

FADEC:

You know how some things just don't live up to their hype. You hear a lot of promises and then when you get to experience it for yourself you're left, well, disappointed. Take heart fellow aviators, I'm here to tell you that FADEC (Full Authority Digital Engine Control), doesn't just live up to all the advanced billing, it leaps over it.

BY DALE SMITH

Having flown behind the “standard” type piston engine controls for a lot longer than I care to admit, I was a bit skeptical about what FADEC would really bring to the piston party. But after spending the day with Diamond's new DA42-TDI Twin Star, I can tell you it's quite a lot. And be warned, once you fly FADEC you won't be satisfied with the “old three-knob method” of engine management again.

The Thielert powered Diamond DA42 and the Teledyne Continental Motors powered Liberty XL-2 are the only two production piston engine airplanes currently available in the U.S. that have factory-installed FADEC. I have had the pleasure of flying both aircraft and with the basic differences between Thielert's diesel and TCM's piston aside (we'll leave that for another story) the advantages of the FADEC are shared by both.

Light the Fires

I experienced one of the biggest FADEC advantages right off the bat. Even after being flown for more than two hours prior to my flight, the already hot Twin Star started with the turn of the key. It is literally as simple as starting your car. Master on. Check the G1000's display to see that the glow plugs are out, (this is a diesel remember) flip on the fuel pump switch and turn the key to the left. The left engine comes to life. Repeat for the right side. That's it. If you've ever suffered through a hot-start — and what pilot hasn't — FADEC is as close to perfection as you will ever find.

Many pilots describe it as “a piston engine that acts like a turbine.” I couldn't agree more. Push the throttles forward to go fast. Pull them back to go slow. It's also turbine-like in its operation. In fact, I performed the “run up” as we were taxiing to St. Augustine Airport's runway 13. Since the entire engine/propeller/fuel system is controlled by a pair

of Engine Control Units (ECUs), all you need to do to check the system is press the two ECU buttons on the panel. The system's computer takes care of everything else. If there's a problem, it will be displayed on the G1000's multifunction display. That's about it. No fiddling with throttles, checking mags, cycling propellers — when you're flying a FADEC-equipped airplane, that's all so last century. By the time we reached the end of the taxiway we were ready to go.

Another key benefit to the FADEC control is when things aren't going quite right and in a twin like the DA42 that's during an engine out. When it was time to simulate an engine failure on take-off, my demo pilot, Earle Boyter, VP and partner in Premier Aircraft Sales switched off the right engine. Quicker than you can read this sentence, the FADEC had the engine shut down and the three-bladed propeller feathered.

Since it was all done automatically, I could concentrate totally on keep-



Making a Piston Engine Act Like a Turbine

ing above blue-line, stowing the gear and flying the airplane. FADEC is the system piston engine pilots have been dreaming of for a long time.

The question is, why has it taken so long to get it into a piston airplane?

FADEC — The Beginning

“The systems have not found their way to piston aircraft engines until recently for a number of reasons, including production unit costs and development and certification costs of a unit robust enough to meet the safety standards of aviation,” Bryan Lewis, president, Teledyne Continental Motors said.

As Lewis explained it, the predecessors of the FADEC systems found on today’s piston aircraft engines were used in automobile and turbine engines for decades. But costs kept getting in the way. “A typical commercial turbine FADEC has a price tag in excess of \$100,000, with an equally pricey maintenance cost,” he said.

“The piston FADEC had to have a price tag closer to automotive, but with the reliability and design compliant with the FAA. For aircraft, the system must pass high levels of lightning, vibration, and EMI testing that far exceeds automotive standards.”

The breakthrough came in the late 1990s when Aerosance (a TCM company) embarked on an aggressive program to certify such a system for piston aircraft engines. Rumor has it that the system Aerosance developed was “reverse-engineered” from General Motor’s then new Cadillac Northstar V-8, which used a computer to control the mixture and spark advance system for each cylinder.

“By the year 2000, STCs were granted for several installations and in 2005 the Liberty XL2 became the first OEM production aircraft to be certified with the Aerosance PowerLink Full Authority Digital Engine Control (FADEC),” Lewis said. “In addition to the electronic

engine control systems, the PowerLink suite of products includes integrated starting panels, serial data controllers, maintenance and service data storage devices, and Internet-based engine condition monitoring systems.” Clearly, FADEC is not your father’s engine ignition and fuel control system. In fact, FADEC is much more than just an engine ignition and control system. As Lewis explained it, the PowerLink FADEC has three major functions: engine control, safety and diagnostics, and data logging.

Engine Control

With TCM’s PowerLink system, engine functions such as speed, temperature, manifold pressure, power setting, starting conditions, etc. are controlled electronically by advanced computer processors, which automatically collect data and compute the settings for optimum engine performance. These settings include the ignition tim-

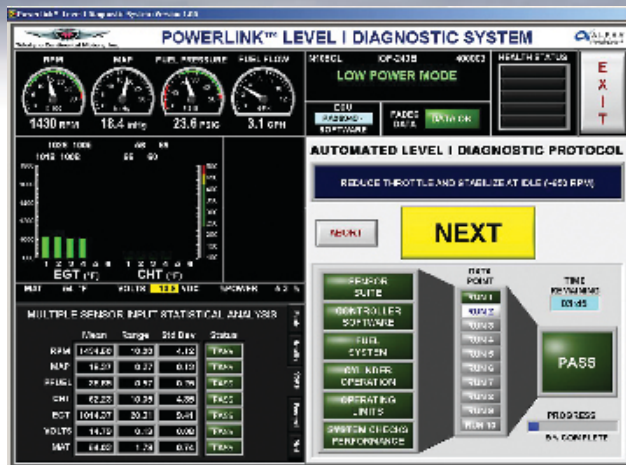
ing and fuel mixture to deliver improved starts, best power or best economy as required. In the PowerLink system, each cylinder of the engine is independently optimized continuously, which means the pilot always gets top performance and fuel efficiency.

Safety and Diagnostics

The system is designed with the FAA-required backups including diagnostics software that runs in the background to conduct pre-flight checks and constantly monitor the health of all the PowerLink components and their associated backup systems. PowerLink systems have demonstrated more than 12,000 hours of continuous operation in development testing.

Data Logging

The PowerLink system can record approximately 100 individual elements of data every second with con-



FADEC diagnostic display

solidated data being held on a flash memory chip. All data are constantly logged for troubleshooting and engine diagnostics and prognostics. Using the data logging function, TCM is planning on eventually pursuing an on-condition service model for its PowerLink controlled engines.

More Than the Sum of Its Parts

All of the various capabilities found in a modern piston engine FADEC sys-

tem are another reason why you haven't seen them being dropped into every airplane built since 2005. Bringing the system's sophistication and integration into an already certified airplane is a significant challenge for aircraft manufacturers. This is not a plug-and-play upgrade.

"Components of the FADEC system are installed on the engine and on the airframe. Therefore the certification is intertwined between airframe requirements and engine requirements," Lewis explained. "In addition, the Aerosance PowerLink system has been made compatible with most modern avionics providing the opportunity to share data and to display pilot information on these products. In addition, there have been a number of market and OEM customer factors, which have lengthened the introduction of the PowerLink system." Lewis also stated that TCM

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is currently pursuing five PowerLink installations and STCs, and that's very good news for everyone who flies.

The FADECs are Coming...The FADECs are Coming

While the start has been understandably slow, there is no questioning that FADEC is the future of piston engine technology. While Diamond and Liberty are currently the only two OEMs to offer factory FADEC, other companies are already offering Thielert's FADEC-equipped, jet fuel diesel CENTURION engine (see sidebar this page) as an aftermarket alternative on Cessna 172s. And, no doubt, others are in the works.

Thielert and TCM are taking steps now to help technicians prepare for the day when a FADEC-equipped engine shows up in their shop. In fact, both companies are already offering training sessions for these new-generation engines. Thielert is providing training at the Dallas, Texas headquarters of

their U.S. subsidiary, Superior Air Parts. A schedule of upcoming FADEC-equipped CENTURION Engine maintenance classes can be found at: www.centurion-engines.com.

According to TCM's Lewis, TCM dedicates a full day to PowerLink FADEC training as part of its monthly engine training classes (see FBO Services on www.TCMLink.com). In addition, TCM will provide on-site training to the technicians and other maintenance personnel for operators with PowerLink-equipped fleet aircraft.

As you can see, both FADEC manufacturers are making big investments in preparing shops to work on these advanced systems, and preparation is the key word here. Because of the reliance on sophisticated electronics and system integration, troubleshooting a FADEC system will be a whole different process than the way you approach a piston engine's diagnosis today.

Laptop computers, voltmeters, software updates and the like will be just as

Thielert Diesels Take Advantage of FADECs

Diesel engine manufacturer Thielert has been keen on using FADECs because modern diesel engines need an electronic control unit to actuate the injectors, head of electronic development, Bodo Metzdorf, told *Aviation Maintenance*. The German company's products are based on automobile engines that use common rail injection. Thielert claims its FADEC equipment is also used on other manufacturers' engines.

"Everything is done in house—development, testing and production, both hardware and software," Thielert spokesman Sebastian Wentzler told *AM*. The engine is controlled by a 32-bit microprocessor. "The system controls all aspects of engine operation based on the load level selected by the pilot," Wentzler said. Control algorithms ensure engine and propeller operation at maximum safety and efficiency.

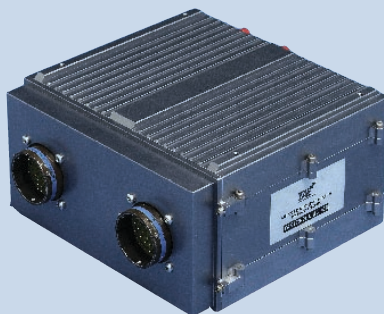
The system is redundant. Two independent management subsystems continuously monitor each other. In case of a failure, the engine control automatically shifts to the healthier subsystem. Before takeoff, an automated procedure checks full functionality of both subsystems. This means all engine and propeller sensors and actuators are checked.

During scheduled maintenance, a technician can detect potentially damaging events earlier. The integrated diagnostic event log and an operating hours meter work jointly in that direction. During maintenance, all data are downloaded, sent to the factory and then analyzed through Thielert's experts.

The engine originally was that of a car but the FADEC is engineered to aviation standards. It is tested against electromagnetic interference to 200 V/m and is thus certified to comply with DO-160. "The DO-178 standards ensure that the FADEC works under all conditions," Metzdorf added.

Wentzler insisted FADECs alleviate the pilot's workload. On Thielert's CENTURION engines, a single lever replaces the usual combination of throttle, mixture, pitch and possibly other control levers. The FADEC's hardware is located on the pilot's side of the instrument panel to protect it from heat.

— By Thierry Dubois



Modern, automobile-based diesel engines need an electronic control unit to actuate the injectors.

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much part of diagnosing and repairing a FADEC-equipped engine as they are when working on integrated avionic in today's advanced cockpits. "Although the technical talk on FADEC often centers on improved fuel consumption and pilot friendliness," Lewis said, "the PowerLink system is expected to revolutionize the piston aircraft [engine] maintenance experience."

"The Aerosance FADEC continues to evolve both in its performance features and maintenance capabilities. For example, the system as certified today contains expansion capabilities that can contact the FBO over a cellular phone line and download required maintenance information so that the technicians are ready to service the aircraft upon its arrival," Lewis said. "This is used by commercial airlines today but is a first in piston aviation. It is such innovative advances that TCM and Aerosance are bringing to the market and both expect the PowerLink system to become standard fare on their OEM engine fleets in the future."

With that in mind, it still is a piston engine and both TCM and Thielert are doing all they can to keep as much commonality in the troubleshooting and repair process as possible. "The PowerLink FADEC was designed to address a number of common experiences with the service and maintenance of aircraft piston engines. In short, TCM expects that when fielded, the service aspects of the PowerLink system will be those most sought by the owners," Lewis said. "The key to this new feature is the Serial Bus Controller (SBC) and Engine Data Interface (EDI) models of the PowerLink system.

"PowerLink equipped aircraft will come equipped with a flash data chip that can maintain operational data for the engine for the complete TBO period of the engine. Using software delivered with the PowerLink system, the servicing FBO can conduct diagnostics and maintenance using a portable laptop computer in the aircraft or with the flash data card in a remote condition," he continued. "Using the EDI data stored and controlled by the SBC, the PowerLink system identifies faults and recommends maintenance

actions consistent with modern automotive engine service systems." (Now if your customers would only pay you the same hourly rate they pay their car's mechanic — but I digress...).

Like any new system, TCM's FADEC is designed to grow as new capabilities are introduced. Lewis said that TCM's ultimate goal for PowerLink maintenance is to be able to integrate oil analysis, compression analysis, and the EDI trend monitoring data to obtain an integrated view of the engine state, selecting maintenance only when nec-

essary. By doing this, TCM is addressing the need to have the PowerLink maintenance requirements simplified for the FBO technician, with a minimal list of special tools. In short, the PowerLink maintenance can be performed with an appropriate computer and an Internet link.

Of course the goal of both TCM and Thielert is to not only make a FADEC-equipped airplane easier and more efficient to fly, but also to make it easier and more cost effective to own. Sounds like an idea whose time has finally come. **AM**

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