

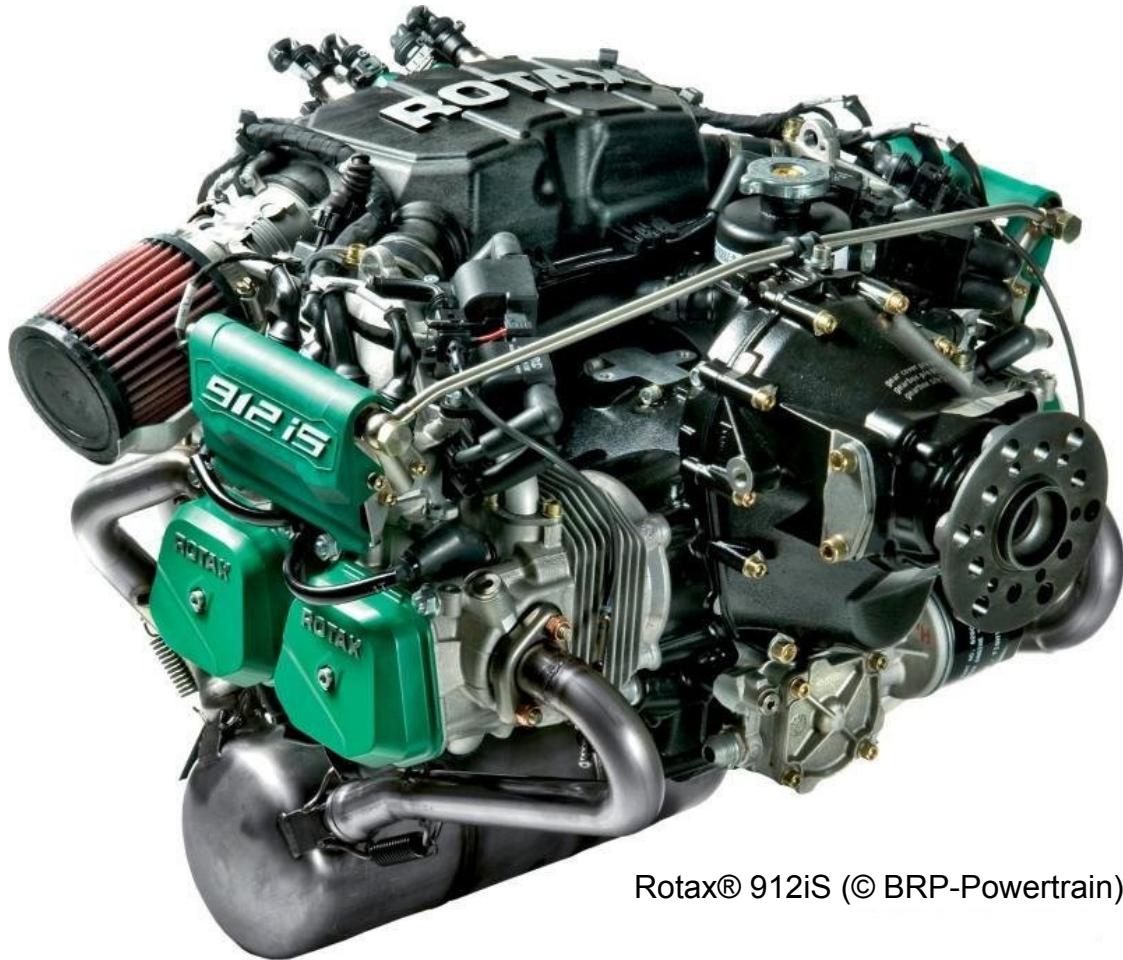
# Rotax® 912iS Engine Management and Cockpit Display Unit

[www.stockflightsystems.com](http://www.stockflightsystems.com)



Rotax® 912iS (© BRP-Powertrain)

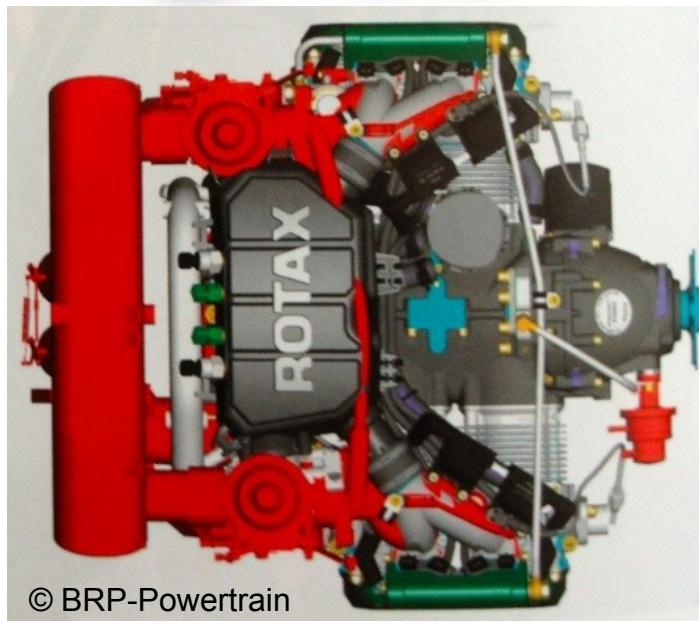
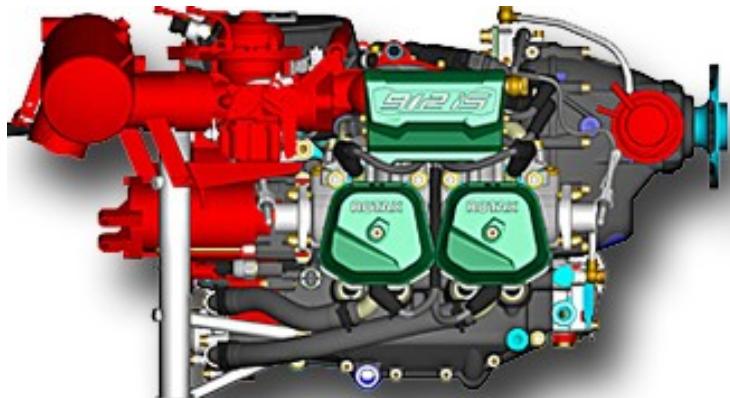
# Rotax® 912iS Overview (1)



Rotax® 912iS (© BRP-Powertrain)

- Fuel injection and ignition of the 912iS is controlled by a duplex redundant **Engine Control Unit (ECU)** that uses two individual sets of injectors/sparc plugs per cylinder.
- The ECU controls the fuel/air mixture and the ignition timing electronically to optimize fuel consumption and engine performance. The ECU also monitors all engine parameters continuously.
- Two independent, dual redundant sets of CANaerospace data buses for cockpit instrumentation and engine maintenance purposes.

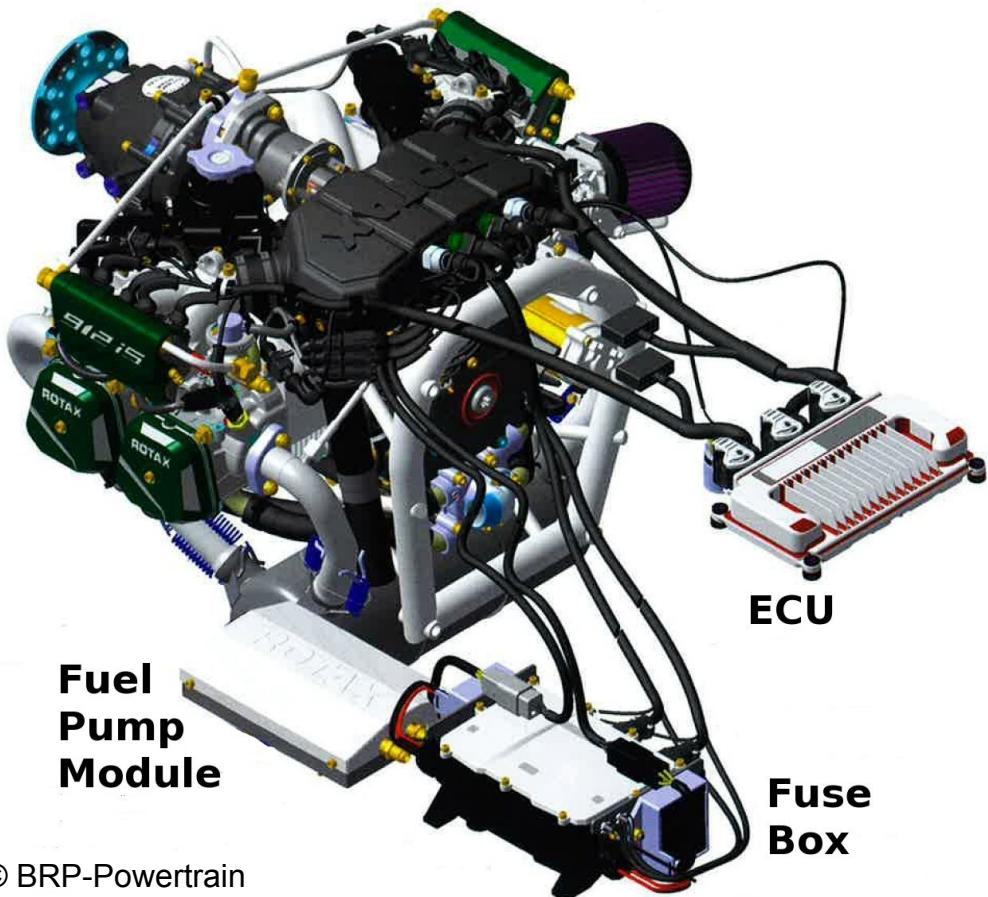
# Rotax® 912iS Overview (2)



© BRP-Powertrain

- The 912iS replaces the carburetors and associated components of the well-known Rotax® 912S engine (shown in red) with an electronic fuel injection and ignition system.
- An airbox on top of the engine carries the throttle valve, and sensors to measure pressure and temperature of the air intake.
- The generator and starter of the 912S have been replaced by newly developed components. The new generator system is fully dual redundant, with two independent alternators and voltage regulators.
- Fuel consumption of the 912iS is significantly less than that of the 912S with carburetors.

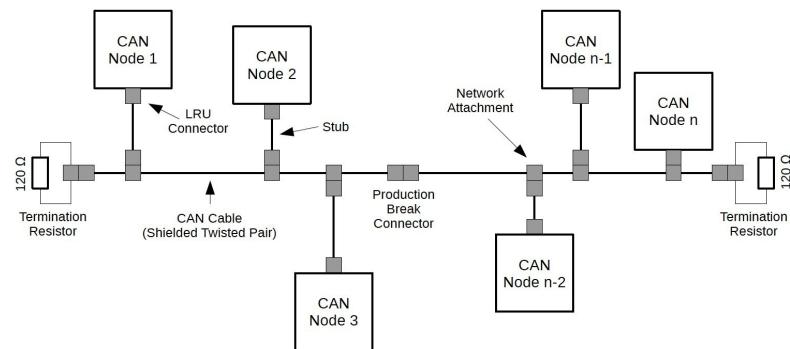
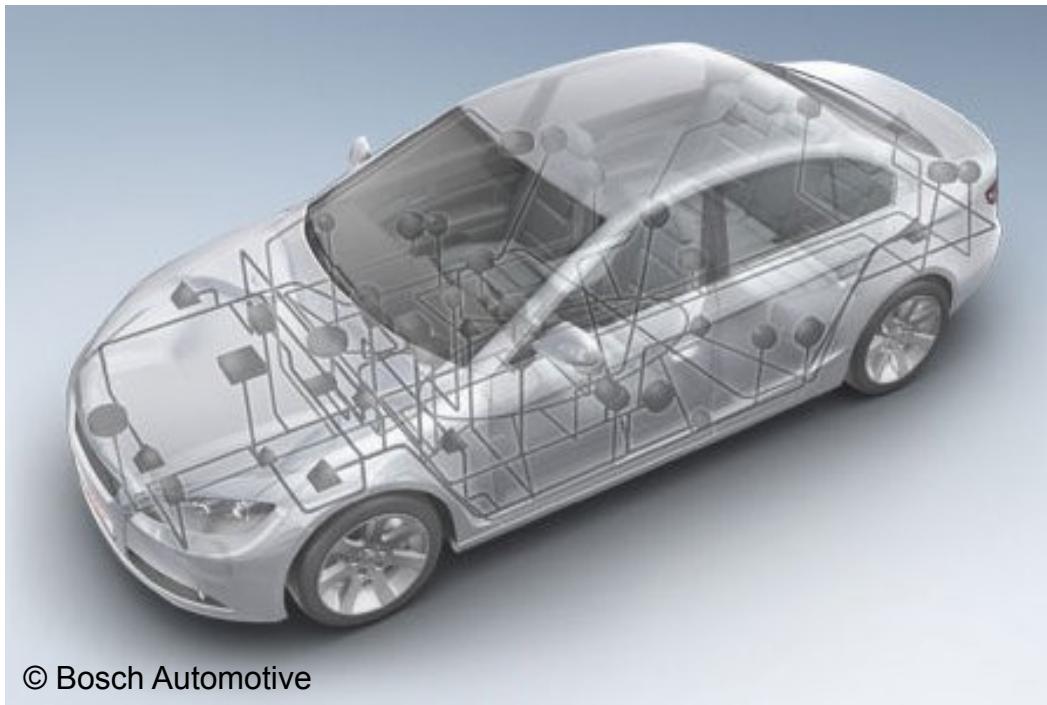
# Rotax® 912iS System



© BRP-Powertrain

- The 912iS engine is accompanied by three dual redundant secondary systems:
  - Engine Control Unit (ECU)
  - Fuel Pump Module
  - Fuse Box (electric energy management)
- The wire harness providing the subsystem interconnection is delivered with the engine. There is no access to individual engine sensors for cockpit instrumentation.
- Without doubling all engine sensors, the only way to provide the pilot with the 912iS engine parameters is an electronic cockpit display unit which interfaces to the redundant CAN data bus system with CANaerospace protocol.

# What is the CAN Data Bus ?



- The Controller Area Network (CAN) serial communication bus was developed by the German company Bosch Automotive in 1991.
- CAN uses a single twisted pair cable to transmit serial information at a rate of up to 1 Mbit/s (125 kbit/s used for the 912iS ECU Display Buses, 500 kbit/s for the 912iS ECU Maintenance Buses).
- CAN is a full duplex, multi-master network by design and provides an effective bus arbitration concept.
- CAN provides a very high data integrity through sophisticated error detection.
- CAN became a worldwide standard for the automotive industry with hundreds of million installations to date.



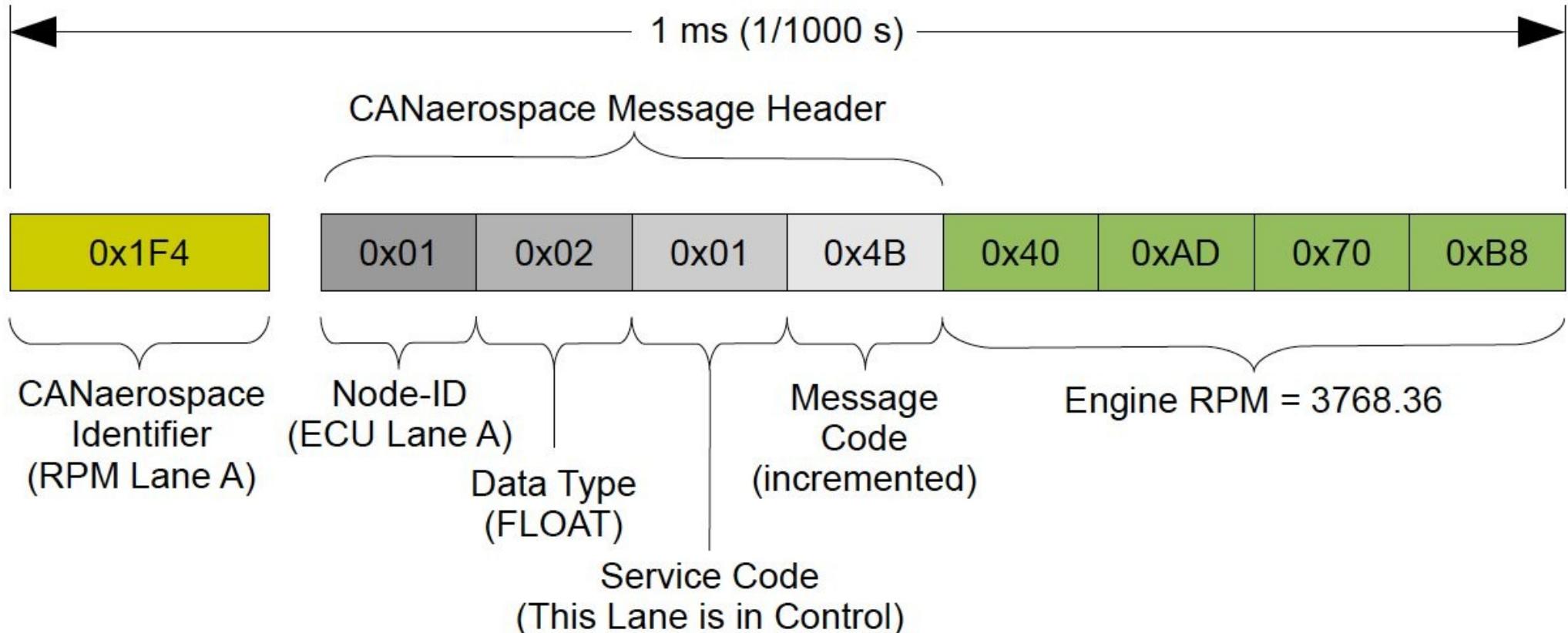
# What is CANaerospace ?



- CANaerospace is a higher layer protocol based on Controller Area Network (CAN) which was developed by Stock Flight Systems in 1998.
- CANaerospace defines communication mechanisms, data type standardization and other means to turn CAN into a network suitable for the specific requirements of airborne systems.
- CANaerospace supports data transmission using floating-point data formats and engineering units (i.e. m/s, K), and dynamic interrogation of network nodes.
- During the NASA/Industry/FAA Advanced General Aviation Transport Experiments (AGATE) program, CANaerospace was chosen as the AGATE data bus standard.
- CANaerospace is used as communication protocol by several general aviation avionics suppliers.

# CANaerospace Message Example

- The 912iS ECU transmits all engine display parameters 10 times per second.
- At 125 kbit/s, the maximum network throughput is 1000 CANaerospace messages per second. The 912iS system uses only 30% of the available bandwidth.



# List of Rotax® 912iS ECU CANaerospace Messages

[www.stockflightsystems.com](http://www.stockflightsystems.com)



Parameter	Range	Parameter	Range
Engine Speed	0 – 8000 1/min	Ambient Air Temperature	200 – 450 K
Throttle Position	0 - 100%	ECU Supply Bus Voltage	0 – 30 VDC
Oil Pressure	0 – 10000 hPa	Engine Status	32 discrete values
Oil Temperature	200 – 425 K	Sensor Fault Status	32 discrete values
Cylinder Head Temperature	200 – 450 K	Device Fault Status	32 discrete values
EGT Cylinder 1	200 – 1400 K	ECU Hours	0 – $10^6$
EGT Cylinder 2	200 – 1400 K	ECU Hours	0 – $10^6$
EGT Cylinder 3	200 – 1400 K	<ul style="list-style-type: none"> <li>• Each parameter is available for ECU Lane A/B</li> </ul>	
EGT Cylinder 4	200 – 1400 K	<ul style="list-style-type: none"> <li>• Total number of parameters: <math>2 \times 111 = 222</math></li> </ul>	
Fuel Flow Rate	0 – 50 l/h	<ul style="list-style-type: none"> <li>• The EMU 912iS uses ALL parameters to ensure optimum pilot awareness about the engine state at all times</li> </ul>	
Manifold Air Pressure	0 – 1500 hPa		
Manifold Air Temperature	200 – 450 K		
Ambient Air Pressure	0 – 1500 hPa		

# EMU 912iS Overview



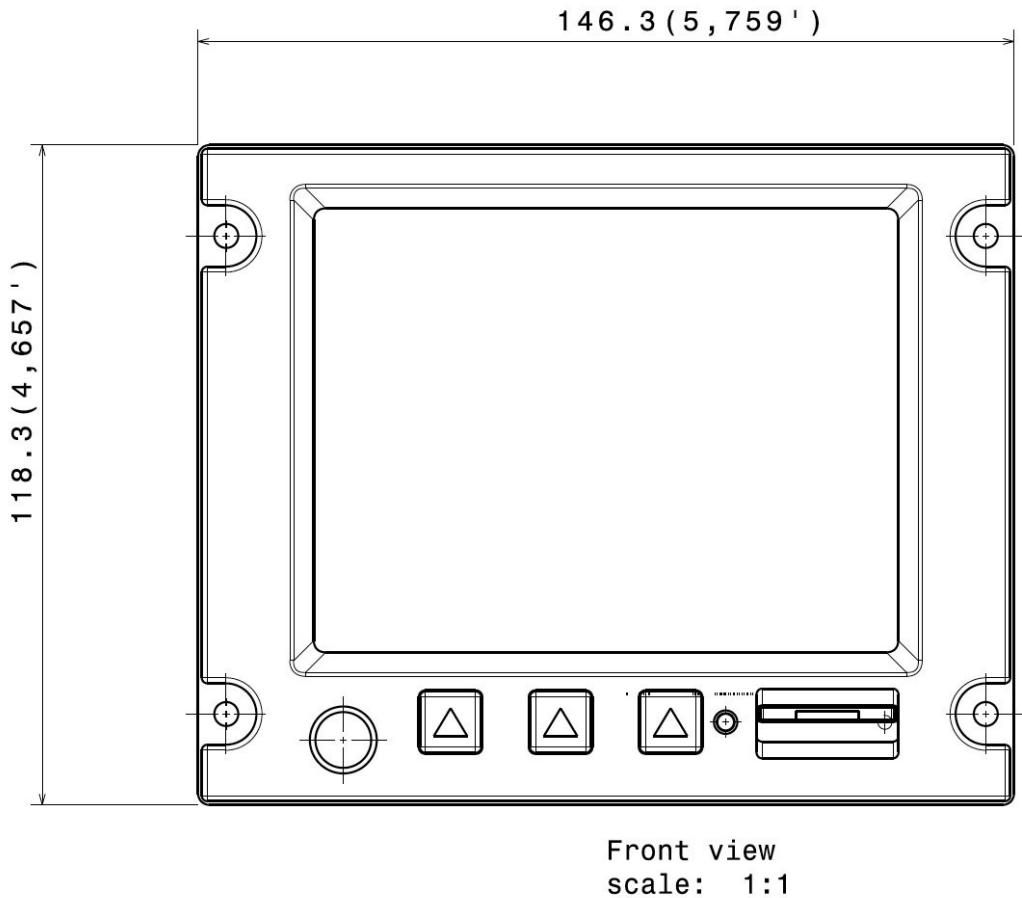
- The **Engine Management Unit (EMU 912iS)** has been designed along with the Rotax® 912iS engine and test flown in several airplanes and gyrocopters.
- It makes full use of all resources available with the dual redundant CANaerospace data buses and provides the pilot with an unprecedented level of awareness about engine status and performance.
- Indications and pilot informations have been developed and verified during the 912iS flight test program.
- Flight tests included operation at temperatures as low as -18 deg. C and altitudes as high as 18.000 ft.
- Integrated data recording and computer tools support post-flight data analysis.

# EMU 912iS Specification

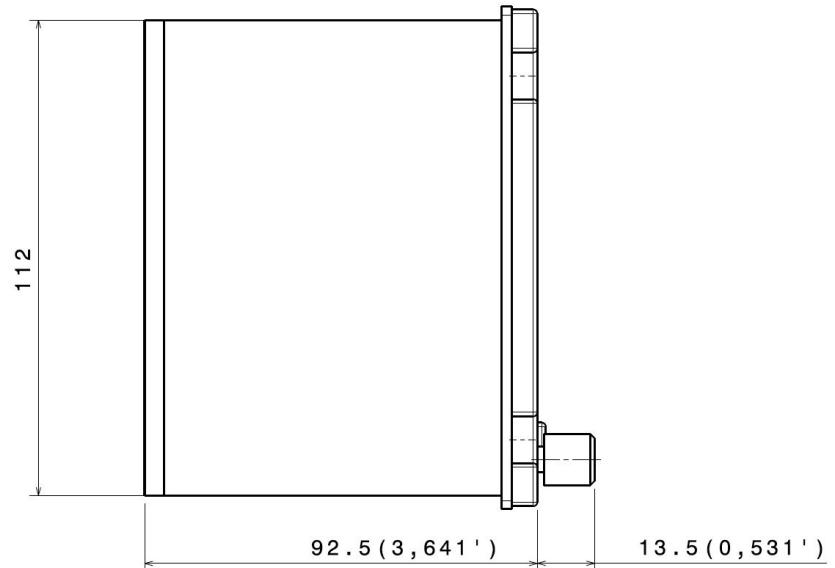
## EMU 912iS

Mechanical Dimensions	146.3 mm x 118.3 mm x 92.5 mm (W x H x D) 5.76" x 4.66" x 3.64"
Mass	0.8 kg (1.8 lbs.)
Electrical Power Supply	9 – 28 VDC
Power consumption	0.3 A @ 28 VDC, 0.6 A @ 14 VDC
CANaerospace Interfaces	According to ISO 11898-2, optically isolated
Display Resolution	640 x 480 pixels
Display Size (Diagonal)	127 mm (5.0")
Display Brightness	600 cd/m <sup>2</sup> (dimmable between 2% and 100%)
Operating Temperature Range	-20° C to + 75° C (-4 F to 167 F)
Operating Altitude	Up to 7.620m (25.000 ft)
Humidity	Less than 95%, non-condensing

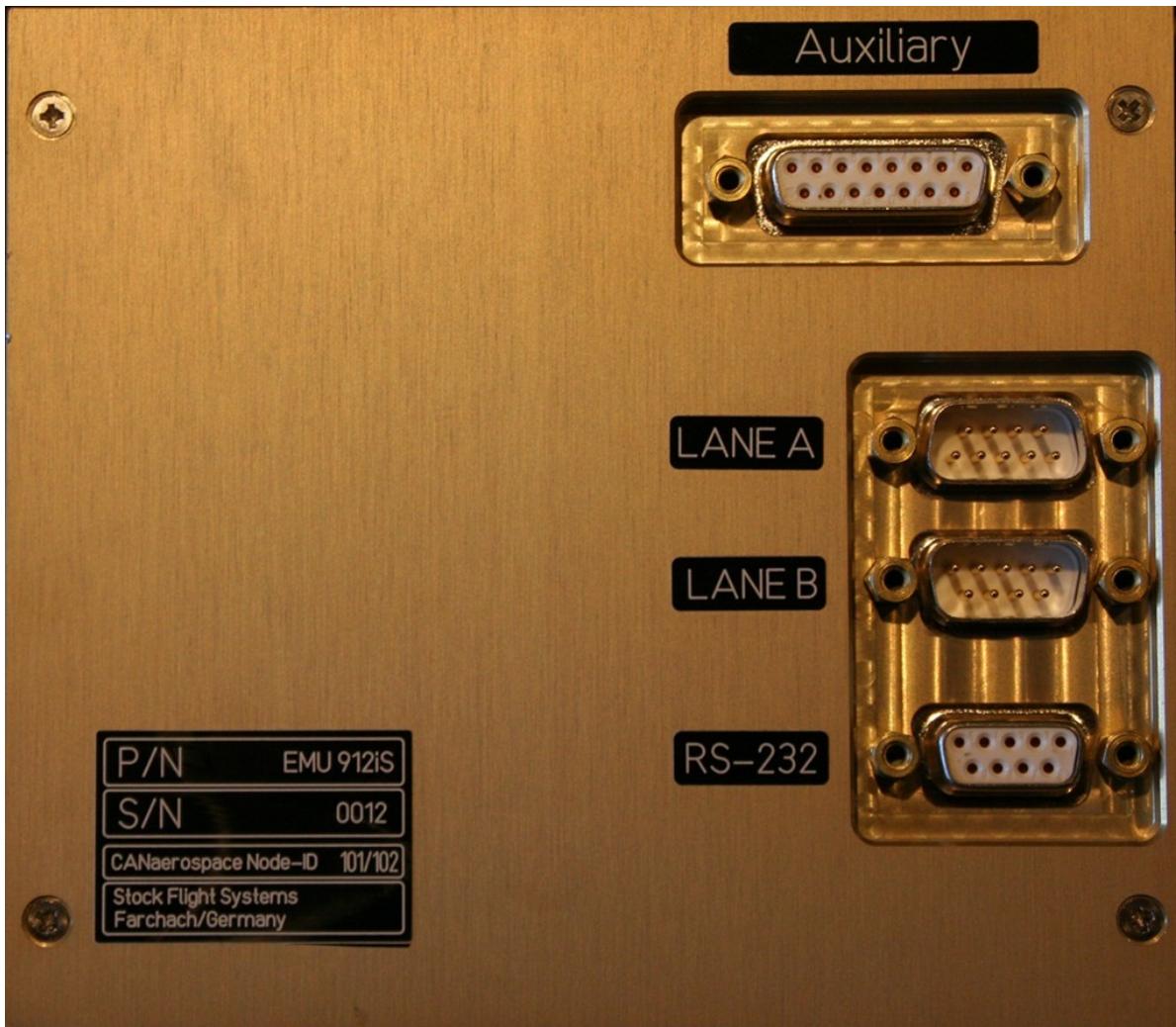
# EMU 912iS Dimensions



- The EMU 912iS is installed in the instrument panel from the front, using four M4 screws.
- Instrument panel attachment: M4 threads or rear mount cage nuts.

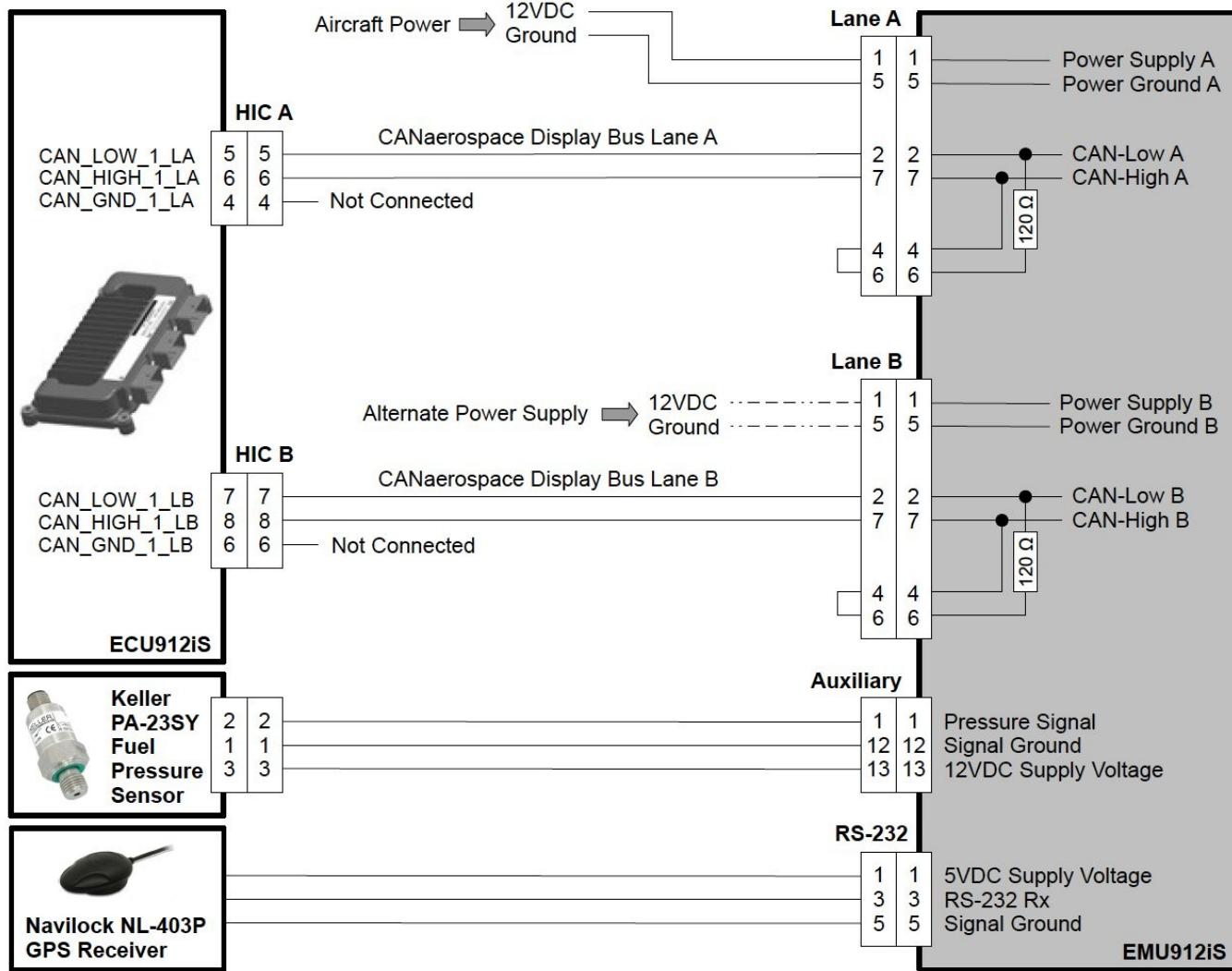


# EMU 912iS Rear View



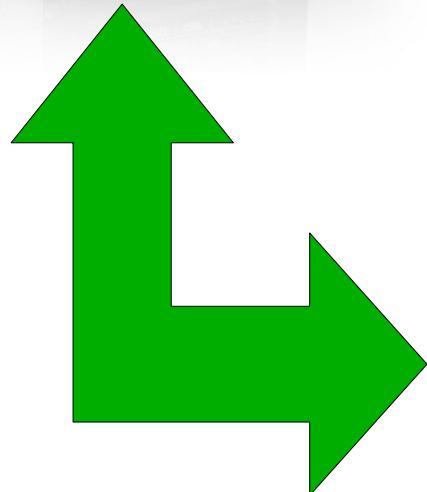
- The EMU 912iS has four Sub-D rear wall connectors:
  - CANaerospace Lane A and power supply
  - CANaerospace Lane B and power supply
  - RS-232 (GPS)
  - Auxiliary (Fuel Pressure Sensor, Start Power Relay Output, RPM Signal Output)
- All signals are isolated from the EMU enclosure.
- Only high quality, aerospace grade connectors are used.

# EMU 912iS Connections



- The EMU 912iS interfaces to the 912iS ECU via the two CANaerospace Display buses only.
- Redundant inputs are available to supply the EMU 912iS with electrical power from different sources.
- The EMU 912iS supports an external fuel pressure sensor to be installed in the pressure line of the Fuel Pump Unit.
- An external GPS receiver (delivered with the EMU 912iS) provides additional information which is displayed and recorded together with engine data.

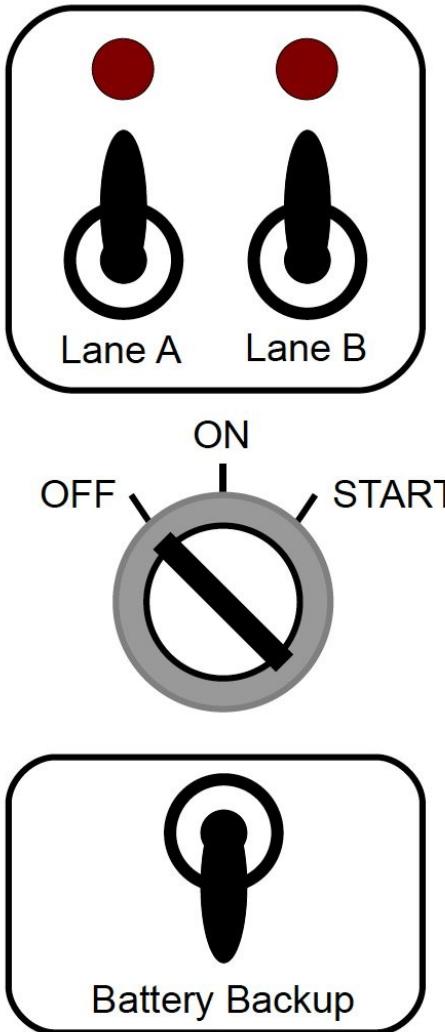
# EMU 912iS System Integrity



- The EMU 912iS is 100% electrically isolated from the 912iS ECU.
- Dual, optically isolated CANaerospace network interfaces provide independent connections to both ECU lanes.
- Integrated 120Ω CAN termination resistors allow proper network termination for the EMU 912iS without requiring external components.
- The EMU 912iS fully complements the Rotax912iS® system redundancy concept without exceptions.
- An integrated CAN monitor/analyizer allows to detect network problems at an early stage and assist during trouble shooting.

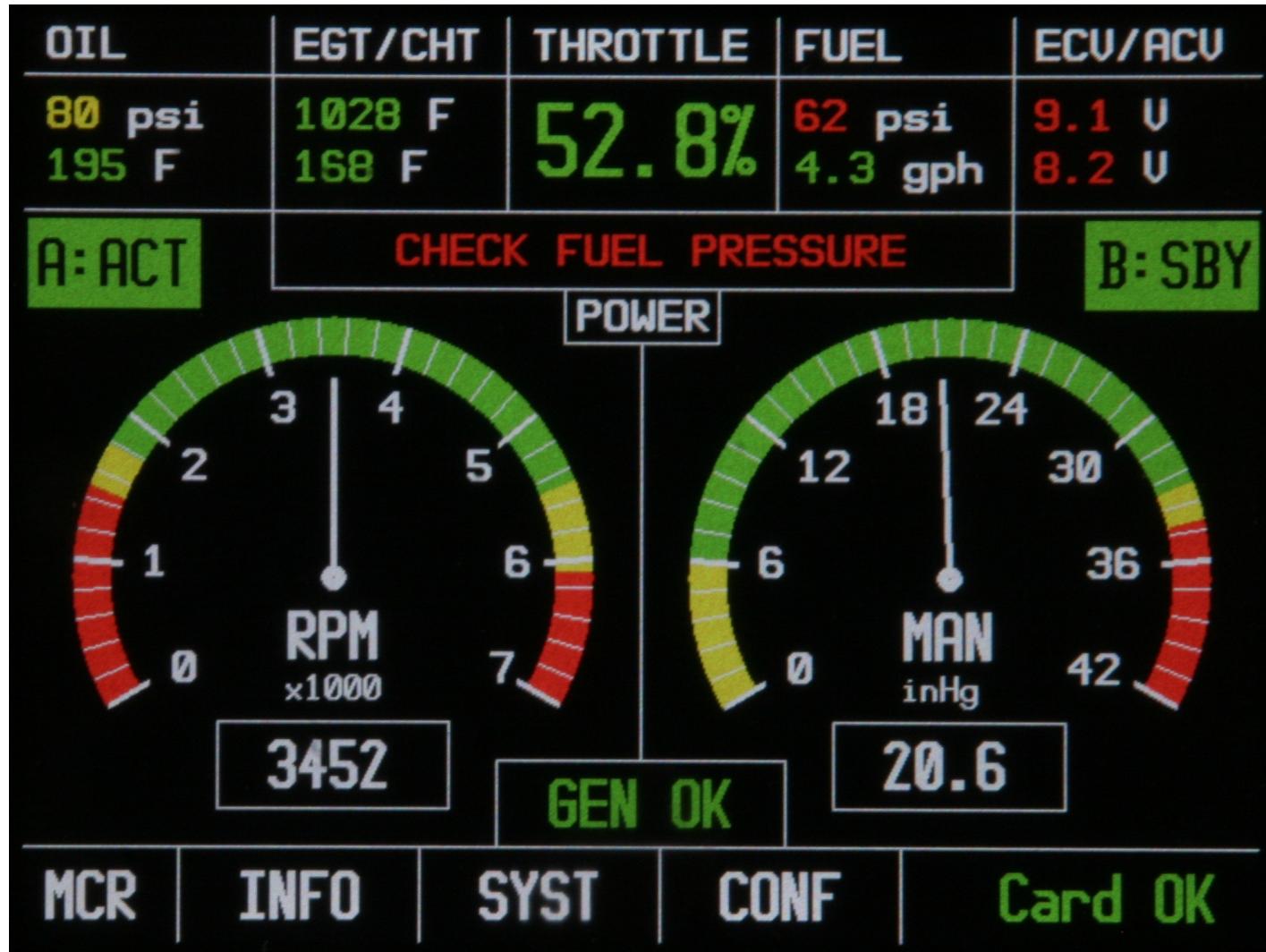
# EMU 912iS Start Power Function

[www.stockflightsystems.com](http://www.stockflightsystems.com)



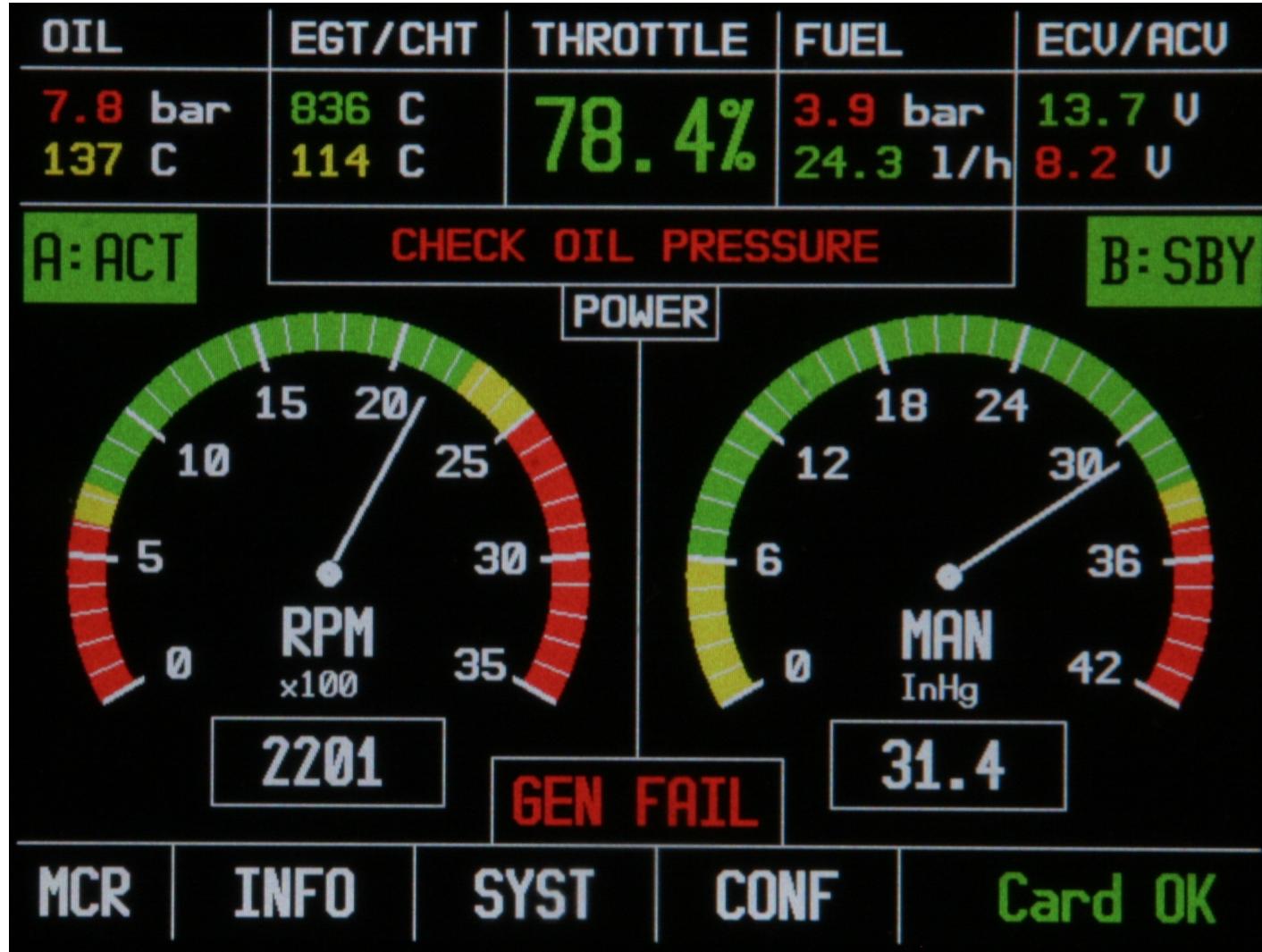
- The EMU 912iS Start Power function provides “912S style” engine start and handling.
- Engine start is accomplished using the main key switch with three positions (OFF, ON, START) as follows:
  - OFF: Aircraft unpowered;
  - ON: All cockpit instruments and EMU 912iS powered;
  - The EMU 912iS activates the external Start Power Relay within three seconds and displays all engine data within 15 seconds;
  - If the external temperature is below freezing, the EMU 912iS provides guidance for cold start throttle position setting;
  - START: Engine is started, after reaching 1500/min the EMU 912iS automatically deactivates the Start Power Relay. Restart requires to switch to the “OFF” position again (for certification reasons).
- The Battery Backup Switch allows engine start in any case.

# Main Display Page (1)



- The Main page displays all relevant engine parameters of the active lane (A or B).
- The general ECU lane status and the active lane is indicated in green/amber/red.
- The Master Caution field displays the most important warning and may be cleared by pressing MCR (Master Caution Reset).
- All colors change according to the limits as specified by BRP.

# Main Display Page (2)



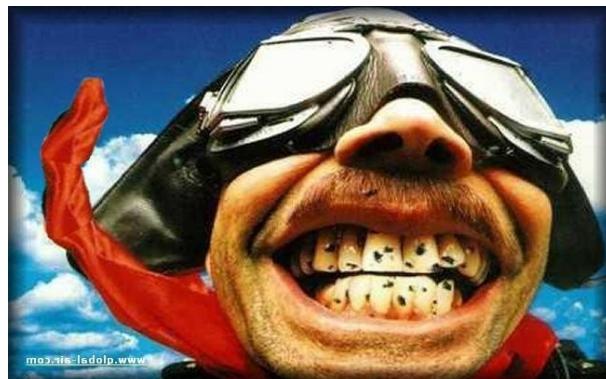
- The EMU 912iS allows user selection of the following display options:
  - Crankshaft vs. Propeller RPM
  - Metric vs. US units
  - InHg vs. hPa manifold pressure gauge indication
  - GPS on/off control
- These selections may be stored permanently.
- Custom display options are available on request.

# EMU 912iS Advanced Main Display Page Functions

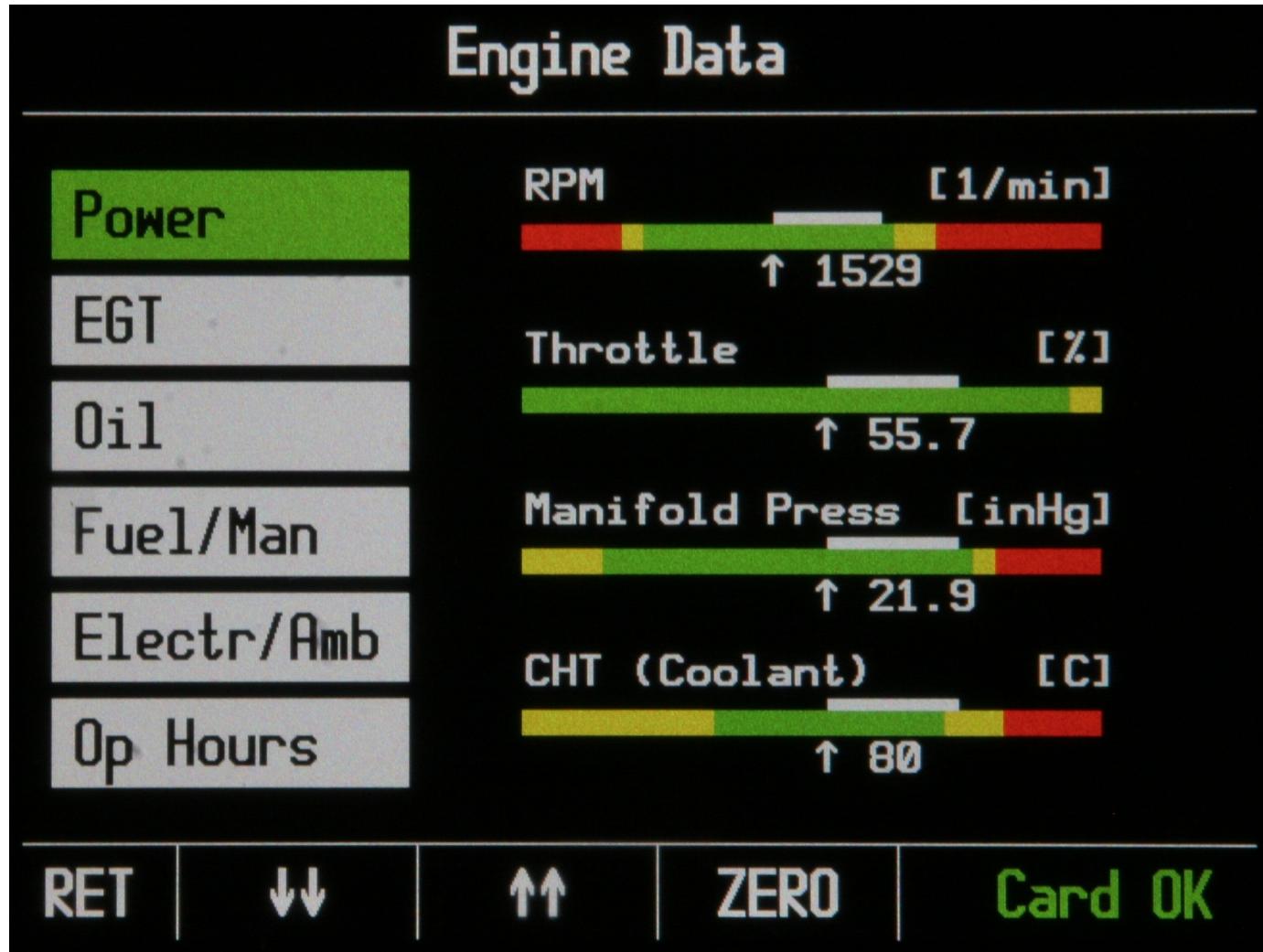
[www.stockflightsystems.com](http://www.stockflightsystems.com)



- The EMU 912iS Main Display Page provides the 912iS pilot with advanced 21<sup>st</sup> century features:
  - Quick information at a glance: All green means “don't care”
  - Assistance for cold start throttle settings
  - Immediate information about fuel economy (ECO = lean, POWER = rich)
  - Realtime information about the computed fuel flow
  - Correction of oil/fuel pressure with ambient pressure
  - Information about the status of the redundant ECU lanes (lane in control, lane with detected warnings/failures)
  - Top marker inserted into the recording data stream by pressing the Master Caution Reset (MCR) for post processing of recorded data
  - Information about upcoming fuel/air filter cleaning or replacement through fuel/air pressure data computation



# INFO Page



- The INFO page displays all engine parameters in bars.
- The engine parameters are grouped by topic.
- Each parameter group has its own drag indicator which can be reset using the “ZERO” button.
- All limitations are as specified by BRP.
- All units are according to user settings (refer to CONF page).

# SYST Page (1)

## System Status Information

Warnings	CHECK OIL TEMPERATURE CHECK FUEL PRESSURE CHECK COOLANT TEMP CHECK AIRCRAFT VOLTAGE
ECU Faults	
ECU Status	
ECU Config	
Data Rec	
CAN BusMon	

RET    ↓↓    ↑↑    Card OK

- The SYST page displays system status, warning and informational data.
- The data is grouped by topic.
- “Warnings” is at the top of the selection and displays all current EMU warnings in their corresponding color (amber or red).
- The Up/Down arrows allow to move between the data groups.
- The RET key allows to return to the MAIN page.

# SYST Page (2)

## System Status Information

Warnings

ECU Faults

ECU Status

ECU Config

Data Rec

CAN BusMon

A: Coolant Temperature Sensor Fault

B: Oil Temperature Sensor Fault

A: Lane Synchronization Fault

B: Lane Synchronization Fault

- The ECU Faults group provides detailed information about the source of failures as detected through the Continuous Built-In Selftest (CBIT) of both ECU lanes.
- All faults are displayed in their corresponding color:
  - Red: Fault
  - Amber: Warning
  - White: Unclassified

RET

↓↓

↑↑

Card OK

# SYST Page (3)

## System Status Information

Warnings

ECU Faults

ECU Status

ECU Config

Data Rec

CAN BusMon

Lane A is in Control  
Power Mode  
Generator 2 in Use  
Warning Lamp Off  
ETPU Not Initialized  
Cylinder #1 EGT Not Excited  
Cylinder #2 EGT Not Excited  
Cylinder #3 EGT Not Excited  
Cylinder #4 EGT Not Excited  
EGT Disabled  
EGT Not in Steady State  
EGT Disabled

RET

↓↓

↑↑

Card OK

- The ECU Status group provides detailed information about the internal processing functions of both ECU lanes.
- This additional information is helpful to analyze faults and further reduces the effort for trouble shooting.

# SYST Page (4)

## System Status Information

**Warnings**

**ECU Faults**

**ECU Status**

**ECU Config**

**Data Rec**

**CAN BusMon**

EMU Internal Temp-> 38 deg. C

ECU Serial # → 110205  
Software A # → 811-4576-025  
Software B # → 811-4576-025  
ECU Model → ECU-204-102A  
Engine Serial # → 0  
Engine Type → 912iS  
Engine Hours → 38.0

RET | ↕ | ↑↑ | Card OK

- The ECU Config group provides detailed information about:
  - Model and serial number of the ECU
  - Type and serial number of the engine
  - Software revisions of both ECU lanes
  - Engine operating hours
  - Software revision and internal temperature of the EMU

# SYST Page (5)

## System Status Information

Warnings

Data Recording → Lanes A + B  
New File after → 1800 seconds  
Current Topmark → 2 [0x0002]  
Current Filename → DAT\_0000.CAN  
Current Filesize → 0 kBytes

ECU Faults

ECU Status

ECU Config

Data Rec

CAN BusMon

GPS UTC → 00:00.00  
GPS Date → 0.0.0  
GPS Ground Speed → 0.0 km/h  
GPS Height → 0.0 m  
GPS True Track → 0.0 deg  
GPS Latitude → 0.0000  
GPS Longitude → 0.0000

RET

↓

↑

Card OK

- The Data Rec group provides detailed information about the data recording function of the EMU 912iS.
- The GPS data is stored on the SD card together with the engine data of both ECU lanes (GPS data recording may be disabled).
- Time correlation is accomplished by GPS.
- Each CANaerospace message carries a time stamp with 31.25ns resolution for data post processing.

# SYST Page (6)

## System Status Information

**Warnings**

**ECU Faults**

**ECU Status**

**ECU Config**

**Data Rec**

**CAN BusMon**

Lane A

CAN Baudrate	-> 125 kbit/s
CAN Status	-> Bus OFF
CAN Errs (Rx/Tx)	-> 7/120
Rx Messages	-> 0
Tx Messages	-> 0

Lane B

CAN Baudrate	-> 125 kbit/s
CAN Status	-> Error Warning
CAN Errs (Rx/Tx)	-> 0/0
Rx Messages	-> 0
Tx Messages	-> 0

RET |  |  | Card OK

- The CAN Bus Monitoring function provides information about the integrity of the CANaerospace network interfaces for both ECU lanes.
- In a proper installation, the number of CAN Bus Errors should be zero at all times.
- The EMU does not only receive CANaerospace messages but also transmits (GPS data, ECU interrogation, aircraft voltage and fuel pressure data).

# EMU 912iS SD Card

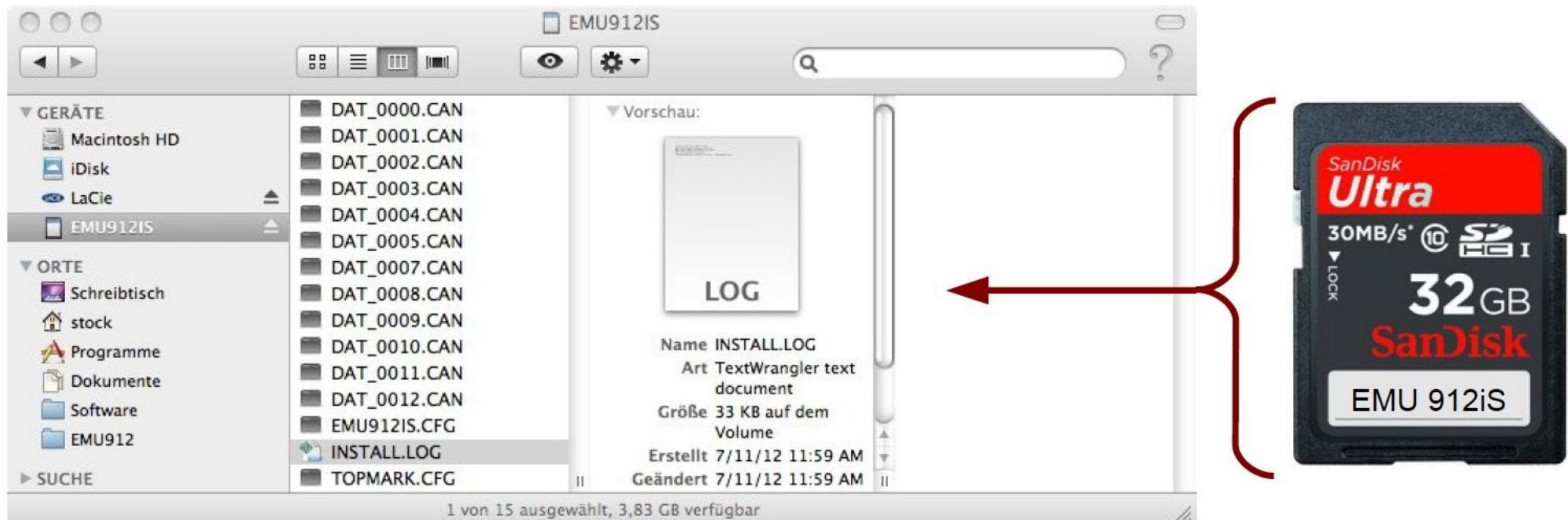


- Card size up to 32GB, standard FAT32 computer file format.
- The SD card is used for:
  - Software upgrades
  - Configuration data storage
  - Flight data recording



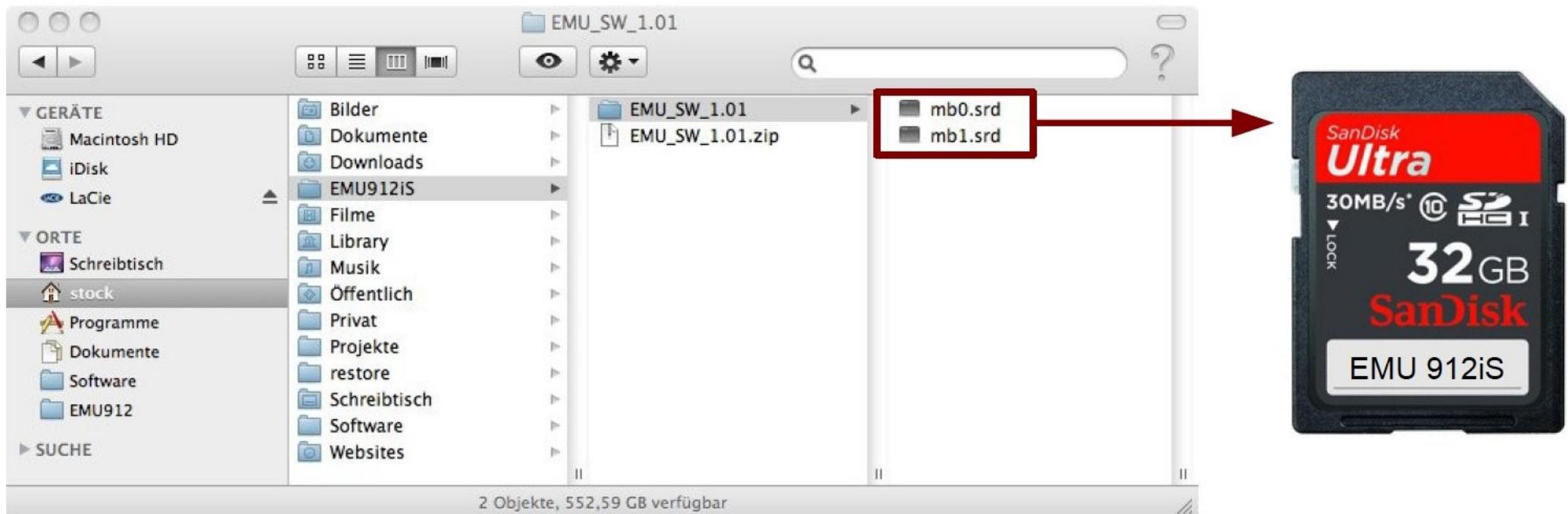
# EMU 912iS SD Card Content

- The SD card contains:
  - EMU configuration file (EMU912IS.CFG)
  - Flight data recording files (DAT\_1234.CAN)
  - Top marker file (number of next recording file)

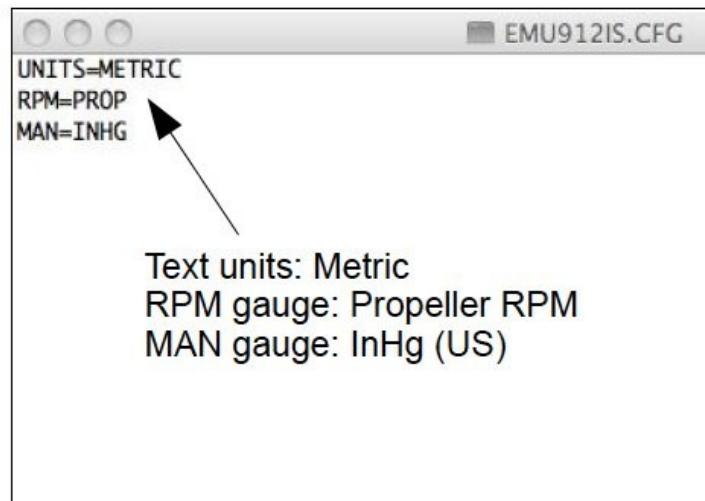


# EMU 912iS Software Upgrades

- EMU 912iS software upgrades are extremely simple:
  - Download new software version from website, extract the ZIP-File.
  - Copy the mb0.srd and mb1.srd files to the SD card.
  - Insert the SD card into the EMU 912iS, power the unit up and wait 45 seconds.



# EMU912iS Configuration File



- The EMU912IS.CFG file contains the display options specified through the EMU 912iS CONF page:
  - UNITS=METRIC / UNITS=US sets the units for all parameters displayed in text.
  - RPM=PROP / RPM=CRANKSHAFT sets the main page RPM gauge to display either engine crankshaft or propeller RPM (2.43 : 1 red. gear).
  - MAN=HPA / MAN=INHG sets the main page MAN gauge to display manifold pressure either in hectopascal (hPa) or inches mercury (InHg).
  - GPS=ON / GPS=OFF controls GPS data recording.
- EMU912IS.CFG is a plain text file and can be edited using a raw text editor (i.e. Wordpad). The syntax is case sensitive and no spaces are allowed.
- The EMU912IS.CFG file may be copied from a host computer to the SD card and vice versa.

# CONF Page

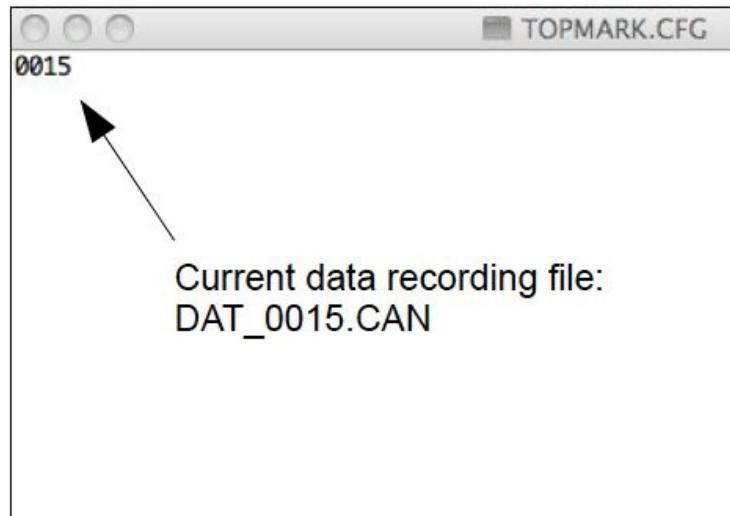
## System Configuration

Units      Crankshaft  
RPM      Propeller  
MAN  
Save

RET    ↓    ↑    OK    Card OK

- The System Configuration Page allows to change the settings in the EMU 912iS configuration file.
- Selections become effective immediately.
- To make selections permanent, the “Save” function has to be activated.
- GPS ON/OFF selection will be added soon. With GPS OFF, no GPS data will be recorded together with engine data.

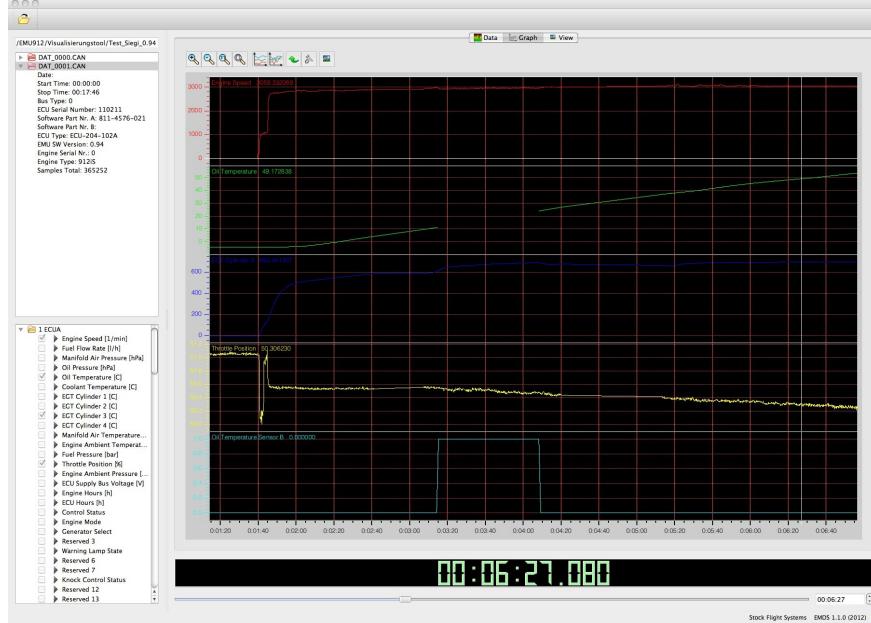
# EMU 912iS Topmark File



- The TOPMARK.CFG file contains the number of the flight data recording file currently in use.
- The EMU 912iS allows 10000 binary recording files to be stored on the SD card (DAT\_0000.CAN to DAT\_9999.CAN).
- Every 30 minutes, a new recording file with a corresponding file number is created automatically.
- Recording files have a size of typically 11.2 MB and may be compressed to 4.7 MB (which is compatible with most Email systems worldwide).
- Recording files are in binary format and not user-readable. Processing of these files is accomplished using the Engine Management Debriefing Station (EMDS) host tool.
- The EMDS tool is included with the purchase of the EMU 912iS (no additional cost).

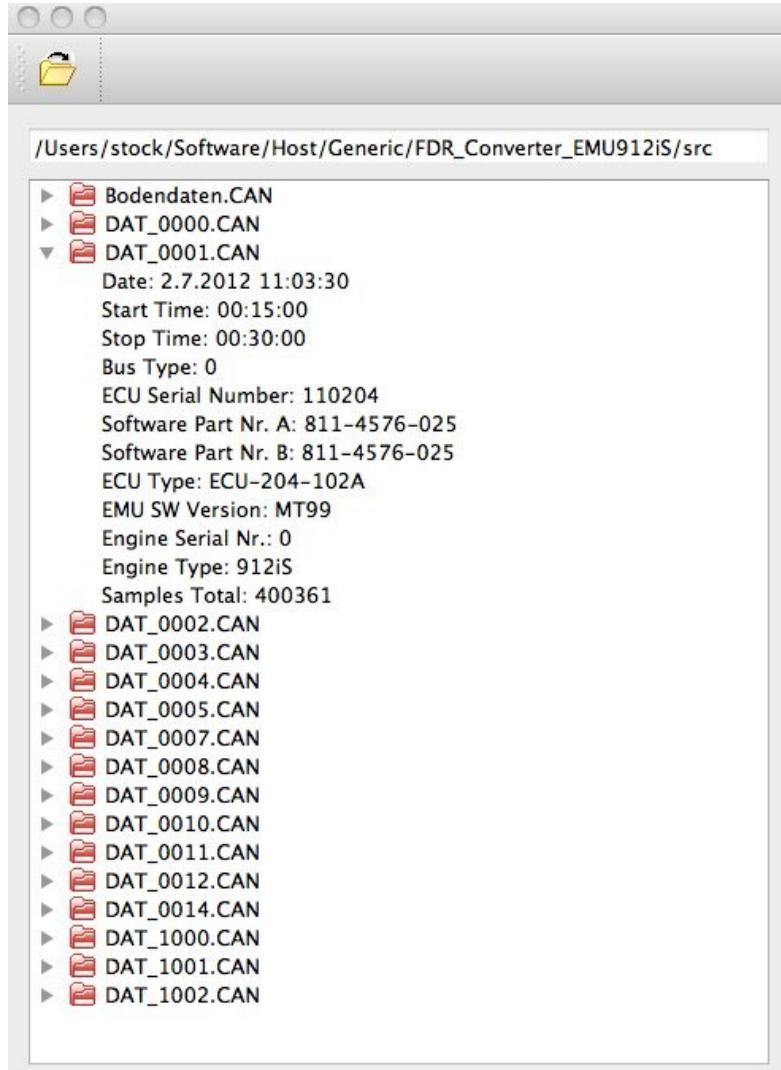
# Engine Management Debriefing Station (EMDS) Tool

[www.stockflightsystems.com](http://www.stockflightsystems.com)



- The EMDS allows to import EMU 912iS flight data recording files and display them in various graphic formats (virtual view, graph, data, fault matrix).
- EMDS is free, runs on multiple operating systems (Mac OS X, Linux, MS Windows) and supports several languages (English, Deutsch, Français, Portugese, Espanol).
- Precise time correlation between all engine and GPS parameters, selectable units (metric/US).
- All CANaerospace messages of both lanes are available: Zooming into the data reveals even the smallest detail.
- Screenshots may be made at any time by pressing a single button.
- Recorded data may be exchanged with Rotax Service Centers.

# ECU/GPS Information Display



- The EMDS examines the loaded EMU 912iS recording files and displays the following data:
  - Date and time at which the selected file has been recorded (GPS time);
  - Start/stop time of the recording file in minutes;
  - CANaerospace bus the data was recorded from (0 = display bus, 1 = maintenance bus);
  - ECU configuration (ECU and engine type, ECU and engine serial number, software revision of each lane);
  - Software revision of the EMU 912iS the data was recorded with;
  - Total number of samples which the recording file contains.

# Virtual EMU View



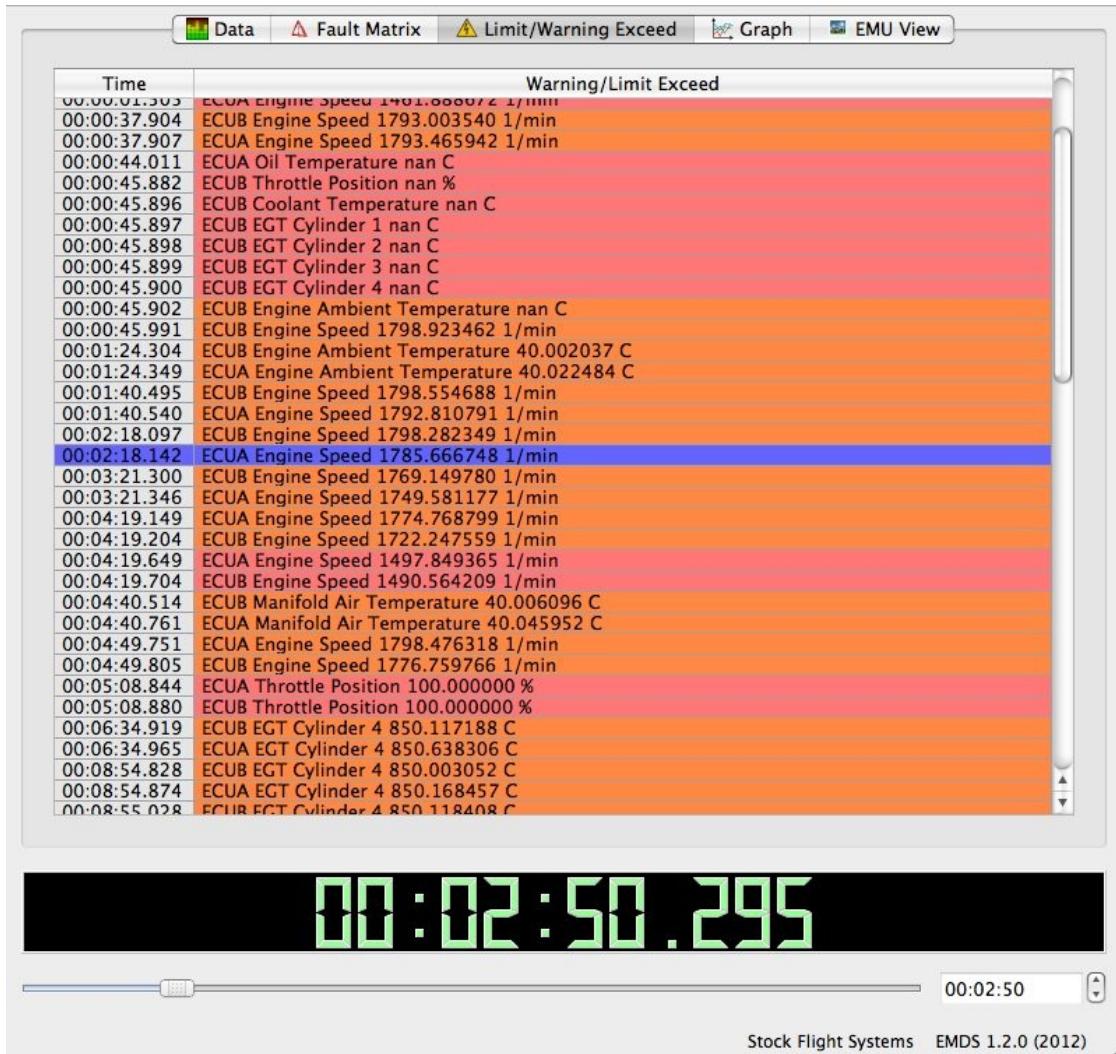
- The virtual EMU allows to replay a flight and analyze the EMU 912iS indications as if in the cockpit.
- Moving back and forth in the data is accomplished by a simple slider at the bottom of the display.
- All displays retain the time setting made through this slider for quick reference.



# Fault Matrix View



# Limit Exceedance View



- The Limit Exceedance View displays any out of range condition.
- Limit exceedance display colors (amber, red) are according to BRP specification.
- Together with the Fault Matrix View, the Limit Exceedance View provides a quick information about engine or installation problems.
- Moving the slider to a specific value and switching to the Graph or Virtual EMU View immediately displays the time relationship of the exceedance with other engine parameters.

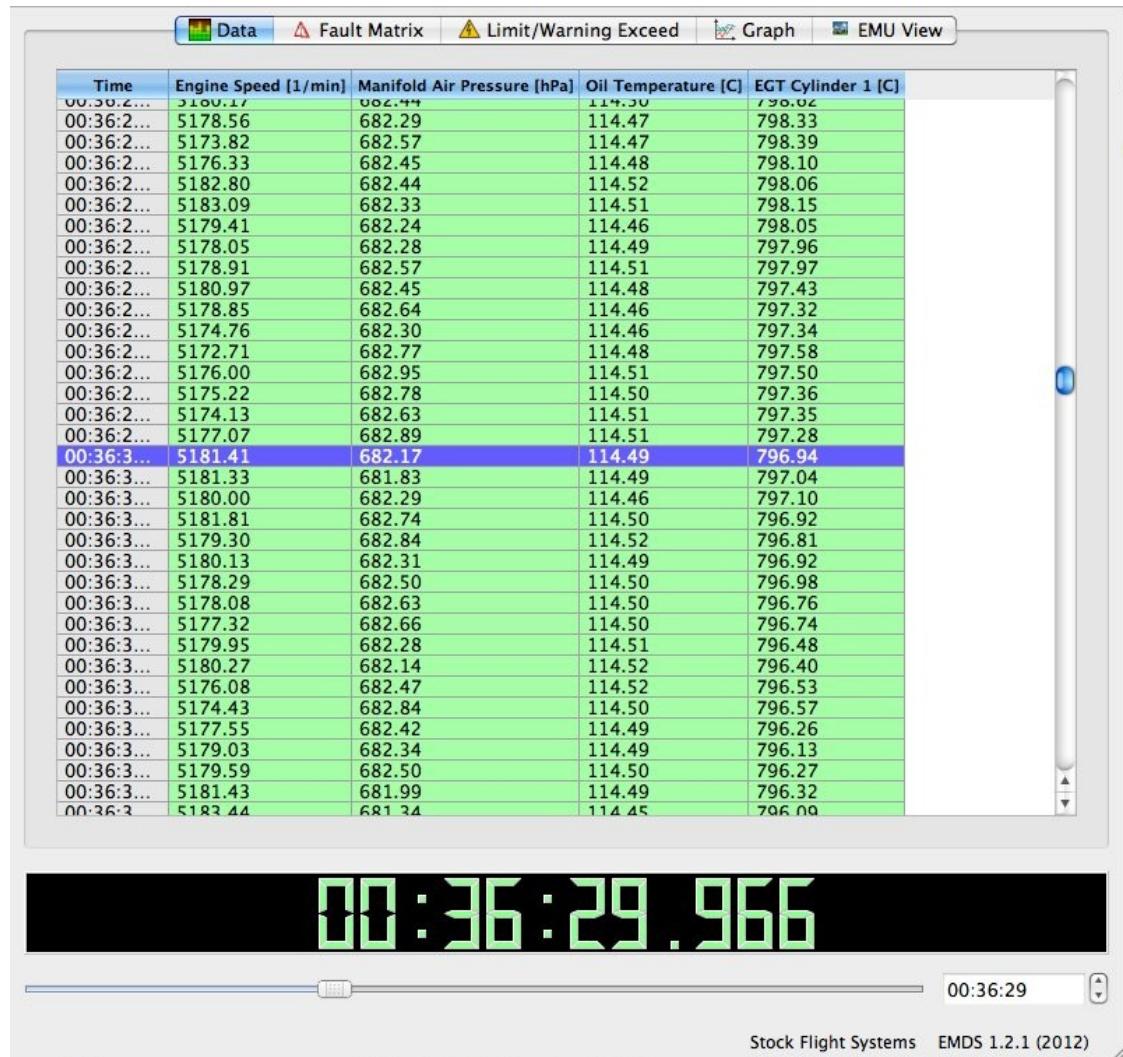
# Data Selection Display

1 ECUA

- Engine Speed [1/min]
- Fuel Flow Rate [l/h]
- Manifold Air Pressure [hPa]
- Oil Pressure [hPa]
- Oil Temperature [C]
- Coolant Temperature [C]
- EGT Cylinder 1 [C]
- EGT Cylinder 2 [C]
- EGT Cylinder 3 [C]
- EGT Cylinder 4 [C]
- Manifold Air Temperature [C]
- Engine Ambient Temperature [C]
- Fuel Pressure [bar]
- Throttle Position [%]
- Engine Ambient Pressure [hPa]
- ECU Supply Bus Voltage [V]
- Engine Hours [h]
- ECU Hours [h]
- Latitude [deg]
- Longitude [deg]
- GPS Height [m]
- GPS Ground Speed [km/h]
- GPS Track [deg]
- Year
- Month
- Day
- Hour
- Minute

- The Data Selection Display allows to select any combination of the 111 available parameters per ECU Lane to be included in the data visualization.
- ECU Lane A and lane B parameters are clearly separated.
- Any combination of ECU Lane A and Lane B data may be displayed.
- All data will be displayed in the unit as specified through the EMDS “preferences” menu (metric vs. US units).
- All selected parameters will be used for the Data and Graph Views.
- All selected parameters are included in the Google Earth KML file exported by the EMDS.

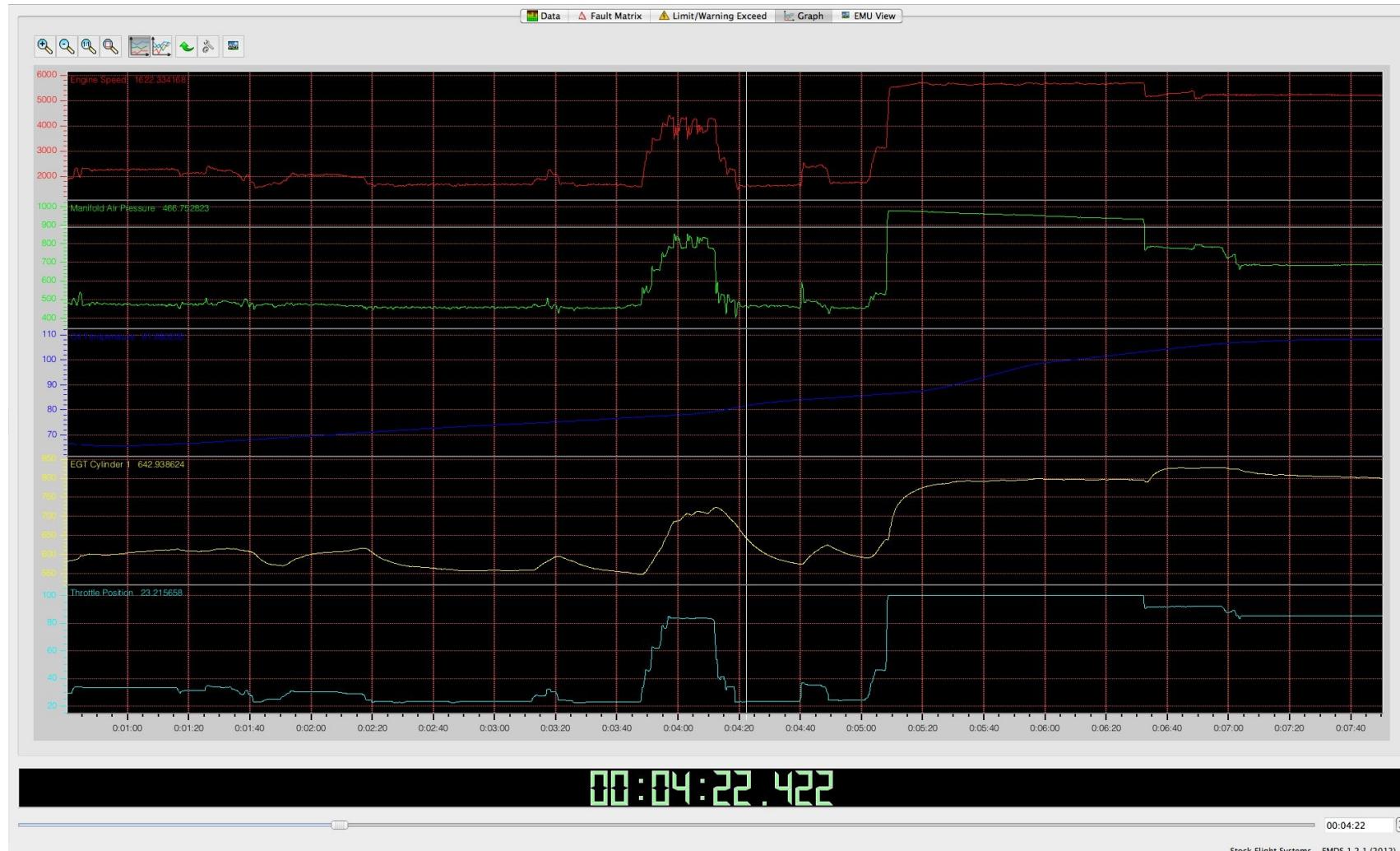
# Text Data View



- The Text Data View shows all parameters selected through the Data Selection Display in engineering values.
- Display color changes to amber/red for parameters exceeding their limits.
- Each line represents 1/10 of a second.
- Scrollbars allow to move freely through the window (if many parameters have been selected).



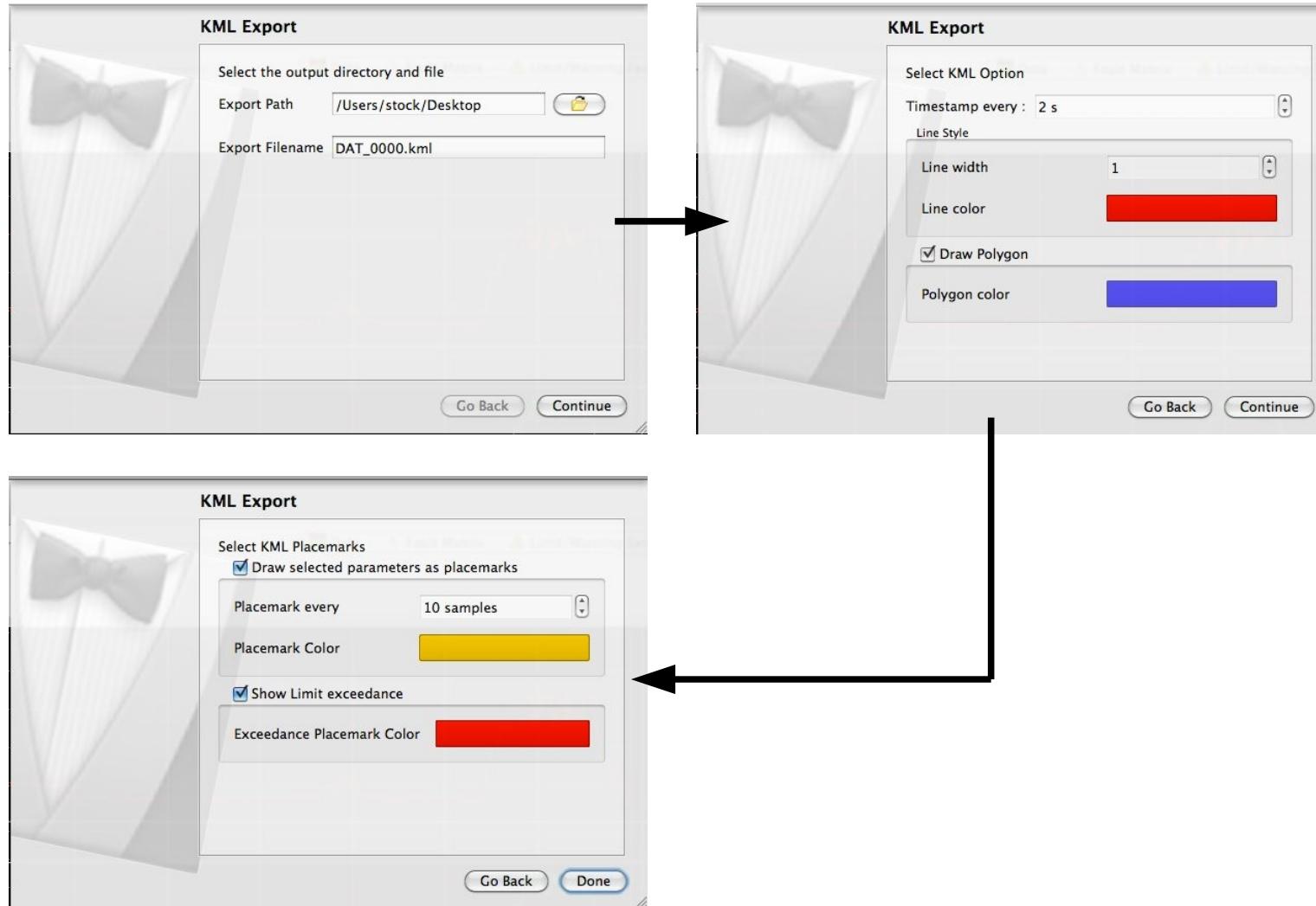
# Graphical Data View



- Display data configurable via Data Selection Display.
- Automatic scaling of displayed values.
- Zooming in/out and screen snapshot support.
- Easy to use!



# Google Earth KML File Export



- Simple, three step approach for KLM file export.
- Engine data snapshot time resolution is configurable.
- Optional limit exceedance information.
- Configurable flight path colors.
- Individual files with same flight path but different data content generated easily.

# Google Earth File generated by EMDS

[www.stockflightsystems.com](http://www.stockflightsystems.com)



- Engine data snapshots (yellow pins) contain current value of selected parameters.
- Clicking on the pin displays the data.
- Limit exceedance information (red pins) shown where the exceedance actually occurred.

# What else can the EMU 912iS do for you?

[www.stockflightsystems.com](http://www.stockflightsystems.com)



- The combination of engine data with flight data allows to detect and analyze cooling problems caused by engine, cowling or baffle installation.
- Transient problems of any kind, encountered during flight may be investigated afterwards by inserting a Top Marker in the recorded data stream (pressing the “MCR” button on the EMU 912iS).
- Long-term data analysis of recorded engine and flight data may reveal engine problems beforehand, reducing the likelihood of inflight engine failures.
- Together with CANaerospace-compatible Air Data Computers (ADC) and/or Attitude/Heading Reference Systems (AHRS) the EMU 912iS provides a complete flight data recording system for research programs or initial flight testing of experimental aircraft using the Rotax® 912iS.
- Flight schools obtain the possibility to monitor the use of their aircraft and schedule maintenance more efficiently.
- The EMU 912iS recorded engine and flight data together with the EMDS tool may also be used to support accident investigation.
- **The EMU 912iS brings large transport aircraft engine monitoring technology to the LSA world!**

# Summary

- The EMU 912iS provides 21<sup>st</sup> century engine management technology for the new Rotax® 912iS aero engine:
  - Maximum pilot awareness of engine status and performance
  - “All Green” display concept for engine information at a glance
  - Real time information about fuel economy (Power vs. Economy) and fuel flow
  - Powerful engine data visualization including monitoring of ECU internal data
  - Simple installation, integrates seamlessly into the Rotax® 912iS engine system
  - Reliable operation at low or high temperatures (even below zero degrees Fahrenheit)
  - Helpful information for trouble shooting and preventive maintenance
  - Assistance for engine start procedures (start power activation, cold start throttle settings)
  - Integrated flight data recording function including “Top Marker” function
  - Extremely sophisticated post processing tool with Google Earth file export
  - Proven technology: Installations in several aircraft in the USA, England, Austria, Germany, Slovakia, Czech Republic, Slovenia, Ghana (West Africa).
- **The EMU 912iS is the Rotax® 912iS owner's friend!**

# EMU 912iS Equipped Aircraft at Airventure 2012

[www.stockflightsystems.com](http://www.stockflightsystems.com)



© Pipistrel ([www.pipistrel.si](http://www.pipistrel.si))

- Award-winning Pipistrel Virus LSA with Rotax® 912iS.
- Dual NASA PAV price winner.
- Booth 292A (Runway side of Hangar B)

# EMU 912iS Equipped Aircraft at Airventure 2012

[www.stockflightsystems.com](http://www.stockflightsystems.com)



© AIRTEAMIMAGES.com

[www.arrow-copter.com](http://www.arrow-copter.com)