE 24.7nm 00:08	*Identifier, distance, and time-to-go (HH:MM) for the next waypoint in the flightplan
ETA Next Waypoint	ETA > BOSOX 17:35 LCL	*Estimated time of arrival in local time at the next waypoint in the flightplan
ETE Last Waypoint	To Dest. ETE 410.7nm 02:35	*Distance and time-to-go (HH:MM) for the last waypoint in the flightplan
ETA Last Waypoint	ETA > Dest. 01:20 LCL	*Estimated time of arrival in local time at the last waypoint in the flightplan
Track & Groundspeed	MTrk098 Var GS292kt W13.8	*Magnetic track and groundspeed of the aircraft, and magnetic variation in the area
Wind Speed & Direction	Wind/Drift 072/18kt 07R	*Current wind direction from and speed based on the GPS drift angle of the aircraft
Heading & Drift Angle	Headng/Drift 321/ 9L"	*Current heading and drift angle of the aircraft based on GPS track
Heading & Turn Rate	Heading/ ROT 135/ -05.8	Current heading and rate of turn of the aircraft

*A hot-swapping radio configuration with a GPS must be active for these pages to display data.



FUEL File - Fuel Flight Planning Data

Page Name	Example	Description
Full Fuel	Full Fuel 290.6GL	Full fuel payload of the aircraft in gallons
Fuel Required to Last Waypoint	Fuel to KTPA 84.9 GAL	*Fuel required to reach the last waypoint in the flightplan at current consumption rate
Fuel at Last Waypoint	Fuel at KTPA 42.7 GAL	*Fuel remaining at the last waypoint in the flightplan at current consumption rate
Specific Range	Specfic Range 2.12NM/GAL	*GPS groundspeed divided by fuel consumption in GPH - flight efficiency
Fuel Flow	F/Flow GPH 45.6	Fuel flow in gallons per hour
Fuel Used & Fuel Remaining	F/Use 24.8GL F/Rem 107.4GL	Fuel used since power was applied to the ETM unit, and fuel remaining in gallons
Endurance	T/Rem 01:40HR F/Use 24.8GL	Time remaining until empty at current rate of consumption, and fuel used in gallons

*A hot-swapping radio configuration with a GPS must be active for these pages to display data.



AIRDATA File - Aircraft Sensor & Flight Data

Page Name	Example	Description
Local Date & Time	THU 6 JUL23 08:17:43 EST	Current local date and time
Universal Time	TIME 12:17:43 GMT	Current Greenwich Mean Time
Flight Timer	FLIGHT TIMER 02:10:35	Time elapsed since airspeed exceeded the takeoff threshold set by maintenance
OAT & Density Altitude	OAT D.ALT -08C 10800	Outside air temperature in °C, and calculated density altitude in feet
Pressure Altitude & Density Altitude	P.ALTft D.ALT 16000 18400	Pressure altitude, and calculated density altitude in feet
IAS, TAS, MACH	IAS TAS MACH 184kt220 0.291	Indicated airspeed, calculated true airspeed, and calculated mach number
Gross Weight	Gross Weight 6145LB	Current calculated gross weight of the aircraft, accounting for fuel burned



Alarms

The ETM 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 while the exceedance is occurring. To cancel the active alarm press the ENTER button, or use the PAGE UP/DOWN switch. 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	High Limit
High Interstage Turbine Temp	Exceedance ITT 921	850 °C (Normal) 1,090 °C (Starting)
High Propeller Torque	Exceedance TQ 1971	2,300 FT-LBS
High Gas Generator RPM	Exceedance NG 107.2	105.5%
High Propeller RPM	Exceedance NP 2552	2,050 RPM

Stopwatch

The ETM possesses a stopwatch, which can be accessed from any mode via the “CLOCK” controls on the right of the unit. In this mode, the words “STOP WATCH” will appear at the top of the display, with hours, minutes, and seconds elapsed below. The START/STOP switch is used to start and stop counting. The RESET button will stop and reset the time to all zeros.



Normal Checklists

Preflight (Cockpit)

Crash Lever	Up
Source Selector	Off
Generator Selector	Main
Starter	Off
Ignition	Auto or Off
Exterior Lights	All Off
Gyro Instruments	All Off
Emergency Lights	Test
Circuit Breakers	All In
Deicing Switches	All Off
Landing Gear Control	Down
AP/Trim Master	Off
Radio Master	Off
Bleed Air	Off
Air Cond	Off
Dump Switch	Guarded
Ram Air Handle	Pushed In
Auto Fuel Selector	Manual
Aux Boost Pump	Off
Tank Selector	L or R
ELT	Armed
Parking Brake	Set
Manual Override Lever	Off
Power Lever	Flight Idle
Propeller Lever	Max. RPM
Condition Lever	Cutoff
Flap Control	Up
Battery Bus Power	Check Supply
Source Selector	BAT or GPU
Voltmeter	Above 25V
Exterior Lights Panel	Light Test
Fuel Gauges	Check Quantity
Advisory Panel	Check 1 & 2
OXYGEN Annun.	Extinguished
Interior Lights	As Required
Environmental Panel	Light Test
Flaps	Down
Landing Gear Panel	Light Test
Pitot Heat 1	On
PITOT 1 Annun.	Extinguished
Pitot & Stall Heat 2	On
PITOT 2 & STALL HTR Annun.	Extinguished
Pitot Heat	Off
Deicing Panel	Light Test
Source Selector	Off

Before Starting Engine

Preflight Inspection	Complete
Nose Baggage Door	Closed
Engine Compartment	Closed
Cabin Access Door	Latched
Pilot Door	Latched

Parking Brake	Set
Seats & Seatbelts	Fastened
Oxygen Pressure	Check
Oxygen Supply	On
Passenger Oxygen	Off
Microphone Selector	Normal
Starter	Off
Ignition	Auto or Off
Landing Gear Control	Down
Radio Master	On if Clearance Req.
Source Selector	BAT or GPU
Horn Test	Hold
DOOR Annun.	Extinguished
Fuel Gauges	Check Quantity
Auto Fuel Selector	Auto
AUTO SEL Annun.	Extinguished
Auto Fuel Selector	Shift
Engine Instruments	Check
ITT Test	Hold
ITT Annun.	Illuminated
ITT Needle	Functioning
Exterior Lights	As Required

Engine Start (Battery)

Manual Override Lever	Off
Power Lever	Flight Idle
Propeller Lever	Max. RPM
Condition Lever	Cutoff
Source Selector	BAT
Aux Boost Pump	On
AUX BP ON Annun.	Illuminated
FUEL PRESS Annun.	Extinguished
Fuel Pressure	Green
Ignition	Auto
Starter	On
STARTER Annun.	Flashing
IGNITION Annun.	Illuminated
Gas Generator	13% or Maximum
Condition Lever	Low Idle
ITT	Below 870 in 20s & 1090 Max
Starter	Off at 50% Ng
OIL PRESS Annun.	Extinguished
Condition Lever	High Idle
Engine Instruments	Check
Aux Boost Pump	Auto
AUX BP ON Annun.	Extinguished
FUEL PRESS Annun.	Extinguished
MAIN GEN Annun.	Extinguished
Voltmeter	~28V
Ammeter	Charging (+)

Engine Start (GPU)

Manual Override Lever	Off
Power Lever	Flight Idle
Propeller Lever	Max. RPM
Condition Lever	Cutoff
Source Selector	GPU
GPU Annun.	Illuminated
BAT OFF Annun.	Illuminated
Voltmeter	~28V
Aux Boost Pump	On
AUX BP ON Annun.	Illuminated
FUEL PRESS Annun.	Extinguished
Fuel Pressure	Green
Ignition	Auto
Starter	On
STARTER Annun.	Flashing
IGNITION Annun.	Illuminated
Gas Generator	13% or Maximum
Condition Lever	Low Idle
ITT	Below 870 in 20s & 1090 Max
Starter	Off at 50% Ng
OIL PRESS Annun.	Extinguished
Source Selector	BAT
BAT OFF Annun.	Extinguished
Propeller Lever	Feather
GPU	Have Disconnected
GPU Annun.	Extinguished
Propeller Lever	Max. RPM
Condition Lever	High Idle
Engine Instruments	Check
Aux Boost Pump	Auto
AUX BP ON Annun.	Extinguished
FUEL PRESS Annun.	Extinguished
MAIN GEN Annun.	Extinguished
Voltmeter	~28V
Ammeter	Charging (+)

After Starting Engine

Gyro Instruments	All On
Gyro Suction	Green
Gyro Slaving	Slave
Bleed Air	Auto
Fan Flow	As Required
Air Cond	On
Cabin Temperature	Set
Air Flow Distributor	As Required
Cabin Altitude	Field Elevation -500 FT
Cabin Climb Rate	Arrow Up
Prop Deice	On - Check Green
Prop Deice	Off
L Windshield Heat	On - Check Green
R Windshield Heat	On - Check Green
Windshield Heat	Off
Airframe Deice	On - Green Cycles
Airframe Deice	Off
Inertial Separator	On
Ammeter	Below +50A
Generator Selector	Standby

Voltmeter	~28V
Ammeter	Zero or Charging
Generator Selector	Main
Flaps	Up
Weather Radar	Off/Standby
Radio Master	On
EFIS Master	On
AP/Trim Master	On
EFIS AHRS Source	Left
Electric Trim	Test & Set
Taxi Light	On
INERT SEP Annun.	Illuminated
Parking Brake	Release
PARK BRAKE Annun.	Extinguished
Toe Brakes	Check

Before Takeoff

Parking Brake	Set
PARK BRAKE Annun.	Illuminated
Terrain Test	Push
Terrain Warning Lights	Test
Power Lever	1900 RPM
Exercise Propeller	To Feather
Prop Governor	Hold to Test
Prop RPM	~1800 RPM
Prop Governor	Release
Prop RPM	1900 RPM
Power Lever	Flight Idle
Fuel Imbalance	Less Than 15 Gal
Auto Fuel Selector	Auto
Aux Boost Pump	Auto
Auto Fuel Selector	Shift to Fullast
Flaps	As Required
Pitot Heat	On
Deicing Systems	As Required
Inertial Separator	As Required
Advisory Panel	All Off Ex. BRAKE & INERT
Engine Instruments	Check
Flight Controls	Free & Correct
Ammeter	Below +50A
Parking Brake	Release
PARK BRAKE Annun.	Extinguished
Strobe Lights	On

Takeoff

HSI Compass	Check
Attitude	Check
Altimeter	Set
Altitude Selector	Set
Weather Radar	On
Landing Lights	On
Ignition	On if Heavy Precip
Interior Lights	Dim for Takeoff
Cabin Lights	Off
Parking Brake	Release
PARK BRAKE Annun.	Extinguished
Taxi...	Onto Runway
Advisory Panel	All Off Ex. IGNITION & INERT

Power Lever	100% Torque
Landing Gear Up	Positive Rate
Flaps	Retract
Flaps Confirmed Up...	850 Mode
Power Lever	121.4% Torque
Autopilot	Engage
Taxi Lights	Off
Landing Lights	As Required

Climb

Power Lever	Observe Limits
Cabin Altitude	Cruise Alt. + 1000 FT
Cabin Climb Rate	500-700 FPM
Cabin Differential	Monitor
Cabin Temperature	As Desired
Fuel Qty. & Balance	Check
Deicing Systems	As Required
Inertial Separator	As Required

Transition Altitude

Altimeters	Standard
Cabin Pressurization	Monitor
Pulse Lights	Off
Deicing Systems	As Required
Inertial Separator	As Required

Cruise

Power Lever	Adjust for Performance
Fuel Qty. & Balance	Check
Cabin Pressurization	Monitor
Deicing Systems	As Required
Inertial Separator	As Required
Ignition	On if Heavy Precip

Descent

Altimeters	Local
Cabin Altitude	Field Elev. +500 FT
Pulse Lights	On
Deicing Systems	As Required
Inertial Separator	As Required
Air Flow Distributor	As Required
Ignition	On if Heavy Precip
Fuel Qty. & Balance	Check
Auto Fuel Selector	Shift to Fullest

Before Landing

Cabin Lights	Off
Altimeters	Check
Decision Height	Set
Fuel Qty. & Balance	Check
Inertial Separator	On Under 200 kts
Propeller Lever	Max. RPM
Landing Gear	Down Under 178 kts
Flaps	Approach Under 178 kts

Landing Lights	As Required
Autopilot Disconnect	Press Once
Flaps	Full Under 122 kts

Landing

Power Lever	Idle
Reverse Thrust	As Required
Braking	As Required

Go Around

Power Lever	100% Torque
Flaps	Approach
Landing Gear Up	Positive Rate
Flaps	Retract

Touch & Go

Flaps	Approach
Elevator Trim	Green
Power Lever	100% Torque

After Landing

Deicing Systems	Off
Inertial Separator	On
Bleed Air	As Required
Weather Radar	Off
Flaps	Up
Landing Lights	Off
Taxi Light	On
Strobe Lights	Off
Pulse Lights	Off
Oxygen Supply	Off

Shutdown & Securing

Parking Brake	Set
PARK BRAKE Annun.	Illuminated
Taxi Light	Off
Bleed Air	Off
Cabin Differential	Depressurized
Fan Flow	As Required
Air Cond	Off
Power Lever	Idle for 1min
Gyro Instruments	All Off
EFIS Master	Off
AP/Trim Master	Off
Radio Master	Off
Propeller Lever	Feather for 15s
Condition Lever	Cutoff
Aux Boost Pump	Off
Auto Fuel Selector	Manual
Tank Selector	Pull for Off
Inertial Separator	Off
Exterior Lights	All Off
Interior Lights	All Off
Ignition	Off

Generator Selector
Source Selector
Crash Lever

Main
Off
Down

28.5-30.0 Volts (YELLOW)
30.0 Volts (RED)

Instrument Markings & Colors

Engine Torque:

0-121.4% (GREEN)
100% (YELLOW)
121.4% (RED)

Vacuum Suction:

4.5 inHg (RED)
4.5-5.2 inHg (GREEN)
5.2 inHg (RED)

Propeller RPM:

450-1,000 RPM (YELLOW)
1,600-2,000 RPM (GREEN)
2,000 RPM (RED)

Gan Generator RPM:

51-104 % (GREEN)
101.5 % (RED)

Interstage Turbine Temperature:

400-840 °C (GREEN)
840 °C (NORMAL RED)
840-1090 °C (YELLOW)
1090 °C (STARTING RED)

Oil Temperature:

-40 °C (RED)
-40-0 °C (YELLOW)
0-110 °C (GREEN)
110 °C (RED)

Oil Pressure:

60 psi (RED)
60-100 psi (YELLOW)
100-135 psi (GREEN)
135 psi (RED)

Main Fuel Quantity:

0-150 gal

Fuel Pressure:

10-50 PSI (GREEN)

Bus Voltage:

14.0-22 Volts (RED)
22.0-26.5 Volts (YELLOW)
26.5-28.5 Volts (GREEN)

Abnormal & Emergency Checklists

Rejected Takeoff

Power Lever	Idle
Reverse Thrust	Maximum
Braking	Maximum
If No Runway	Remaining...
Power Lever	Idle
Condition Lever	Cutoff
Tank Selector	Pull for Off
Crash Lever	Down

Engine Failure After Rotation

If Landing	Possible...
Landing Gear	Down
Flaps	As Required
Airspeed	Above 85kts
Propeller Lever	Feather

Before	Touchdown...
Power Lever	Idle
Condition Lever	Cutoff
Tank Selector	Pull for Off
Crash Lever	Down
Evacuation	Begin

Engine Failure During Flight

Propeller Lever	Feather
Power Lever	Idle
Condition Lever	Cutoff
Remaining Fuel	Check
Tank Selector	Switch Tanks
Airstart	Attempt

Engine Airstart

Generator Selector	Main
Essential Bus Tie	Normal
Bleed Air	Off
Air Cond	Off
Electrical Load	Reduce
Power Lever	Idle
Propeller Lever	Feather
Condition Lever	Cutoff
Tank Selector	Check
Aux Boost Pump	On
Ignition	Auto or On
Starter	On
Gas Generator	13% or Maximum
Condition Lever	Low Idle
Starter	Off at 50% Ng
Condition Lever	high Idle
Propeller Lever	Max. RPM
Power Lever	Increase

Aux Boost Pump
Bleed Air

Auto
As Required

Engine Motoring

Manual Override Lever	Off
Power Lever	Idle
Propeller Lever	Max. RPM
Condition Lever	Cutoff
Tank Selector	L or R
Aux Boost Pump	On
AUX BP ON Annun.	Illuminated
FUEL PRESS Annun.	Extinguished
Ignition	Off
IGNITION Annun.	Extinguished
Starter	On for 15s
Aux Boost Pump	Off

Engine Fire (Ground)

Power Lever	Idle
Condition Lever	Cutoff
Bleed Air	Off
Air Cond	Off
Tank Selector	Pull for Off
Crash Lever	Down
Evacuation	Begin

Cabin Fire (Ground)

Power Lever	Idle
Condition Lever	Cutoff
Crash Lever	Down
Evacuation	Begin

Engine Fire (Flight)

Power Lever	Idle
Propeller Lever	Feather
Condition Lever	Cutoff
Aux Boost Pump	Off
Tank Selector	Pull for Off
Bleed Air	Off
Air Cond	Off
Emergency Descent	Begin
Engine	Do Not Restart

Electrical Fire or Smoke

Oxygen Supply	On
---------------	----

Passenger Oxygen	As Required
Crew Oxygen Masks	As Required
Emergency Descent	Begin
Bleed Air	Off
Air Cond	Off
Pressurization	Dump
Differential Pressure	Minimal
Ram Air Handle	Pull Open
Nonessential Equipment	Off
Land	As Soon as Possible
Observe	If Fire Persists...
Source Selector	Off
Generator Selector	Off
Circuit Breakers	Pull Off
Source Selector	BAT
Generator Selector	Main
Restore Power	Circuit by Circuit
Land	As Soon as Possible

Oil Pressure Drop

OIL PRESS Annu.	If Illuminated...
Oil Pressure	If Above 60 PSI...
Land	As Soon as Practical
Oil Pressure	If Below 60 PSI...
Propeller RPM	Monitor
Land	As Soon as Practical
Torque	If Dropping...
Power Lever	Idle
Condition Lever	Cutoff
Forced Landing	Begin

Loss of Power Regulation

Power Lever	Idle
Engine Instruments	Check
Tank Selector	Switch
Manual Override	Advance
Land	As Soon as Practical
Reverse Thrust	Do Not Use
Minimum Obtainable Power	If Excessive...
Airspeed	Pitch up to 178 kts
Inertial Separator	On
ITT	If Above 840C...
Inertial Separator	Off
Landing Gear	Down
Flaps	Approach
When Runway	Is Assured...
Condition Lever	Cutoff
Propeller Lever	Feather
Flaps	Full Down

Loss of Propeller Control

Land	As Soon as Practical
Propeller RPM	If Below 2000 RPM...
Go Around	Do Not Attempt

Propeller Overspeed

Power Lever	Reduce to Limit RPM
Land	As Soon as Practical
Go Around	Do Not Attempt

Maximum Rate Descent

Power Lever	Idle
Propeller Lever	Max. RPM
Air Conditions	If Smooth Air...
Landing Gear	Up
Flaps	Up
Airspeed	Maintain 266 kts
Air Conditions	If Rough Air...
Airspeed	Below 178 kts
Landing Gear	Down
Flaps	Up
Airspeed	Maintain 178 kts

Maximum Range Descent

Power Lever	Idle
Propeller Lever	Feather
Condition Lever	Cutoff
Landing Gear	Up
Flaps	Up
Airspeed	Maintain 120 kts
Bleed Air	Off
Air Cond	Off
Pressurization	Dump
Differential Pressure	Minimal
Ram Air Handle	Pull Open
Sky Conditions	If No Icing...
Essential Bus Tie	Emergency

Sky Conditions	If Icing...
Essential Bus Tie	Normal
Nonessential Equipment	Off
Deicing Systems	Check On
Circuit Breakers	Pull Off

Engine Out Landing

Power Lever	Idle
Propeller Lever	Feather
Condition Lever	Cutoff
Tank Selector	Pull for Off
Aux Boost Pump	On
Bleed Air	Off
Air Cond	Off
Pressurization	Dump
Airspeed	Maintain 120 kts
Essential Bus Tie	Normal
Landing Gear	Down
Landing Lights	As Required

Gear Up Landing

Approach	Standard
Flaps	Full Down
Bleed Air	Off
Air Cond	Off
Pressurization	Dump
When Runway	Is Assured
Power Lever	Idle
Propeller Lever	Feather
Condition Lever	Cutoff
Tank Selector	Pull for Off
Crash Lever	Down after Landing
Evacuation	Begin

Engine Does Not Shutdown

Ignition	Off
Auto Fuel Selector	Manual
Tank Selector	Pull for Off
Wait for	Engine to Stop
Exterior Lights	All Off
Interior Lights	All Off
Crash Lever	Down

Low Fuel Pressure

FUEL PRESS Annun.	If Illuminated...
Remaining Fuel	Check
Tank Selector	Switch Tanks
Fuel Pressure	Check
Aux Boost Pump	Auto
FUEL PRESS Annun.	If Persists...
Aux Boost Pump	On
AUX BP ON Annun.	Illuminated
Fuel Pressure	If Still Low...
Descend	Below 18000 FT
Land	As Soon as Possible

Main Generator Failure

Generator Selector	Main
MAIN GEN Annun.	If Illuminated...
Main Generator	Reset
MAIN GEN Annun.	If Illuminated...
Electrical Load	Reduce
Generator Selector	Standby
Voltage & Charge	Monitor

Low Volts (On Main Gen.)

LO VOLT Annun.	If Illuminated...
Voltmeter	If Below 26V...
Electrical Load	Reduce
Generator Selector	Standby
Voltage & Charge	Monitor

Low Volts (On Stby. Gen.)

MAIN GEN Annun.	If Illuminated...
LO VOLT Annun.	If Illuminated...
Voltmeter	If Below 26V...
Electrical Load	Reduce
Generator Selector	Main
Main Generator	Reset
Generator Selector	Standby
Standby Generator	Reset
LO VOLT Annun.	If Dual Failure...
Generator Selector	Off
Emergency Lights	As Desired
Sky Conditions	If No Icing...
Essential Bus Tie	Emergency

Sky Conditions	If Icing...
Essential Bus Tie	Normal
Nonessential Equipment	Off
Deicing Systems	Check On
Circuit Breakers	Pull Off
Land	As Soon as Practical

CABIN PRESS Illuminated

Differential Pressure	If Above 6.2 PSI...
Bleed Air	Off
Emergency Descent	Begin
Cabin Altitude	If Above 10000 FT...
Oxygen Supply	On
Passenger Oxygen	On
Crew Oxygen Masks	Don
Bleed Air	Auto
Air Cond	On
Dump Switch	Guarded
Ram Air Handle	Pushed In
Emergency Descent	If Necessary
Limit Altitude	Less Than 12000 FT

BLEED OFF Illuminated

Bleed Air	Off, then Auto
BLEED OFF Annun.	If Illuminated...
Emergency Descent	If Necessary
Limit Altitude	Less Than 12000 FT

BLEED TEMP Illuminated

Air Flow Distributor	Normal
Cabin Temperature	Lowest Setting
Bleed Air	Off
BLEED TEMP Annun.	When Extinguished...
Bleed Air	Auto
BLEED TEMP Annun.	If Illuminated...
Bleed Air	Off
Emergency Descent	If Necessary
Limit Altitude	Less Than 12000 FT

DOOR Illuminated In Flight

Slow Descent	Begin
Reduce Cabin Differential	Select Higher Alt
Cabin Access Door	Inspect
Pilot Door	Inspect
Door Integrity	If Compromised...
Bleed Air	Off
Pressurization	Dump
Emergency Descent	Choose Rough Air

Cabin Pressurized After Landing

Differential Pressure	If Above 0 PSI...
Bleed Air	Off
Pressurization	Dump
Differential Pressure	Minimal
Ram Air Handle	Pull Open

Vacuum Suction Low

Gyro Suction	If Low...
DC Instruments	Check & Reference
Land	As Soon as Practical

Starter Does Not Disengage

Condition Lever	Cutoff
Propeller Lever	Feather
Tank Selector	Pull for Off
Crash Lever	Down

CHIP Illuminated

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

Remote Compass Misalignment

Remote Compass Circuit Breaker	Pull & Reset
Remote Compass Alignment	If Misaligned...
Remote Compass	Free
Compass Position	Align to Magnetic

Flap Failure

Flap Breaker	Check On
Voltmeter	23V Minimum
Flaps	As Required
Flap Indicators	Check
Flaps	Visually Check

Autopilot Failure or Trim Runaway

Autopilot	Disconnect
AP/Trim Master	Off
Trim Circuit Breakers	Pull Off

AP/Trim Master
Determine Defective Trim
AP/Trim Master

AP Off
Circuit by Circuit
On

Airspeed Failure

Pitot Heat	Check On
Alternate Static	Pull Firmly
Airspeed & Altimeter	Apply Corrections

Severe Icing Encounter

Autopilot	Disconnect
Deicing Systems	All On
Inertial Separator	On If Below 200 kts
Bleed Air	High
Air Flow Distributor	Defog
Cabin Temperature	Highest Setting

Severe Precip. Encounter

Ignition	On
Inertial Separator	On If Below 200 kts

Landing Gear Manual Extension

Airspeed	Below 178 kts
Landing Gear Breaker	Pull Off
Landing Gear Control	Down
Floor Panel	Open
Bypass Selector	Pull On
Pump Handle	65 Cycles
Gear Indicators	Three Green
Gear Down Test	Hold

Landing Gear Up after Man Ext

Airspeed	Below 128 kts
Bypass Selector	Push Off
Landing Gear Breaker	Push On
Landing Gear Control	Up
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-80 Navigation System, and the RDR 1150XL, additional resources are available online for the real world counterparts of these units. In particular the **“KNS-80 Pilot's Guide”**, available on Bendix/King's website, and the **“Weather Radar Pilot Training DVD”** on Bendix/King's YouTube channel. An extensive **EFS 40/50 Pilot's Guide** is also available on the Bendix/King's website. A complete **“Pilot's Operation Manual” to the ETM Engine Trend Monitor** can be found on the Shadin Avionics 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
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
Nose Baggage Compartment Door	L:bksq_BaggageDoor	Boolean
Pilot's Sun Visor Position	L:var_Visor_L	0 - 100
Copilot's Sun Visor Position	L:var_Visor_R	0 - 100
Pilot Door Latching Button	var_PilotDoorLockedLatching	0 - 2
Aft Door Latching Button	var_AftDoorLockedLatching	0 - 2
Open/Close Pilot Door	K:TOGGLE_AIRCRAFT_EXIT_FAST	0
Open/Close Aft Door	K:TOGGLE_AIRCRAFT_EXIT_FAST	2
Pilot Door Ladder	L:var_PilotLadder	Boolean
Aft Door Ladder	L:var_AftLadder	Boolean

Primary Control Variables

Description	Variable	Range
Condition Lever	B:FUEL_1_Condition_Lever_High_Idle B:FUEL_1_Condition_Lever_Cut_Off L:BKSQ_ConditionLever	Boolean
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
Master Warning Button	L:var_masterWarningLatching	1 = ON, 2 = RESET
Master Caution Button	L:var_masterCautionLatching	1 = ON, 2 = RESET
Electrical Crash Bar	L:var_crashbar	Boolean
Electrical Source Switch	L:BKSQ_SourceSwitch	1 = BAT, 2 = GPU
Generator Switch	L:BKSQ_GeneratorSwitch	1 = MAIN, 2 = STBY
Starter Switch	L:BKSQ_StarterSwitch	Boolean
Ignition Switch	L:BKSQ_IgnitionSwitch	1 = AUTO, 2 = ON
Main Generator Reset Button	L:var_MainGeneratorResetButton	Boolean
Standby Generator Reset Button	L:var_StandbyGeneratorResetButton	Boolean
850 Mode	L:var_850Mode	Boolean (flaps up)
Propeller Overspeed Test Button	L:var_propOverspeedTestButton	Boolean
Manual Override Lever	L:var_emergencyPowerLeverPosition	0 - 100
Annunciator Panel Dimming	L:var_AnnunciatorDim	Boolean
Annunciator Panel Test Circuit 1	L:var_AnnunciatorTest1	Boolean
Annunciator Panel Test Circuit 2	L:var_AnnunciatorTest2	Boolean
Fuel Boost Pump Switch	L:BKSQ_fuelPumpSwitch	1 = ON, 2 = AUTO
Left Windshield Heat	L:var_windshieldHeatSwitch_L	Boolean
Right Windshield Heat	L:var_windshieldHeatSwitch_R	Boolean
Inertial Separator	L:var_InertialSeparatorSwitch	Boolean

Airframe Deice	L:AirframeDeiceSwitch	Boolean
Warning Horn Test	L:var_HornTest	Boolean
Gear Downlock Check	L:var_landingGearDownCheck	Boolean
Gear Light Test Circuit 1	L:GearLightTest1	Boolean
Gear Light Test Circuit 2	L:GearLightTest2	Boolean
Remote Compass (Gyro) Switch	A:CIRCUIT SWITCH ON:57	Boolean
RMI Switch	A:CIRCUIT SWITCH ON:58	Boolean
ADI 2 Switch	A:CIRCUIT SWITCH ON:59	Boolean
HSI 2 Switch	A:CIRCUIT SWITCH ON:60	Boolean
Auto Fuel Selector Switch	A:CIRCUIT SWITCH ON:40	Boolean
Essential Bus Tie Cover	L:var_EssentialBusTieCover	Boolean
Essential Bus Tie Switch	L:var_EssentialBusTieSwitch	Boolean
Emergency Gear Floor Panel	L:var_EmergencyGearDoor	Boolean
Soft Ride Button	L:var_autopilotSoftRideMode	Boolean
Autopilot Test Button	L:var_AutopilotStartupCounter	35
Emergency Gear Bypass Pull Handle	L:XMLVAR_Cabin_Air_1_Position	0 - 100
Alternate Static Source	L:XMLVAR_Cabin_Air_2_Position	0 - 100
Emergency Ram Air Pull Handle	L:XMLVAR_Cabin_Air_3_Position	0 - 100
Microphone Source Switch Cover	L:var_MaskMicCover	Boolean
Microphone Source Switch	L:var_MaskMicSwitch	Boolean

Lighting Control Events & Variables

Description	Variable	Range
Deicing Panel Lights Test Button	L:SwitchesLightTest	Boolean
Pilot's Yoke Map Light	L:var_YokeLightKnob_L	0 - 100
Copilot's Yoke Map Light	L:var_YokeLightKnob_R	0 - 100
Navigation Lights	B:LIGHTING_NAV_1_Toggle (K:TOGGLE_NAV_LIGHTS)	

Strobe Lights	B:LIGHTING_STROBE_1_Toggle (K:TOGGLE_STROBE_LIGHTS)	
Pulse Lights	B:LIGHTING_RECOG_1_Toggle (K:TOGGLE_RECOGNITION_LIGHTS)	
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)	
Instrument Panel Lighting Dimmer	L:var_InstrumentLightingKnob	0 - 100
Glareshield Lighting Dimmer	L:var_PanelLightingKnob	0 - 100
Emergency Lighting Dimmer	L:var_EmergencyLightsKnob	0 - 100
Left Reading Light Switch	L:var_ReadingLightSwitch_L	Boolean
Right Reading Light Switch	L:var_ReadingLightSwitch_R	Boolean
Cabin Lights Middle L Button	L:var_CabinLights_Middle_L_Button	Boolean
Cabin Lights Middle R Button	L:var_CabinLights_Middle_R_Button	Boolean
Cabin Lights Aft L Button	L:var_CabinLights_Aft_L_Button	Boolean
Cabin Lights Aft R Button	L:var_CabinLights_Aft_R_Button	Boolean
Baggage Lights Button	L:var_BaggageLights_Button	Boolean
Access Lights Button	L:var_AccessLights_Button	Boolean

Environmental Control Variables

Description	Variable	Range
Master Oxygen Valve	L:var_oxygenMaster	Boolean
Passenger Oxygen	L:var_passengerOxygen	Boolean
Pilot Oxygen Mask	L:var_pilotOxygen	Boolean
Copilot Oxygen Mask	L:var_coPilotOxygen	Boolean
Bleed Air Switch	L:var_bleedState	1 = AUTO, 2 = HI

Air Conditioning Switch	L:var_airconState	1 = FAN ONLY, 2 = ON
Fan Flow Switch	L:var_FanSwitch	Boolean
Air Flow Selector Knob	L:var_AirFlowSelectorKnob	0 - 100
Environmental Panel Test Button	L:var_EnvironmentalLightTestButton	Boolean
Cabin Temperature Select Knob	L:var_CabinTemperatureKnob	60 - 80
Pressurization Goal Knob	L:var_pressurizationGoal	-1000 - 15000
Pressurization Rate Knob	L:var_pressurizationClimbRate	150 - 2000
Pressurization Dump Switch Cover	L:var_PressurizationDumpCover	Boolean
Pressurization Dump Switch	L:var_PressurizationDump	Boolean

Instrument Variables

Description	Variable	Range
EFIS Power Switch	L:var_EFIS_PowerSwitch	Boolean
Radio Master Switch	L:var_RadioMasterSwitch	Boolean
AP Trims Switch	L:BKSQ_AutopilotMasterSwitch	1 = AP OFF, 2 = ON
Decision Height TEST Switch Position	L:var_efisDecisionHeightTest	Boolean
Decision Height SET Switch Position	L:var_efisDecisionHeightSet	Boolean
RNAV Drives HSI	L:var_rnavDrivesHsi	Boolean
Gyro Slaving Mode	L:var_GyroSlaveModeSwitch	Boolean
EFIS DME Mode	L:var_efisDmeMode	0 - 2
Standby DME Mode	L:var_dmeMode	0 - 4
Cabin Temperature Display Unit	L:var_CabinTempUnitMode	Boolean
GPS 1 Message Cancel	L:var_gpsMessageButton1Latching	2
GPS 2 Message Cancel	L:var_gpsMessageButton2Latching	2
Terrain Test	L:var_TerrainTest	Boolean
Terrain Warning Inhibit	L:var_TerrainInhibited	Boolean
Panel Lights Test Button	L:var_PanelLightTestButton	Boolean
ITT Test Button	L:var_TurbineTempTestButton	Boolean

EFIS Composite Mode Button	L:var_EfisCompositeMode	Boolean
EADI Brightness Knob	L:var_EADI_Brightness	0 - 100
EHSI Brightness Knob	L:var_EHSI_Brightness	0 - 100
Copilot Radar Altimeter Test Button	L:var_RadarAltimeterTest	Boolean
Copilot Radar Altimeter Decision Ht.	L:var_copilotDecisionHeight	0 - 2500
Altimeter Reference Bug	L:var_AltitudeReferenceBug	0 - 1
Chronometer Mode Button	L:var_yokeChronoMode_L	
Chronometer Reset Button	L:var_yokeTimerMode_L L:var_yokeTimerMode_L_Seconds	0 0
Chronometer Date Button	L:var_ChronoDateTimer	0

Instrument Events

Description	Variable
CWS (only if “hardware ctrl. AP pitch”)	K:SYNC_FLIGHT_DIRECTOR_PITCH
Autopilot Master	K:AP_MASTER
Transponder Ident	K:XPNDR_IDENT_ON
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 IAS Hold Mode	K:FLIGHT_LEVEL_CHANGE
Vertical Speed Mode Engage	K:AP_PANEL_VS_HOLD
Yaw Damper Button	K:YAW_DAMPER_TOGGLE
Autopilot Go-Around Mode	K:AUTO_THROTTLE_TO_GA
Flight Director Button	K:TOGGLE_FLIGHT_DIRECTOR
Half Bank Mode (0, or 1)	K:AP_MAX_BANK_SET
IAS Mode Speed Reference Increase	K:AP_SPD_VAR_INC

IAS Mode Speed Reference Decrease	K:AP_SPD_VAR_DEC
Vertical Speed Increase	K:AP_VS_VAR_INC
Vertical Speed Decrease	K:AP_VS_VAR_DEC
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 STD Button	K:BAROMETRIC_STD_PRESSURE
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
Remote Compass Slew CW	K:GYRO_DRIFT_INC
Remote Compass Slew CCW	K:GYRO_DRIFT_DEC
Emergency Gear Extension	K:GEAR_PUMP

EFS 40 Events

Description	Variable
EFIS "1 2" System Source Button	H:EHSI_SystemSource
EFIS NAV Button	H:EHSI_NavSource
EFIS HSI Button	H:EHSI_HsiMode
EFIS ARC Button	H:EHSI_ArcMode
EFIS REF-TEST Button	H:EHSI_TestReference
EFIS Solid Bearing Button	H:EHSI_SolidBearing
EFIS Hollow Bearing Button	H:EHSI_HollowBearing

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

KNS80

Description	Variable or Event
Data Knob Outer Increase	H:KNS80_bigInc
Data Knob Outer Decrease	H:KNS80_bigDec
Data Knob Inner Increase	H:KNS80_smallInc
Data Knob Inner Decrease	H:KNS80_smallDec
VOR Button	H:KNS80_vorModeButton
RNAV Button	H:KNS80_rnavModeButton
DME Hold Button	H:KNS80_dmeHoldButton
Use Button	H:KNS80_useButton
Display Button	H:KNS80_displayButton
Data Button	H:KNS80_dataButton
Data Entry Knob Push/Pull	L:var_rnavKnobPulled
Volume Knob	L:var_RNAV_VOLUME

KX155B

Description	Variable or Event
COM Knob Outer Increase	H:RADIO1_COM_Knob_Large_INC
COM Knob Outer Decrease	H:RADIO1_COM_Knob_Large_DEC
COM Knob Inner Increase	H:RADIO1_COM_Knob_Small_INC
COM Knob Inner Decrease	H:RADIO1_COM_Knob_Small_DEC
COM Knob Push/Pull	H:RADIO1_COM_Knob_Small_PUSH
NAV Knob Outer Increase	H:RADIO1_NAV_Knob_Large_INC
NAV Knob Outer Decrease	H:RADIO1_NAV_Knob_Large_DEC
NAV Knob Inner Increase	H:RADIO1_NAV_Knob_Small_INC
NAV Knob Inner Decrease	H:RADIO1_NAV_Knob_Small_DEC
NAV Knob Push/Pull	H:RADIO1_NAV_Knob_Small_PUSH
COM Volume Increase	K:COM1_VOLUME_INC
COM Volume Decrease	K:COM1_VOLUME_DEC
COM Frequency Spacing Toggle	H:RADIO1_COM_Freq_Spacing_PUSH
NAV Volume Increase	K:NAV1_VOLUME_INC
NAV Volume Decrease	K:NAV1_VOLUME_DEC
NAV Ident Toggle	K:RADIO_VOR1_IDENT_TOGGLE
COM Swap Button	K:COM1_RADIO_SWAP
NAV Swap Button	K:NAV1_RADIO_SWAP

KR87 ADF

Description	Variable or Event
Tuning Knob Push/Pull	L:var_adfKnobPulled
Tuning Increase by 100	K:ADF_100_INC
Tuning Decrease by 100	K:ADF_100_DEC
Tuning Increase by 10	K:ADF_10_INC

Tuning Decrease by 10	K:ADF_10_DEC
Tuning Increase by 1	K:ADF_1_INC
Tuning Decrease by 1	K:ADF_1_DEC
Antenna Button	H:adf_AntAdf
BFO Button	H:adf_bfo
Frequency Swap Button	H:adf_frqTransfert
Timer Mode Button	H:adf_FltEt
Timer Reset Button	H:adf_SetRst

GTX 327 Transponder

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

Weather Radar

Description	Variable or Event	Range
Mode Knob	L:var_radarMode	0 - 5
Brightness Knob	L:var_RadarBrightness	0 - 100
Gain Knob	L:var_RadarGain	0 - 100
Tilt Knob	L:var_RadarTilt	0 - 100
Alert Button	H:bksq_wradar1_radarAlertToggle	
Vertical Profile Button	H:bksq_wradar1_radarProfile	
Map Button	H:bksq_wradar1_radarMap	
Hold Button	H:bksq_wradar1_radarHold	
Range Increase Button	H:bksq_wradar1_radarRangeInc	
Range Decrease Button	H:bksq_wradar1_radarRangeDec	
Track Left Button	H:bksq_wradar1_radarTrackLeft	
Track Right Button	H:bksq_wradar1_radarTrackRight	

ETM Engine Trend Monitor

Description	Variable or Event	Range
Mode Knob	L:var_EtmMode	0 - 3
Enter Button	H:Etm_EnterTest	
Record Button	H:Etm_Record	
Clock Reset Button	H:Etm_ClockReset	
Increase Switch	H:Etm_Inc	
Decrease Switch	H:Etm_Dec	
Page Up Switch	H:Etm_PageUp	
Page Down Switch	H:Etm_PageDown	
Cock Start Switch	H:Etm_ClockStart	
Cock Stop Switch	H:Etm_ClockStop	

KAS 297B

Description	Variable or Event
Data Knob Outer Increase	H:kas297b_1000_INC
Data Knob Outer Decrease	H:kas297b_1000_DEC
Data Knob Inner Increase	H:kas297b_100_INC
Data Knob Inner Decrease	H:kas297b_100_DEC
Altitude Selector Knob Push/Pull	L:var_VsAdjustMode
VS ENG Button	H:kas297b_VsButton
ALT ARM Button	H:kas297b_ArmButton

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
Propeller Torque	L:BKSQ_TBM_TQ	Number (FT-LBS)
Interstage Turbine Temperature	L:BKSQ_TBM_ITT	Number (°C)
Gas Generator RPM	L:BKSQ_TBM_NG	Number (%)
Fuel Pressure	L:BKSQ_TBM_FUELPRESSURE	PSI
Propeller RPM	A:PROP RPM:1	RPM
Fuel Flow	L:BKSQ_TBM_FuelFlow	GPH
Oil Pressure	A:ENG OIL PRESSURE:1	PSI
Oil Temperature	L:BKSQ_TBM_OILTEMPERATURE	FAHRENHEIT
Fuel Quantity	A:FUEL TANK LEFT MAIN QUANTITY	GALLONS
Fuel Quantity	A:FUEL TANK RIGHT MAIN QUANTITY	GALLONS
Left Vertical Speed Needle	L:BKSQ_TBM_VerticalSpeed_1	FPM
Right Vertical Speed Needle	L:BKSQ_TBM_VerticalSpeed_2	FPM
Turn Coordinator Ball	L:BKSQ_TurnCoordinatorBall	0 - 100
Battery Temperature	L:var_batteryTemperature	FAHRENHEIT
Starter-Generator Temperature	L:var_starterTemperature	FAHRENHEIT
Standby Generator Temperature	L:var_alternatorTemperature	FAHRENHEIT
Oxygen Pressure	L:var_oxygenPressure	PSI
Cabin Climb Rate	L:var_cabinClimbRate	FPM
Cabin Pressurization Altitude	L:var_cabinPressurizationAltitude	FEET
Cabin Differential Pressure	L:var_cabinPressureDifferential	PSI
Main Bus Voltage	L:var_correctedBusVolts	Volts

Battery Ammeter	L:var_correctedBatteryLoad	Amps
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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
Copilot HSI CDI Needle	L:BKSQ_TBM_HSI_LOC	0 - 100
Copilot HSI CDI Flag	L:BKSQ_TBM_HSI_LOC_FLAG	Boolean
Copilot HSI TO Flag	L:BKSQ_TBM_CDI_1_TO_FLAG	0 - 100
Copilot HSI FROM Flag	L:BKSQ_TBM_CDI_1_FROM_FLAG	0 - 100
Copilot HSI Glideslope Needle	L:BKSQ_TBM_HSI_GLIDE	0 - 100
Pilot Localizer CDI Needle	L:BKSQ_TBM_LOC_2	0 - 100
Pilot Localizer CDI Flag	L:BKSQ_TBM_LOC_2_FLAG	Boolean
Pilot Localizer TO Flag	L:BKSQ_TBM_LOC_2_TO_FLAG	0 - 100
Pilot Localizer FROM Flag	L:BKSQ_TBM_LOC_2_FROM_FLAG	0 - 100
Pilot Localizer Glideslope Needle	L:BKSQ_TBM_GLIDE_2	0 - 100
Pilot Localizer Glideslope Flag	L:BKSQ_TBM_LOC_2_GS_FLAG	Boolean
RMI Solid Needle	L:BKSQ_TBM_RMI_ADFNEEDLE	0 - 100
RMI Hollow Needle	L:BKSQ_TBM_RMI_VORNEEDLE	0 - 100
RNAV CDI Linear Deviation Mode	L:var_rnavCourseLinearFlag	Boolean
RNAV CDI Approach Deviation Mode	L:var_rnavApproachMode	Boolean
RNAV Data Entry Mode	L:var_rnavDataEntryMode	Number
RNAV Waypoint Number	L:var_RNAV_WAYPOINT_NUMBER	1 - 4
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 AnalogTBM.XML. Search for “BKSQ_DIMMABLE_ANNUNCIATOR” to find them all. Each one is accessible via an L:Var named according to the “NODE_ID” of the annunciator in the XML file, following the pattern (L:var_**#NODE_ID#**_readonly, bool).

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

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

Frequently Asked Questions

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

Click the back of the tablet **on the side of the throttle quadrant pedestal**. 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.

Is beta range simulated?

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

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

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

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

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

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

Why do my engines always fail or lose health?

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

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

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

Why is the GTN 750 GPS screen black?

Make sure you have the PMS GTN 750 or TDS GTNxi 750 installed properly in your community folder. The mod can be obtained for free from the following link. Installation instructions are included in the “Installation, Updates & Support” section of this manual.

<https://pms50.com/msfs/downloads/gtn750-basic/>

Can the autopilot track KNS-81 RNAV waypoints?

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

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

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

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

The engine will not fail immediately upon limit exceedances, as is true of the real engine. Different engine parameters contribute differently to reducing the health of the engine. The “Engine Stress Failure” option must also be enabled in the MSFS Assistance menu for the engine to fail completely. Engine condition can be monitored on the “SYSTEMS” page of the weather radar by rotating its mode knob to “NAV”.

Do the doors open?

Yes. Unlike the Black Square aircraft developed under the Steam Gauge Overhaul title, Black Square's TBM 850 has been developed from the ground up, avoiding the limitations of many other Black Square aircraft.

I have the TDS or PMS GTN 750 installed. Why do they not automatically show up on the panel?

The “automatic detection” of the TDS or PMS software refers to automatic switching between the freeware PMS, and the TDS or PMS payware products. There are six different choices for avionics available for this aircraft that must be manually selected with the two selector switches located above the environmental control panel. Your avionics selection is automatically saved and restored between sessions. For more information on selecting different avionics, see the “Avionics” section of this manual. **It is now possible to manually switch between PMS and TDS products while the aircraft is loaded. Click on the blue memory card on the left of the unit's bezel.**

Is beta range simulated?

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

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Managing a turboprop engine without FADEC or automatic torque limiters may be easier than managing a reciprocating engine in some ways, but damage can happen much more easily. The most likely culprit is **exceeding engine torque or ITT limits**. Be sure to watch the engine

instrumentation and see the “Turboprop Engine Operation” section of this manual for more information.

Why is the autopilot behaving strangely, not changing modes (HDG/NAV), or not capturing altitudes?

This is indicative of GPS add-on 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 changelog and “Third Party Navigation & GPS Systems” section of this manual for more information.

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 left of the cockpit lighting dimmers, labeled “**AP TRIMS MASTER**” is in **the on position**. Additionally, check the trim motor circuit breakers on the top of the circuit breaker panel to make sure power is available to the autopilot servo motors.

Why do the localizer cards rotate with the EHSI course needle?

This is due to a limitation of the simulator, which does not allow for an arbitrary number of navigation radio antennas and receivers. For this reason, the course must be synchronized across all NAV1 and NAV2 instruments.

Why do screens flicker at night when adjusting lighting intensity?

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

How do you open the baggage door and engine cowlings?

All doors in the aircraft can be opened and closed via the payload page on the tablet interface.

Additionally, the baggage door is toggled open/closed by clicking the silver key, labeled “Baggage Door” within the cupholder forward of the main cabin entry door. The baggage door will not open when the aircraft is in motion.

The engine cowlings are opened with the rudder pedal adjustment levers on the cockpit sidewalls under the panel. They are curved, black levers, in a recessed cavity. In real life, these levers are used to release the spring-loaded rudder pedal mechanism. The engine cowlings will not open when the aircraft is in motion.

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.

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.

Why does pitch control seem overly sensitive in MSFS 2024?

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

Change Log

v1.0 - Initial Release

New Features:

- **Beta range fully simulated** in user friendly fashion. Throttle input of 15% corresponds to the flight idle gate. Sound added to detent. See manual for more details.
- **Improved hotstart dynamics** with added nonlinearity. This is a significant improvement over the previous ITT calculations which results in more aggressive hotstarts when fuel is introduced too early, and reduced the peak ITT during normal starts. In both cases, temperatures much more closely resemble real world values.
- **Residual heat added to ITT calculation.** ITT may remain hot enough after shutdown to require dry-motoring to reduce temperature before starting in high ambient temperature and low wind conditions. See the “Residual Heat & Dry Motoring” section of this manual for more details. **ITT also increased at high density altitude.**
- **Improved gas generator dynamics.** This is a significant improvement over the previous Ng calculations which results in more stable and higher Ng settings at normal cruise throttle settings. Ng now much more closely resembles real world values.
- **Improved density altitude torque response.** Torque numbers are now within 2% of POH values. Thank you JayDee! Fuel controller and torque limiter also recalculated.
- **Improved oil temperature simulation.** Oil cooling connected to new ITT calculation.
- Revised EFIS/GPS handling of autopilot CDI source. Now behaves as in the real world. VOR2 can now be used to drive the autopilot, but not with the WT GNS530 as COM1.

Bug Fixes:

- **Propeller RPM increased at idle.** The propeller governor will now keep the RPM above the caution range in high idle. **Prop drag in flight has also been increased.**
- **Increased FF and Ng difference between low and high idle.** This was already part of the custom fuel flow controller, but was being suppressed by a configuration file entry.
- **Manual Override logic corrected.** Now the lever can only be used to increase fuel flow.
- Improved takeoff and cruise performance. Perfectly on the book numbers now.
- Condition lever will now default to high idle when loading simulation with engine running.
- Fixed ETM ETA screens timezone offsets. All ETA times are now in local time.
- Fixed ETM Flight Timer showing over 60 minutes when time exceeded one hour.
- ETM engine start dialog now resets after every start, and uses correct voltage variable.

- Added missing electrical circuit check to ETM. The unit will now receive power from the “Engine Instruments 2” circuit, which is normally powered during engine start.
- Added leading zeros and reduced update time on ITT LCD readout to match real aircraft.
- Fixed GPS1/COM1 and RMI circuit breaker logic.
- Fixed missing interior window scratch detail map.
- Replaced “atc_model” parameter with “850” statically, which should fix aircraft type recognition in 3rd party applications.
- Increased turning radius to match POH diagram.
- Fixed missing altitude alert light on primary altimeter.
- Landing lights instead of taxi lights will be on when loading a flight on a runway.

v1.1 - Aerodynamics, Beta & Requested Features

New Features:

- **Significantly improved aerodynamics.** All airfoils and control surface dimensions now match the POH values. The aircraft now has a heavier feeling for increased stability in gusty or turbulent conditions. Unusual trimming tendencies have been eliminated with adjustments to the propeller torque reactions (see below), and the takeoff trim positions (see below). Adjustments to the modern propeller simulation and aerodynamic coefficients have resulted in increased drag in approach regimes, meaning the aircraft is easier to slow on approach, and will decelerate rapidly in ground effect at flight idle.
- **Massive improvement to propeller beta simulation.** The correct blade angle values for the propeller’s twist are now used to produce net zero thrust. This has the side effect of improving low power propeller drag on approach, thereby reducing apparent floating. Erroneous torque effects caused by the native engine simulation have been filtered out. The beta range fuel controller has also been adjusted for finer control of taxi speed.
- **Improved turbine engine dynamics.** The torque decrease with altitude has been increased, and now decreases from a maximum of 150% at SL, to 105% at FL300. Maximum allowable torque of ~120% is attainable until around FL260. Sudden momentary changes in torque at high altitude were caused by a single miscalculated configuration value. ITT increase with altitude has also been increased, especially with the bleed air switch in the high position. An example from real world flight data:

Real world: 30,000ft, TQ=90%, RPM=2,000, OAT=-26°C, Bleed=Auto, ITT=800°C.
Under the exact same conditions, the resulting ITT with the TBM 850 in MSFS is 804°C.
- **Propeller torque effects on takeoff increased.** The torque effects were actually correctly simulated in the v1.0 flight model, but were being suppressed by an overzealous Asobo assistance feature, meant to make flying aircraft with strong torque effects (like the default TBM 930) easier for novice pilots. Thank you JayDee for helping me test and tweak all the above changes over a dozen iterations in just the last week!

- **St. Elmo's Fire & Static Discharge** effects added. When aircraft fly quickly through areas of charged particles, such as thunderstorms, the metal airframe can accumulate significant charge. When this charge becomes great enough, electrostatic discharges may occur over sharp areas of the aircraft, such as the cockpit windshields. The static wicks or other sharp areas of the aircraft may also glow purple with corona discharge, which can precede larger discharges across the windshields. See the "St. Elmo's Fire & Electrostatic Discharge" section of this manual for more information.
- **Added deicing boots** animation using the same technique as the default TBM 930. Future Black Square aircraft will use an even better technique.
- **Improved icing effects** on windshields, heated cowlings, and boots. Ice on the windows will now crystalize from the outside-in, and airframe ice will remain when leading edge ice is shed with the deicing boots. Heated cowlings will now deice separately from the rest of the deicing systems.
- **Added working wheel chocks.** The chocks are retrieved and deployed by clicking the aft seat area where the chocks are stored behind the seats. The chocks will stop the aircraft from moving, so the brakes may be depressurized after shutdown.
- **Improved exterior lighting** with brighter landing and taxi lights. The landing lights are now visible from inside the cockpit, and look better from a distance. Thank you to flightsim.to user eatpizza2 for the idea.
- **New custom strobe light system.** Just as in the real world, strobe light volumetric effects are now visible at night on dark nights. The strobe lights will now become disorientingly bright flashes surrounding the aircraft while operating in clouds, especially at night. Finally, you have a reason to heed the warning in , "Turn off strobe lights when operating in clouds or low visibility." See the "Realistic Strobe Bounce" section of this manual for more information.
- **Solar calculations for display backlighting** have been added for a much smoother dimming effect during sunrise and sunset. Unlike other 3rd party implementations, this takes all factors into account, including leap years, and the earth's tilt.
- Residual heat in the engine will now be suppressed by the gas generator during cooling, but some residual heat will return after the airflow subsides.
- The default copilot character can now be toggled on while in cockpit view using the "CREW MUSIC" switch on the copilot's lower panel. The pilot and copilot models will now also only be visible when the payload weight in their seats exceeds 70lbs.
- The Altimeter and ITT LCD screen reflected light color now changes from day to night.
- The condition lever position can now be controlled via the L:Var L:BKSQ_ConditionLever from 0-2. This should not be necessary, since the condition lever is most easily controlled via the default mixture bindings; however, it was added for convenience.

- The KMC 321 Mode Controller's rocker switch previously could only be used to adjust target vertical speed in 100ft increments. Now, the rocker switch can be used to adjust the target altitude in 500ft increments, and indicated airspeed holding speed by 1kt increments. When the rocker switch (or external hardware) causes a change in the target vertical speed, the KAS 297B will now momentarily display the vertical speed information for a few seconds, if the inner knob is not currently pulled out.
- An optional power lever beta range annunciator has been added to the annunciator panel for those who do not have hardware or software detents for their throttle input. The annunciator is disabled by default, and can be enabled by changing the variable "BKSQ_ShowBetaAnnunciator" from 0 to 1 in the aircraft's flight (.flt) files.
- The control wheel steering (CWS) buttons on the yokes can now be used to synchronize the indicated airspeed holding value with the aircraft's current indicated airspeed.
- The white outlines on the annunciator panel have been reduced in their prominence, and the color of the amber annunciators has been adjusted for a more pleasing effect.
- Added emissive light source on the back of the glareshield flood light tubes.
- The EHSI course select knob can now be used to control the TDS GTNxi in OBS mode.
- Pressing "REPAIR ENGINE" on the weather radar's engine condition display will now recharge the main aircraft battery.

Bug Fixes:

- Altimeter and OAT LCD screens will no longer appear blank with conflicting Honeycomb bindings. If you ever have switches or avionics that do not seem operable in Black Square aircraft, Honeycomb hardware bindings are very often the culprit.
- Possible fix for intermittent configuration saving between flights. This bug could have affected anyone using hardware peripherals to control the avionics master switch state.
- Green elevator trim takeoff band now corresponds to correct takeoff trim position, center of gravity adjusted, and horizontal stabilizer angle of incidence now matches book value.
- The EFIS power switch code has been modified so that its functionality can be controlled via the L:Var L:var_EFIS_PowerSwitch.
- Added proper L:Var control for the AP/Trims master switch via BKSQ_AutopilotMasterSwitch.
- Fixed rear passenger window geometry, and one polygon on co-pilot's window.
- The go-around button on the power lever has been fixed, and will now issue the native TOGA command to the autopilot. The behavior of this command may differ depending on which autopilot (GPS software) is in use, but will default to 8 degrees pitch up on the EFIS flight director.
- The PMS50 GTN 750 will now work with ground clearance mode.
- Dynamic registration fixed to allow outline strokes again.
- Changed panel.cfg files to reference new WT GNS 530 to force users away from using outdated default GNS 530 modifications, which are incompatible with this aircraft.

- Fixed crew and passenger oxygen consumption rate payload variable.
- Code change required for PMS50 GTN 750 WTT Mode compatibility.
- Sound volume for autopilot disconnect and altitude alert slightly increased.
- The amber BAT OFF annunciator light will now illuminate when the GPU is selected as a source.
- The main generator will not produce voltage until the starter motor is disconnected.
- Forward baggage compartment payload moment moved closer to centerline.
- Fixed ETM showing positive fuel flow before condition lever was in idle.
- The starter motor relay is now connected to the battery source bus, instead of the hot battery bus, meaning that the crash-bar must be lifted to start the engine.
- Autopilot will now enter pitch holding mode when engaged with no other modes active.
- Spoiler animation corrected to include travel inside of the wing when the opposite aileron is deflected upwards.
- Aileron and rudder trim animations corrected; however, the elevator trim has remained as is. The POH refers to the other trims as “trim tabs”, and the elevator trim as “anti-tabs”. The aileron trim indicator in the cockpit has also been corrected.
- Right hand elevator static wick reconnected to elevator animation.
- Transponder state will now be set to standby when loading in cold-and-dark state.
- The standby radar altimeter decision height annunciator light was rendered inoperative by a previous model change. Its functionality has been restored.

v1.2 - Major Update: Tablet, Exterior Elements & RNAV Autopilot

New Features:

- **NEW TABLET INTERFACE!** The same great tablet interface you’ve come to enjoy in the Black Square Duke’s added to the Black Square TBM 850 for free. Configuring options, hot-swapping avionics, payload settings, failure management, from the tablet, with real time visualizers for engines, electrical schematics, and environmental systems.
- **Improved environmental system accuracy** necessary for the tablet visualizer
- **Exterior elements** available via the tablet interface, such as pitot covers with “Remove Before Flight” flags that blow in the wind, engine covers, wheel chocks, and external power cart.
- **Improved external power logic** for use with the exterior elements options on the tablet.
- **Wing flex added.**
- The **KNS80 RNAV unit is now capable of controlling the autopilot** when no GPS is selected as the primary radio. See the “Using the KNS-80 RNAV Navigation System” for more information.

- **Added turbine engine specific failures** enabled by the improved engine simulation required for the tablet visualizer, such as compressor stall and surging, P2.5 bleed valve failures, and fuel control unit failures.
- **Improved deicing visuals** on the exterior model. Ice will now break off of the leading edge of the wings only where there are boots, and melt slowly from heated surfaces.
- Added **SU15 ground handling parameters**.
- Added **functional weather radar gain**, controlled by the existing gain knob.
- New sections added to the manual on the tablet interface, and **control inputs and output variables**, extending the manual from 109 to 160 pages. Enjoy!
- More equipment temperatures are now calculated for display on the tablet.
- **Instant Beta on Touchdown option added** to the tablet interface. Due to hardware deadbands, Black Square aircraft do not enter propeller beta range after touchdown if the hardware controller was already in the beta range before touchdown. Enabling this option will apply full beta after touchdown to begin slowing the aircraft without the need to “bump” your hardware throttle.
- **Added true Pitch Sync functionality to yoke CWS buttons**. Pressing and holding “L:var_PilotCws” or binding “K:SYNC_FLIGHT_DIRECTOR_PITCH” to hardware controls will now allow the aircraft to be maneuvered in pitch while temporarily disabling the autopilot pitch servo.
- A persistent tablet option has been added for a static **tablet position more comfortable for VR users**. The option, titled “VR Tablet Static Position” will affix the tablet in a location farther away from the camera, obscuring as little instrumentation as possible.
- **Improved propeller governor simulation** for smoother speed adjustments when testing overspeed limiter, and propeller governor failure is now gradual.
- Added a visual detent to the power lever to indicate the flight idle position, as already exists in the Turbine Duke.
- Reverse compatibility for VATSIM clients that use “COM RECIEVE ALL” for monitoring COM2 audio while transmitting on COM1.
- Added emissive light source on the overhead panel lighting posts.
- High bleed air flow torque performance reduction simulated.
- Added support for 0.5 kHz ADF frequency tuning on the KR 87. A secondary click on the power knob will increment the standby frequency by 0.5 kHz, which will indicate on the display with a small dot to the left of the frequency.
- PMS50 WTT Mode has been integrated natively, so no additional packages are required to enjoy the advanced autopilot features available with the PMS50 GTN 750 as the primary source of navigation.
- L:Var outputs have been added to all annunciator lights for use with home cockpits.

- Added support for WeatherSquare 4000.

Bug Fixes:

- Finally! There is a solution for the simulator's internal rounding error when setting COM frequencies above ~134 MHz. These frequencies will now work properly with 3rd party air traffic control clients in all Black Square Aircraft.
- Gas generator vs. density altitude curve corrected for throttle response.
- ITT and torque curves adjusted for more correct limiting factors at altitude.
- Parasitic drag scaler increased by 1%. High altitude cruising speeds are now correct to the knot based on POH tables.
- Dynamic oxygen consumption was erroneously using the outside air pressure, rather than the interior cabin pressure to calculate the biological oxygen requirement. Oxygen consumption in a partially pressurized cabin will now be substantially reduced.
- Fixed several oversights in the electrical system pertaining to the essential bus tie.
- Fixed annunciator panel test logic so active annunciators do not illuminate when the currently tested circuit does not have power.
- Fixed GPS OBS setting with EHSI course knob when using WT GNS and PMS50 GTN.
- Engine Trend Monitor shaft horsepower and specific fuel could read slightly high when ram air pressures were low.
- RNAV distance would wind up to 999.9nm when a valid DME station was tuned, but the aircraft was on the ground. This was due to interpolation added for autopilot control.
- Performance fix for when both PMS50 GTN 750 and TDS GTNxi 750 are installed.
- The autopilot would not follow the NAV2 VOR course deviation when selected on the EFS 40 EHSI in some circumstances.
- Volume knob momentary push on the TDS GTNxi was producing "Knob Stuck" warning.
- Airframe deicing controller circuit breaker was not tripping with failure.
- Torque will no longer diminish at middle throttle settings when using time acceleration.
- Overtorque annunciator warning and ETM exceedence redline adjusted.
- Annunciator panel test switch inverted to test correct circuit.
- Elevator control sensitivity reduced at low dynamic pressures.
- VR Pilot Camera position set to match non-VR pilot viewpoint by default.
- Fixed secondary GNS 530 com volume knob incorrect animation name.
- Fixed COM 1 KX155 volume knob animation that had a lower maximum position than the COM 2 KXX155.
- Increased glareshield light emissive intensity.

v1.3 - Marketplace Update

New Features:

- Upgraded KNS-80 RNAV, and KR87 ADF push button interactions to conform to latest Black Square standards.
- Added optional PMS50 GTN 750 configuration for go-around nose-up angle, which will now match the 8° pitch-up commanded by the other autopilot systems.
- Added headphone cable visual model and clickspots in preparation for custom soundset at a later date.

Bug Fixes:

- The tablet “Load with Covers & Chocks Deployed” option had no effect in v1.2.
- The tablet payload page’s maximum allowable weights have been corrected, and the manual updated with more specific loading information for the nose storage compartment. The center of gravity envelope display on the tablet payload page has also been corrected accordingly.
- It was possible in v1.2 for the primary Working Title GNS 530 to load incorrectly if selected at the beginning of a flight (via state saving) that would render the autopilot mode indications inoperable.
- KNS-81 output L:Var values for hardware interfaces only updated when there was a valid VOR signal being received.
- Several instances of information relevant to operation of the Black Square Turbine Duke were removed from the manual.
- Improved colors of EFS40 EHSI pointer needles for clarity.
- Rearranged After Starting Engine checklist so bleed air valve would be open before attempting to check deicing boot inflation.
- Ground effect slightly reduced for more assertive on-speed landings.
- Improved gas generator behavior at high power settings.

v1.4 - MSFS 2024 Compatibility & Altitude Selector Update

New Features:

- **Added preflight/walk-around interactivity** for MSFS 2024 including collision model, clickspots for engine covers, pitot covers, chocks, door handles, baggage doors, etc.
- **Overhauled behavior of the KAS 297B** to implement vertical speed arming. See the “Bendix/King KAS 297B Altitude Selector” section of this manual for more information.
- **NEW Magnetic Compass Effects** including physics filtering and erratic behavior from onboard magnetic fields. See the “Magnetic Compass Effects” section of this manual for more information.

- **Added GTNxi 750 & 650 bezels** and improved model switching technique.
- **Added Ear Discomfort Index** to the cabin visualizer page of the tablet interface.
- Interior lighting completely retooled for MSFS 2024.
- Added persistence to tablet payload unit switch between sessions.
- Implemented custom toe brake animations and sounds to prevent jittery or looping animations when hardware brakes are used in conjunction with the parking brake.
- Added engine driven fuel pump failure and corresponding engine visualizer behaviors.
- Changed torque calculation source variable for faster torque indication changes.
- Workaround to fix MSFS 2024 light flare bleed-through.
- Added tablet option to enable exterior registration meshes in MSFS 2024. There is a hard-coded bug in MSFS 2024 that interferes with the ultra-custom dynamic registration system in Black Square aircraft. Sim Update 3 failed to resolve this issue, but a potential fix may be in the works for Sim Update 4. Currently, the dynamic registration may work depending on how the aircraft was loaded.

Bug Fixes:

- During a complete electrical failure, some essential variables would fail to update. This included fundamental variables used to drive Black Square's advanced engine simulation, sounds, avionics displays, and external hardware or displays.
- The air conditioning system would fail to operate on ground power alone, and cooling ability would not be affected by the speed of the cooling turbine.
- The cooling turbine depiction on the cabin visualizer did not respect the bleed air valve positions, and would spin up/down with the gas generator.
- The fuel pressure annunciator would extinguish when the fuel pump was running, even if there was no pressure indicated by the fuel pressure needle. The fuel pump would also still cycle when there was no fuel pressure due to the tanks being empty, or the fuel selector being in the off position.

Credits

Black Square TBM 850
Publishing
Manual
Testing

Nicholas Cyganski
Just Flight
Nicholas Cyganski
Just Flight Testing Team

Dedication

This product was previously dedicated to Edwin Albert Link, creator of the Link Trainer. This dedication now appears at the end of the Turbine Duke manual.

This virtual representation of the TBM 850 is dedicated to the man whose name has become synonymous with the TBM 850, Steveo1Kinevo of YouTube fame. During the nearly ten years that Steve has been sharing videos of flying N851TB on YouTube, he has inspired countless viewers to become pilots, improve their proficiency, and even relocate to South Florida.

During the pre-release phase of the Black Square TBM 850, we learned that Steve would no longer be flying N851TB in an emotional video for any pilot to watch, but especially for aircraft owners. This announcement signaled the end of an era, and served as a reminder that technological advancement continues to shape aviation and flight simulation, often as soon as we feel comfortable with the existing technology.

My hope is that this product can serve to commemorate a decade of flying with Steveo1Kinevo for the million or more viewers who grew to admire the TBM 850, and our devoted pilot host. Thank you, Steve, for all you have done for general aviation. We all wish you luck in the next chapter of your flying career, and will do our part to keep the legacy of N851TB alive in virtual reality for all to enjoy.

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