



**Savvy Aircraft Maintenance Management, Inc.**  
4801 Braeburn Drive • Las Vegas, NV 89130

## Choosing and Upgrading Your Engine Monitor

Aircraft owners often ask us for advice about what kind of engine monitor equipment we recommend installing in their airplanes. Owners who already have engine monitors installed often seek advice about upgrading them with additional capabilities or replacing them with newer, more advanced equipment.

Engine monitor technology has been a fast moving target. More and more avionics manufacturers are now offering engine monitor equipment, both as stand-alone monitors and as monitoring capability integrated into multi-function displays (MFDs). New makes, models and features are being introduced all the time. In addition to the traditional firms that manufacture avionics for certificated aircraft, there are now many companies specializing in uncertified avionics for the experimental amateur-build (E-AB) market.

Consequently, we're not going to recommend any specific makes and models here. (If we did, this document would probably be obsolete before it was posted to the Internet.) Instead, we will talk about what features and capabilities we believe are most important in digital engine data monitor equipment, and what you should be looking for when choosing an engine monitor for your airplane.

There are two major dimensions to consider: what kinds of data does the equipment capture, and what features does it offer?

### What kinds of data does the equipment capture?

The earliest digital engine monitors captured only **cylinder head temperature (CHT)** and **exhaust gas temperature (EGT)** for each cylinder on the engine. A monitor that captures only CHT and EGT is unquestionably useful. However, the condition-monitoring and diagnostic value of the data is greatly enhanced if the equipment captures additional kinds of data beyond just CHT and EGT.

- **Fuel Flow (FF)** is probably the next most important engine parameter to capture. Having FF information logged is essential to diagnosing mixture distribution problems, incorrect fuel system adjustments, dirty fuel nozzles, stuck carburetor floats, and a host of other fuel-related issues. Many earlier-generation engine

monitors are not configured to capture FF, but often this can be easily remedied at modest cost; see “Upgrading your engine monitor” below.

- **Manifold Pressure (MAP) and Tachometer (RPM)**—Instrumenting MAP and RPM in addition to FF allows the analyst to tell exactly what the pilot was doing with all three primary engine controls (throttle prop and mixture) throughout the flight being analyzed. If these parameters are not logged, then the analyst has to guess what the pilot was doing (which can be difficult or impossible), or alternatively “play 20 questions” with the pilot to try to determine what he was doing when some interesting combustion event occurred (if the pilot even remembers). Logging MAP and RPM also allows the analyst to determine whether the prop governor is adjusted and working properly, and (for turbocharged engines) whether the turbosystem is working properly.
- **Turbine Inlet Temperator (TIT)**—Applicable only to turbocharged engines, having TIT logged can be valuable in determining whether magnetos are timed correctly, and whether the pilot is managing the powerplant properly for maximum turbocharger and exhaust system longevity.
- **Electrical Voltage (VOLTS) and Current (AMPS)**—Logging aircraft bus voltage permits analysis of whether or not the charging system is working properly. For aircraft with dual alternators and dual-bus electrical systems, it’s important for the bus voltage of both buses to be logged. Logging of current provides additional useful information on both alternator performance and battery condition.
- **Air Data**—Some of the more advanced engine monitor systems, particularly those that are integrated into the aircraft’s MFD, have the capability of capturing air data parameters such as outside air temperature (OAT), indicated airspeed (IAS), pressure altitude (ALT), and rate-of-climb (ROC). Some also have the capability to capture GPS position data (LAT, LON) and other GPS-derived information such as groundspeed (GS) and GPS altitude. Logging this kind of data is occasionally useful, but it’s relatively unimportant for diagnostic and troubleshooting purposes.
- **Vibration Data**—A few engine monitor systems (notably the Insight G-series) can be equipped with vibration sensors and have the capability of displaying and logging vibration data. We are not yet convinced that such data has much diagnostic value, but we’re still investigating this.

Obviously, the more parameters the system captures and logs, the more our data analyst has to work with in preparing your analysis reports. However, some kinds of data are

more important than other kinds. We've attempted to list these different kinds of data in decreasing order of diagnostic value, with CHT, EGT and FF being extremely valuable, MAP, RPM, TIT and VOLTS/AMPS being very nice to have, and Air Data and Vibration Data being of marginal diagnostic value.

## What features does the equipment have?

Beyond simply capturing various kinds of engine parameters and other data, there are also a number of key functional features that an engine monitor may have. Again, we will attempt to enumerate these in order of importance, starting with the most important ones.

- **Data Logging**—The ability to log the captured data is clearly the most important feature for an engine monitor to have, because without it there's nothing to analyze. This might seem obvious, yet most early engine monitors installed prior to the mid-1990s lacked any data logging capability. Until very recently, even the state-of-the-art Garmin G1000 glass cockpit system did not offer data logging. Among the engine monitors that do support data logging, there is a wide variation in data memory capacity. Early engine monitor designs have limited memory capable of holding only the last few flights' worth of data, while more recent designs can store many gigabytes worth, often on a plug-in memory card.
- **Data Download**—It does little good for an engine monitor to log data unless there's a convenient way to download the data for analysis. Engine monitors from the 1990s typically accomplish this via some sort of serial port, and downloading requires bringing a laptop computer into the cockpit and hooking it up to the instrument via a data cable—or in the case of early Insight GEMs via an IrDA infrared data link—making the downloading process a real chore. Many later designs from the 2000s provide a USB port that allows plugging in a USB “thumb drive” to receive the downloaded data. (JPI offers a nifty little \$210 download box for its early EDM-700/800 units that automatically downloads from the serial port to a thumb drive, eliminating the laptop-in-the-cockpit routine.) The most recent designs log data directly onto a SD memory card that plugs into a front-bezel slot. This eliminates the download process altogether: You just remove the SD card from the airplane, take it home, plug it into your laptop and you're good to go.
- **Programmable Alarms**—While data logging and downloading are the most important features for post-flight analysis, a good alarm capability is probably the most important feature for in-flight use. Any time a critical parameter—CHT, TIT, oil pressure, bus voltage, etc.—goes outside the acceptable range, you want to

know about it RIGHT NOW so you can take immediate corrective action. In this area, we've not seen much progress; in fact, we've seen considerable regress. While most engine monitors have alarm functions, earlier designs tend to provide alarm thresholds that are user-programmable. In contrast, many late-design units have their alarms "hardwired" to the red-line values established by the aircraft or engine manufacturer. We consider this really unfortunate. For example, if a cylinder starts experiencing detonation that causes its CHT to run away, you really want to find out about it the moment CHT rises past 400°F or so. If the instrument doesn't alarm until CHT reaches 460°F (Continental's red-line) or 500°F (Lycoming's red-line), it may be too late to save the engine from catastrophic failure. That's why when choosing an engine monitor, we consider lack of user-programmable alarms to be a deal-breaker.

- **Sensors**—An important part of any engine monitor installation are the sensors that are installed in various locations on the engine and the airframe. Many of these are temperature probes, which are one of two basic types: thermocouple probes and thermistor probes. Thermocouple probes consist of a junction of dissimilar metal alloys—typically chromel and alumel—which generate a tiny voltage (measured in millivolts) that is proportional to the junction temperature. Thermistor probes consist of a special solid-state resistor whose resistance changes with temperature. In engine monitor applications, very high temperatures like EGT and TIT are always measured with thermocouple probes, while moderate temperatures like CHT and OAT may be measured using either thermocouple or thermistor probes, depending on the engine monitor manufacturer. In our experience, thermistor probes tend to be more troublesome because small amounts of extraneous resistance in the system (e.g., corrosion of connector pins) can create erroneous data to be captured. We've also found that thermocouple exhaust probes from various engine monitor manufacturers have widely varying response times; fast response-time probes are much better for both leaning and for diagnostic analysis. Other kinds of sensors are used for measuring pressures and flow rates and other parameters. The Flo-Scan 201 sensor is used to measure fuel flow in virtually all of the systems we've looked at. RPM is usually measured by a Hall-effect magnetic sensor mounted on one of the magnetos. MAP, oil pressure and barometric altitude are measured with various kinds of pressure transducers. The vast majority of engine monitor problems are caused by faulty sensors or connectors, so it's important to choose a system with high-quality sensors and reliable connectors.

- **Cockpit Display**—Early engine monitors used a crude LED bar-graph displays. More recent designs use high-resolution flat-panel color displays and are capable of displaying vastly more information with a much more attractive and easy-to-interpret presentation. The display can make a big difference for in-flight use, but has no bearing at all on the kind of post-flight analysis that is done at SavvyAnalysis.com.
- **GPS Integration**—Some engine monitors—including most of the ones that are built into the aircraft’s MFD—are integrated with the aircraft’s GPS navigator. This gives them the ability to log aircraft position (LAT/LON) and various GPS-derived parameters such as groundspeed and GPS altitude. If the engine monitor captures such data, SavvyAnalysis fully supports it. This includes identification of logged flights by origin and destination airport identifier, and charting of the aircraft’s flight path. However, such data has relatively little diagnostic value.
- **Remote Data Acquisition Unit**—Some engine monitors use a remote data acquisition unit (DAU) mounted in the engine compartment (typically on the firewall), while others have the data acquisition function built into the cockpit instrument. Having a remote DAU eliminates the need to run a large multi-wire harness into the cockpit. This is particularly important for twin-engine airplanes, where the sensors can be quite far away from the cockpit and running a large harness through the wings can be difficult and problematic.
- **Certification Basis**—Some engine monitors are certified solely as supplementary instrumentation, while others are certified to service as the aircraft’s primary engine instruments. When an engine monitor is retrofitted into a legacy aircraft, a unit certified for primary instrument replacement permits removal of some or all of the original “steam gauge” engine instruments. On the other hand, an engine monitor that is certified for primary instrument replacement is much more likely to have its alarms hardwired to the manufacturer’s red-lines rather than being user-programmable. (Of course, none of this matters for engine monitors installed in experimental aircraft.)

From the standpoint of post-flight data analysis and diagnosis, the most important features are data logging, data download, and fast-acting EGT sensors. The remaining features mostly affect in-flight use rather than post-flight analysis.

### Upgrading your older engine monitor

Tens of thousands of piston GA airplanes are equipped with older engine monitors that leave a lot to be desired for post-flight analysis and diagnosis. Some—like the original

Insight GEM 600-series and early JPI EDM-700 and E.I. UBG-16—either have no data logging capability at all, or provide no good way to download the logged data. (The IrDA infrared download port of the GEM is no longer well-supported.) Others—like the later JPI EDM-700 units—have data logging and download capability, but do not capture fuel flow information. (As discussed earlier, FF capture is very important for post-flight analysis and diagnosis.)

If your airplane is equipped with one of these older engine monitors, it may be possible for you to upgrade it to a much more useful configuration at relatively modest expense:

- **Insight GEM 600-series and GEMINI 1200-series**—For the original GEM 601/602 that has no data logging, or the later GEM 610 that has data logging but has an IrDA infrared download port that is no longer well-supported, your most cost-effective solution is to replace your old GEM instrument with a JPI EDM-700 or EDM-730 instrument but to keep your existing GEM harness and sensors. JPI offers an adapter that lets you do this. The upgrade kit (including a new EDM-700 instrument and the GEM harness adapter) costs about \$1,300. Installation labor is minimal. The same adapter works for twin owners who want to upgrade their old GEMINI 1200 to a JPI EDM-760 while retaining their existing harness and sensors.
- **JPI EDM-700 with no data logging**—If you have an old JPI EDM-700 with no data logging capability, you can send the instrument to JPI and they'll upgrade it to the latest configuration (with data logging and a serial download port) for just \$160. Turnaround time is normally one week or less.
- **JPI EDM-700 with serial download port**—If you have a JPI EDM-700 with a serial download port and are tired of the laptop-in-the-cockpit download routine, JPI offers two attractive options. For \$210, you can purchase JPI's external download box that plugs into the serial jack and automatically downloads data from the instrument and writes it to a standard USB thumb drive. (The box is tiny, and you can keep in the airplane's glove box or seat-back pocket when you're not using it.) Alternatively, for about \$300 you can send the instrument to JPI and they'll upgrade it to have an integral USB port in place of the serial port; turnaround time is normally one week or less.
- **JPI EDM-700 with no fuel flow**—If you have a JPI EDM-700 that does not capture fuel flow, you can easily add that capability. If you already have some sort of digital fuel flow gauge (e.g., Shadin, Hoskins, etc.), then you can connect the EDM-700 to your existing fuel flow transducer and the upgrade cost is less than \$400. If you don't have a digital fuel flow instrument and need to install a FF

transducer, then the upgrade cost is just over \$600. Either way, we think it's worth it, because logging FF info is very important for analysis and diagnostic purposes.

- **JPI EDM-700 with no MAP or RPM**—If your JPI EDM-700 does not capture MAP or RPM information, you can add that capability for about \$300 per sensor (plus some installation labor). This also applies if you want to add OAT, oil temperature, oil pressure, etc.
- **JPI EDM-700 to -730 upgrade**—Any JPI EDM-700 (with its old-fashioned LED bargraph display) can be upgraded to an EDM-730 with a much nicer high-resolution color flat-panel display for \$1,350. The new EDM-730 fits in the same 2.25" instrument panel hole as the EDM-700, but the screen and bezel are larger so make sure you have sufficient panel space before committing to this upgrade.

**NOTE:** The reason we are emphasizing upgrades to the JPI EDM-700 is because more of these engine monitors are installed in the GA fleet than all other engine monitor makes and models combined. Fortunately, JPI has been quite good about providing reasonably-priced upgrade paths for owners of their older instruments.

### **The bottom line**

To get the most value from SavvyAnalysis, it's important for your engine monitor to capture and log at least CHT, EGT and FF information, and provide a convenient means for downloading the logged data so that it can be uploaded to the SavvyAnalysis site. Most other engine monitor features primarily affect in-flight/in-cockpit use rather than post-flight analysis. It's good to keep this in mind when purchasing a new engine monitor or upgrading an older one.

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