General Aviation Flight Data Monitoring

Fly with Intelligence – Best Practices to Improve the Safety and Efficiency of Flight Operations

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By Stuart K. Lau

General Aviation operators are facing ever-increasing pressure to improve the efficiency of their flight operations – the trick is to reduce fuel, maintenance and insurance costs while increasing the level of safety.

Notably, in recent months, fuel prices have escalated to a national average of nearly $4.00/gallon, engine overhauls can easily exceed $30,000 on a complex single engine aircraft and insurance premiums and deductibles have continually risen. Insurance costs are impacted most by high hull values and an increase in the number of costly claims.

According to the NTSB, the 2005 General Aviation accident statistics were the worst in more than seven years. Of particular interest, one of the "Greatest Killers" was pilots taking too many risks while maneuvering at low altitudes. At the same time, advances in avionics and aircraft technologies have proportionally reduced weather-related accident rates. Eight-out-of-ten General Aviation accidents are now caused by pilot actions.

FDM is the technology and methodology for collecting and analyzing data recorded in flight. Air Carriers have benefited from this practice for nearly 30-years – in the United States, Flight Operational Quality Assurance (FOQA) are FAA-approved programs that standardizes the FDM process – and is commonplace at nearly every major carrier.

Fortunately, recent advances in technology and a confluence of several other events have made low-cost Flight Data Monitoring (FDM) programs a reality for General Aviation operators. FDM is the technology and methodology for collecting and analyzing data recorded in flight. Air Carriers around the world have benefited from this practice for nearly 30-years – in the United States, Flight Operational Quality Assurance (FOQA) programs are FAA-approved providing a level of standardization to the FDM process. FOQA is now commonplace at nearly every major carrier. FDM programs, when adapted to General Aviation, can give operators a competitive edge by increasing, both safety and efficiency.

Of interest, FAA CFR 121 Air Carrier operations have become so safe that accident and incident data are no longer reliable predictors of future incidents and accidents. The FAA sees safety data collection and sharing as the key to the next significant reduction in accidents and incidents. In fact, according to FAA Associate Administrator for Aviation Safety Nicholas Sabatini, "We are on the threshold of reaching the next level in commercial aviation safety. And here is the keystone to the next series of breakthroughs…safety information." The FAA is trying to move from "forensics & diagnostics" to "prognostics & predictions." According to the 2005 Next Generation Air Transportation System (NGATS) Progress Report "NGATS will proactively address risk and anticipate potential safety problems so we can prevent accidents before they happen. The key is information sharing, which has quickly become the next safety frontier."

Origins…a brief history of Flight Data Monitoring

A Flight Safety Foundation study found that airlines with an active FDM program have accident rates that are 50 percent less than those carriers without this important safety program.

Flight Data Monitoring (FDM) programs began in the 1960s with two European airlines – British Airways and TAP Air Portugal. During the late 1990s formal FDM programs became commonplace at major airlines throughout the world. Airlines have recognized the safety and operational benefits of established FDM programs. FDM is an indispensable, non-punitive, risk management tool that allows operators to identify threats and mitigate risks – one component to an effective Safety Management System (SMS). A Flight Safety Foundation (FSF) study found that airlines with an active FDM program have accident rates that are 50 percent less than those carriers without this important safety program – furthermore those carriers that have used FOQA the longest are the safest in terms of accident rates.

Today, FDM programs have been mandated in Europe for most scheduled operators. In the United States, the FAA has adopted a voluntary approach to aviation safety programs rather than making FDM a mandate. One concern of this voluntary approach has been that relatively few operators, other than the largest major

airlines, have established FOQA programs. Former FSF president and CEO Stuart Matthews, in a 2004 speech, said "As a result, we will not be using one of the best tools we have to get the best safety results," he added while commenting on the perceived and unfounded legal wrangling of data collection that "the absence of a FOQA program could be construed by society as a failure to implement industry best practices."

"The absence of a FOQA program could be construed by society as a failure to implement industry best practices." Former FSF president and CEO Stuart Matthews

Currently, the FAA is promoting the expansion of these voluntary safety programs, such as FOQA, beyond the airlines. General Aviation operators, including university flight schools, air taxi operators and fractional ownership programs, are a focus of this new emphasis. Fortunately, much of the work to establish a FDM program has been completed and operators can use FAA AC 120-82 as the framework to begin implementing their program.

In the past, cost has been a significant barrier to equipping General Aviation with flight data recorders. Early this decade, advances in technology and recorder design have made low-cost devices available beyond the air carrier market. Currently, there is a confluence of events that make FDM practical for General Aviation aircraft. These events include a new sophisticated approach to aviation safety by operators and the FAA, affordable computing power and storage, high-speed internet connectivity, precise GPS navigation capabilities, open aircraft systems architecture that allows data acquisition from a digital avionics data bus and the miniaturization of sensors to create new lightweight low-cost devices with accuracy that rivals more expensive inertial measurement units.

Examples of FAA STC'd Data Storage Systems for General Aviation aircraft:

Appareo Systems GAU 2000 (left) and Alakai Technologies Digital Flight Data System (right)

Why General Aviation needs FDM

Each year, the AOPA Air Safety Foundation publishes the Nall Report – a nationally acclaimed annual safety report providing perspective to the previous year's general aviation accident statistics. According to the most recent report, NTSB general aviation safety statistics in 2005 were the worst in more than seven years. In fact, the rate of serious mishaps as calculated per 100,000-flight hours rose to 7.2 when compared to 6.5/100,000 during the previous year. This is a departure from an improving trend and the worst figure since 1998. The General Aviation fatal accident rate, in 2005, climbed to 1.4/100,000 flight hours versus 1.3/100,000 flight hours the previous year.

According to the Nall Report:

Of concern, light aircraft pilots are taking more risks. Identified as one of the "Greatest Killers," mishaps during low-altitude maneuvering increased significantly, while weather-related accidents declined proportionally.

Of concern, the report noted, light aircraft pilots are taking more risks. Identified as one of the "Greatest Killers," mishaps during low-altitude maneuvering increased significantly, while weather-related accidents declined proportionally. In 2005, 82.9% of all accidents were pilot-related accidents – up from 74.9% the previous year. Most maneuvering accidents can be traced to the pilot's decision to engage in a high-risk operation, either willingly or because of a lack of understanding. Besides "buzzing," there are examples of an instructor and student carrying out a simulated forced landing and hitting power lines or a pilot maneuvering dramatically to line up with the runway during a poorly executed final approach and stalling.

FDM – understanding the basics

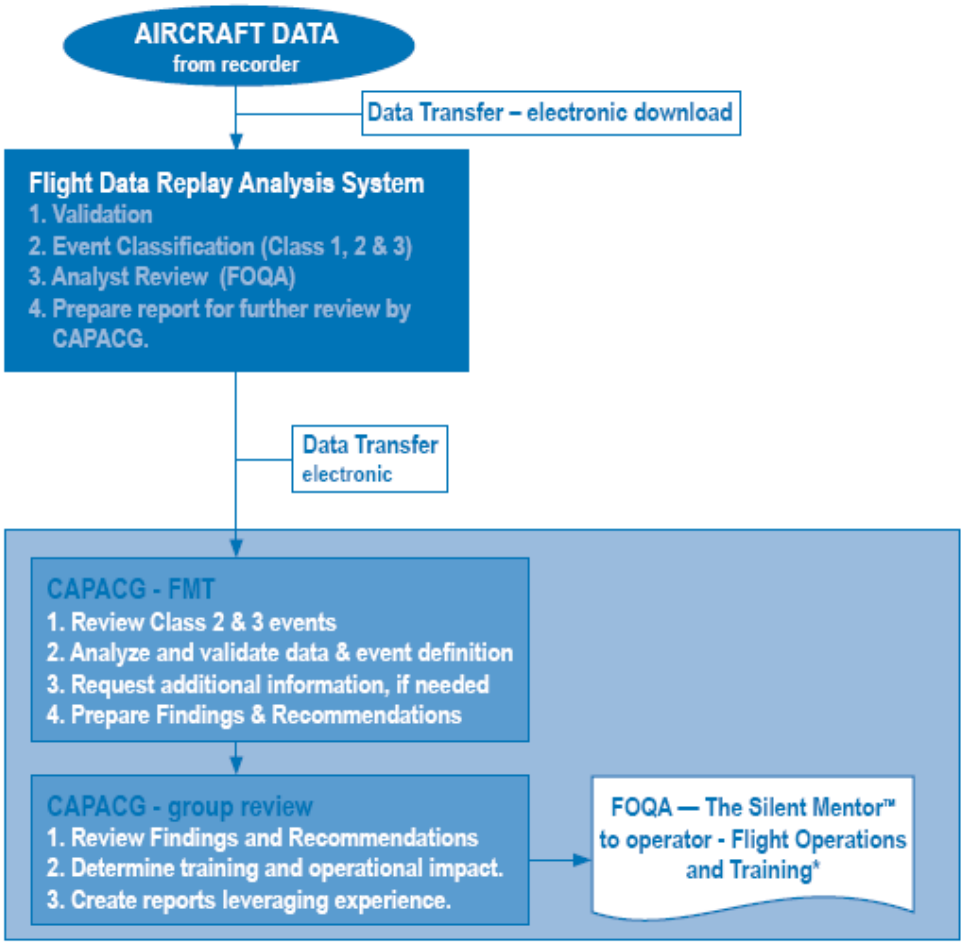
The FDM/FOQA process can be simplified by breaking down each individual step. The "4 R's" are used to describe this process. The 4 R's are outlined below:

1. **Record**
    a. Airborne recorder
    b. Data acquisition and storage
2. **Retrieve** (and host the data)
    a. Removable storage media or wireless transmission
    b. Host data in-house or on remote server
3. **Review** – convert data into useful information
    a. Ground-based analysis software

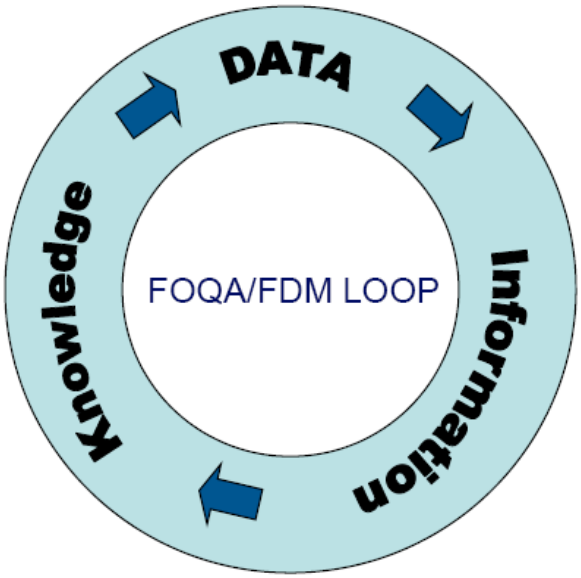
   b. Commercial off the shelf (COTS) hardware/software.
4. **Report** – provide meaningful findings and recommendations to the stakeholders.
   a. Data analysis and visualization tools
   b. Generate reports, graphics and animation.

FOQA Process Model - FOQA "light" concept

The illustration below represents the typical model for General Aviation aircraft.



Each step of this process will be reviewed. As these steps are explained, it's important to consider the impact on the overall FDM/FOQA process.



The basis of any FDM/FOQA program follows these principals (Data-Information-Knowledge continuous loop model):

1. Flight Data Monitoring converts recorded flight data into information.

2. Proper analysis converts this information into knowledge.

3. Knowledge can then be used to enhance safety or flight operations based on meaningful findings and recommendations.

4. Findings and recommendations can be monitored by flight data. (FOQA loop)

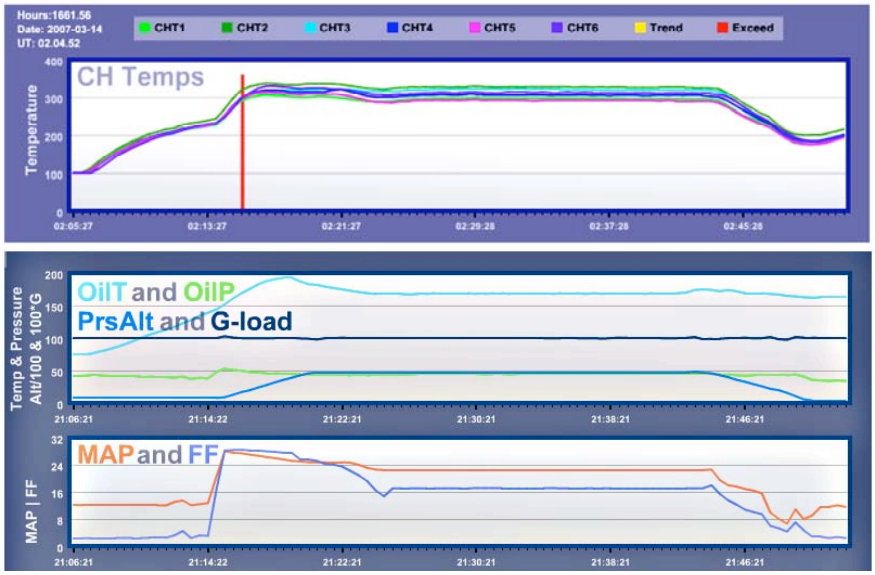
Benefits of FDM in General Aviation

The primary areas of benefit in General Aviation FDM programs exist in four areas: maintenance, operational, safety and training.

1. **Maintenance** – primarily through the application of aggregate and individual airplane data to engine and airframe maintenance cost.

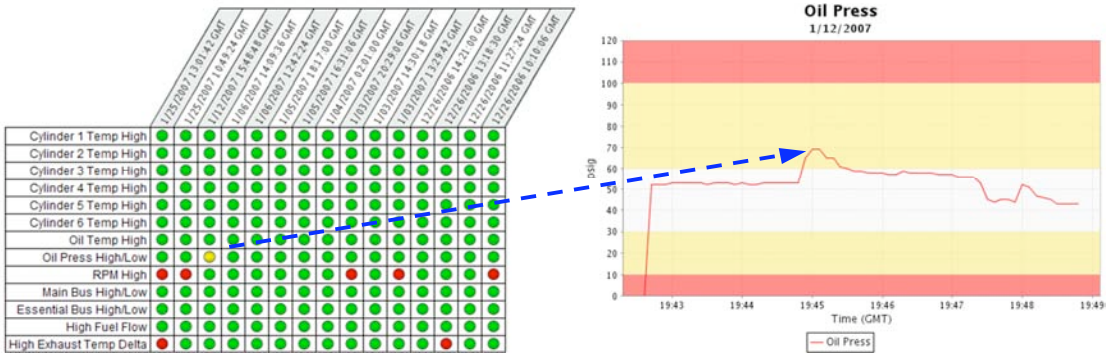
a. Reduce aircraft operating and engine maintenance cost
b. Reduced engine failures and costly overhauls
c. Subject to approvals – enables increased maintenance intervals such as TBOs
d. Reduced manufacturer warranty cost
e. Enhanced maintenance records with G-loading, flap overspeed and other warnings

2. **Operational** – primarily by producing aggregate data to support anecdotal flight operations feedback and to change operating environment or procedures.
   a. Satisfy FAA CFR 135 Engine Trend Monitoring requirements (CFR 135.421)
   b. Improved on-time performance, customer satisfaction and industry growth
   c. Improved long-term engine performance and fuel economy
   d. Insurance benefits: reduced owner's insurance premiums and deductibles; increased insurance coverage limits.
   e. Automated monthly and on-demand airframe/fleet reporting, analysis and comparisons
   f. Supports adherence to Aircraft Operating Manual limitations



Example of FAA approved Engine Trend Monitoring System (ETMS):

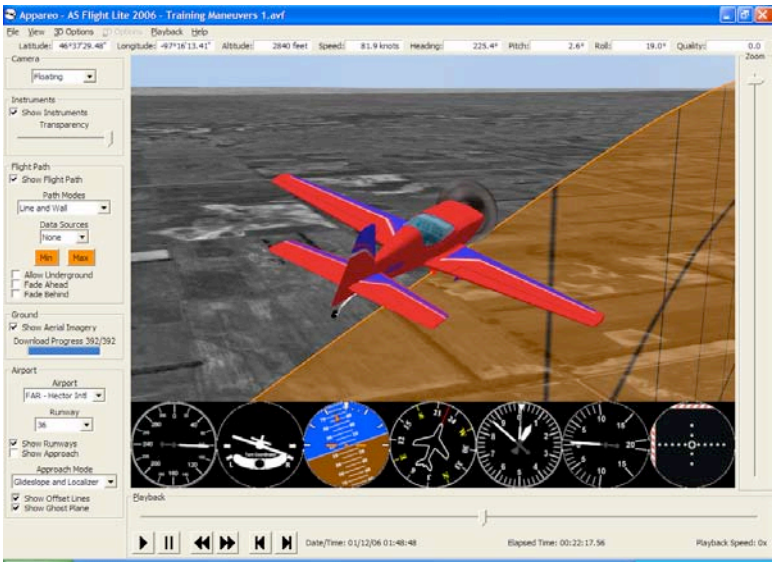
Alakai Technologies satisfies CFR 135.421 requirements for Air Taxi operations.

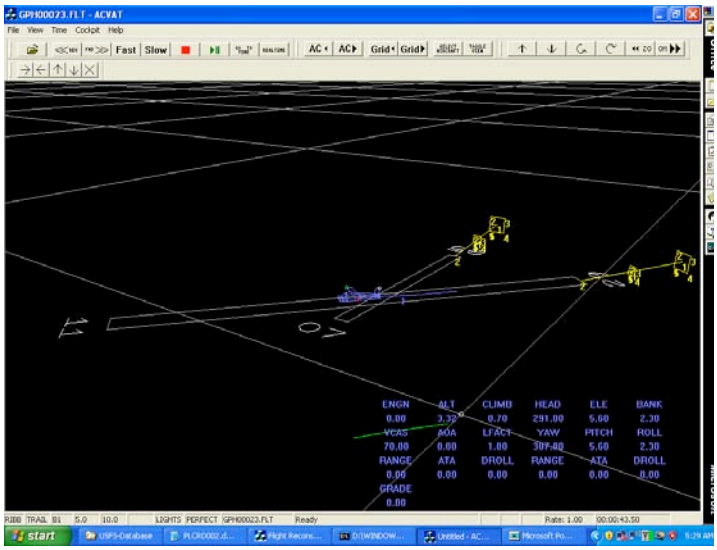


Example of Remote Engine Monitoring System: OpenAero: a web-based maintenance and remote engine diagnostics application.

3. **Safety** – primarily by identifying and intercepting accident precursors.
    a. Formal risk and resource management – one component of a Safety Management System
    b. Identify "system" risk factors such as adverse air traffic practices, challenging terminal procedures, etc.
    c. Early identification of adverse safety trends
    d. Risk mitigation
    e. Flight reconstruction and visualization for accident/incident investigations
    f. Modifies pilot behavior

4. **Training** – primarily through graphic playback of training flights and structured preflight and post flight briefings.
    a. Assure training targets real world needs
    b. Validation of training/mentoring programs
    c. Develop situation-based training scenarios
    d. Objective instructor/student debriefs
    e. Student can rehearse and review flight lessons
    f. Opportunity to shrink training footprints to save cost





Examples of Flight Visualization software: Appareo Systems Flight Evaluator (left) and UHL Research and Associates Flight Reconstruction System (FRS)

Case Study: Remote Engine Monitoring

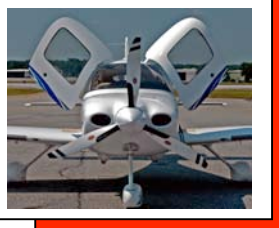
a. The problem

Aircraft operations are negatively impacted by mechanical failures. These failures, if not accurately diagnosed and corrected, can cascade into multiple scheduling delays and potentially result in lost revenue.

b. The solution

Modern avionics systems record engine data and a limited number of flight parameters. This data can be downloaded and processed using sophisticated web-based engine maintenance diagnostic tools, such as OpenAero, at a very low-cost.

The following example is a case study of an aircraft experiencing a mechanical problem during the engine run-up. Each step is detailed – ultimately the maintenance issue was quickly diagnosed and resolved.

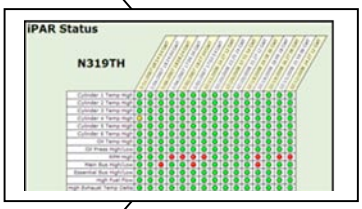


Cylinder temp > 400 Deg F when performing before takeoff engine run-up

Returned to ramp to offload data from Avidyne unit

Engine data downloaded from Avidyne on to USB Thumb Drive

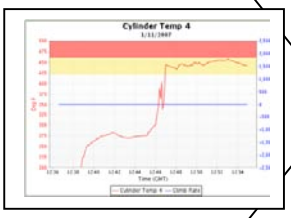
Data sent to OpenAero site via secure Internet connection

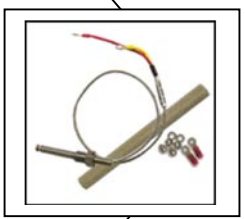


OpenAero identifies first occurrence of problem

Time: + 15

Analysis performed – suspected failed sensor





Mechanic contacted – cleaned/replaced sensor

Time: + 25

Avoided lost aircraft revenue and scheduling impact. Saved business appointment and opportunity.

Total Time: 1+25

Summary

FDM creates a solution for many of the problems facing General Aviation operators, today. FDM brings an increased level of safety and sophistication to General Aviation. Long considered a best practice of air carriers around the world – technology now makes FDM practical in smaller aircraft. Benefits include:

- **Maintenance** – primarily through the application of aggregate and individual airplane data to engine and airframe maintenance cost.
- **Operational** – primarily by producing aggregate data to support anecdotal flight operations feedback and to change operating environment or procedures
- **Safety** – primarily by identifying and intercepting accident precursors.
- **Training** – primarily through graphic playback of training flights and structured preflight and post flight briefings.

A properly implemented and operated FDM program can help curb increasing maintenance and fuel costs while increasing safety. Operators embracing FDM programs should have a competitive economic edge in a very tough marketplace.

Next Steps

To date, many hardware and software companies and service providers have developed individual components of the future General Aviation FDM system. However, there is a current need to combine these efforts to create standardized “plug-and-play” options for the aviation consumer. To facilitate the widespread implementation of this set of industry best practices, CAPACG and a number of industry partners have defined the following as the necessary next steps to bring FDM programs to General Aviation:

1. Integrate the equipment capabilities through open architecture and supplier partnerships.

2. Create opportunities to fund FDM research projects in the major sectors of General Aviation.

3. Provide standard and optional OEM installation packages that facilitate acquisition of the necessary equipment.

4. Establish a General Aviation FDM Steering Committee and a series of conferences and workshops to report out to General Aviation communities on the progress of these initiatives.

Transport category FDM programs took 45 years to develop from the first experiments to today's mature programs. General Aviation has the opportunity to accomplish its maturity development within the next three years by purposeful, systematic and experimental initiatives.

The CAPACG advantage

Founded in 2004, CAPACG (CAP Aviation Consulting Group, LLC.) brings successful Air Carrier-style safety, training and auditing programs and techniques to the business and general aviation community. The objective of CAPACG is to bridge the gap between commercial, military and general aviation to facilitate a smooth and effective transformation, utilizing tools already in place, such as Advanced Qualification Programs (AQP), FAA Industry Training Standards (FITS), proven Human Factors (HF) methods, Flight Data Management or Flight Operational Quality Assurance (FOQA) programs and facilitation training techniques.

CAPACG is a consulting firm and systems integrator focused on helping hardware and software firms develop products specifically for the General Aviation FDM market. Additionally, CAPACG can lend their expertise to help operators develop, implement and operate their FDM programs.

In 2006, CAPACG managed a FDM demonstration trial for the California Department of Forestry and Fire Protection (CDF – now CalFire). Airframe structural health monitoring was the primary focus of this program. This emphasis was based on past catastrophic structural failures of operational aerial firefighting aircraft and the desire to better understand the low-altitude operating environment of which these aircraft are subjected. An additional priority for the CDF FDM program was the ability to use recorded flight data as a mission or training debrief tool. This trial validated the use of low-cost Data Storage Systems as a means to collect flight data for FDM programs.

In early 2007, CAPACG and Embry Riddle Aeronautical University teamed to host a General Aviation FDM Workshop – one of the first to focus exclusively on light aircraft. Currently, CAPACG is conducting two additional FDM demonstration trials with an air taxi operator and flight school. The focus of these trials is centered on using a web-based maintenance and reliability tool provided by two technology partners.

For more information on CAPACG and CAPACG services, visit www.capacg.com.