



A Powerful Beginning for the Era of the GEnx

Following successful completion of the requisite dry motor, wet motor and idle leak check at GE's Peebles Test Operation, the GEnx® first engine to test (FETT) for the Boeing 787® reached a thrust level of 80,500 pounds (sea level, standard day) on its first run to power. The date: March 20.

The certification thrust for this engine is 75,000 pounds.

In addition to the Boeing 787, GEnx engines will also power the Airbus A350® and have been selected as the sole powerplants for the Boeing 747-8 aircraft.

The successor to GE's CF6® engine family—today's most popular powerplant for wide-body aircraft—the GEnx incorporates the proven architecture of the GE90® engine, plus innovative design features that will enable the engine to realize exceptional performance and maintainability, enhanced by the flexibility of modular design. These features contribute directly to lower operating costs and are also factors in the reduction of noise and emissions as part of GE's "ecomagination" product portfolio.

In the fan, the shroudless blades—18 on the GEnx versus 36 on the CF6—are third-generation composite matrix construction, lighter in weight than their metal counterparts, much more resistant to damage and impervious to corrosion. The high-flow, wide-chord blades are designed using the latest 3-dimensional aerodynamic (3-D aero) technology.

Composite matrix material, similar to that used in the fan blades, is used in the fabrication



of the fan case, offering the same advantages of lighter weight and resistance to damage and corrosion. Although approximately half as dense as a metal case, the GEnx case provides significantly better containment.

In the high-pressure compressor, stage 1, 2 and 5 blisks eliminate dovetail wear, and powder alloy disks improve the durability of life-limited parts (LLPs).

The twin-annular pre-swirl (TAPS) combustor pre-mixes fuel and air more efficiently before

ignition, so combustion is cleaner and emissions are reduced significantly. GEnx engines are expected to meet CAEP 4 limits with margin (more than 50% in the case of NOx).

As a result of TAPS technology, peak temperature variations within the combustor are reduced by as much as 400°F, so liner life is improved, as is the life of components downstream from the combustor. In addition, dilution holes are no longer required, which eliminates a source of stress concentrations and reduces liner cracking.

In the high-pressure turbine, next-generation shroud material improves corrosion resistance by 50%, new alloy and coating of the airfoils increase thermal capacity by 50°F and next-generation powder alloys extend the lives of LLPs.

Finally, maintenance on wing is enhanced: access to mounting bolts is improved, safety-wiring of the borescope plugs and line-replaceable units (LRUs) is not required, and fuel nozzles and LRUs require only an idle leak check after replacement.

Contact: **Allen Paxson** allen.paxson@ge.com

Engine	Application	FETT	Certification	Entry into Service
GEnx-1B54	Boeing 787-3	2006	2007	2008
GEnx-1B64	Boeing 787-8			
GEnx-1B70	Boeing 787-9			
GEnx-1A72	Airbus A350-800 Airbus A350-900	2007	2008	2010
GEnx-2B67	Boeing 747-8	2007	2008	2009

OnPoint Diagnostics: Monitoring Engines in Real Time

GE - Aviation's OnPointsm Diagnostics services provide real-time monitoring of customers' engines while they are in flight. Employing information-based technology, innovative diagnostics detect anomalies before they become operational problems, helping to avoid major engine performance and maintenance issues and thereby increase time on wing.

"The U.S. Federal Aviation Administration (FAA) requires operators to trend-monitor engines in service, so we have been providing that information for many years," says Rick Donaldson, manager, Diagnostics and Prognostics Center. "GE first began offering diagnostics monitoring in 1997 and now monitors nearly 9,600 engines for 150 customers worldwide.

OnPoint Diagnostics

In 2005:

Engines monitored 9,039

Avoided events 60

Engine performance issues identified and rectified 150-plus

CNRs issued and successfully closed 899

"With OnPoint Diagnostics tools, we have the power to make decisions as early as possible," says Donaldson. "We receive thousands of data messages from aircraft each day. Once we get the information, we compare it to our data models. If something is unusual, an alert will be triggered to the operator's maintenance control. And once an alert is triggered, GE reviews the information and sends a CNR (Customer Notification Report) recommending actions to take based on the data.

"Early identification of trend changes helps to reduce cost of ownership and shop costs, improve fuel flow and eliminate events such as potential in-flight shutdowns (IFSDs) and unnecessary engine removals," says Donaldson.

Two levels of service

As with all OnPoint Solutions, flexibility is built into the Diagnostics program, with two levels of

service that can be customized to conform to individualized customer needs.

- **Standard Diagnostics:** Offered free of charge to operators of GE and CFM engines, this service extends customers' fleet history beyond their own aircraft. Data is analyzed in real time. Customers provide GE with their raw engine data. The OnPoint team takes care of all storage and processing requirements, including application of GE's advanced algorithmic continuous learning from its extensive fleet operational database.

Also part of the Standard package, GE has developed a web-based self-service operation that allows customers to go online and access their engines' data. Through a variety of tools, including GE's FleetVue, Fleet Manager and Root Cause Analyzer, customers can view real-time aircraft/engine status.

- **Comprehensive Diagnostics:** In addition to the free Standard services, Diagnostics



customers may customize their package, selecting from many additional options, including a complete engine health monitoring service, regulatory reporting and engine exceedance and fault troubleshooting.

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Diagnostics Service Summary

Service Element	Standard	Comprehensive
Data Storage	• Life of engine	• Life of engine
Data Processing	• Automated, immediate	• Automated, immediate
Shift Alerts	• Available on CWC* • Reviewed by GE	• Available on CWC • Reviewed and dispositioned by GE
Shift Diagnosis	• Notification of critical detected anomalies	• Notification of ALL detected anomalies
Watchlists	• Customer-managed via CWC	• GE-managed via CWC • Watchlist reports • Fleet review via teleconference
Reports	• Performance summaries	• Performance summaries • Derate report • Weekly performance highlights • Customized reports
Exceedance Alerts	• Automatic real time • Reviewed by customer	• Automatic real time • Reviewed and dispositioned by GE
Exceedance Diagnosis	• N/A	• Troubleshooting recommendation
Fault Alerts	• Automatic real time • Reviewed by customer	• Automatic real time • Reviewed and dispositioned by GE
Fault Diagnosis	• N/A	• Troubleshooting recommendation • Fault summary reporting

*CWC: Customer Web Center

Upgrade of CF34-8C1 Offers Flexibility, Future Benefits

GE - Aviation's upgrade of the CF34-8C1 engines, originally delivered on more than 200 Bombardier™ CRJ700™ aircraft, is now under way. This upgrade is the start of a five-year program that is expected to reach the entire fleet of 468 CF34-8C1 engines. The CRJ700 regional jets will be powered by a derated variant of the engine used on the CRJ900™ regional jet. The new engine model designation for the CRJ700 fleet is known as the CF34-8C5B1.

The engine upgrade program includes replacing the high-pressure compressor (HPC) rotor, combustor, high-pressure turbine (HPT) rotor, HPT stator and a portion of the low-pressure turbine (LPT) hardware. All life-limited parts (LLPs) are expected to reach 25,000 cycles mature life, while engine inter-turbine temperature (ITT) margin will increase an average of 17°C due to the increased redline limits of the CF34-8C5B1 model engine.

The upgrade program will result in a common turbomachinery configuration for the entire CF34-8 family of engines and will deliver a 10% to 15% reduction in engine life cycle costs compared with the CF34-8C1, exceeding the original cost baseline for this engine. A key element of this program is the flexibility to operate a common engine on both the CRJ700 and CRJ900 regional jets by use of an engine configuration plug and minimal external hardware changes as well as the potential for future performance improvements on the CRJ700.



GE - Aviation is offering existing operators the opportunity to upgrade their engines when they come due for their first major shop visit at 9,000 cycles. Projected time on wing following the upgrade is expected to be in the range of 10,000 to 16,000 cycles. This visit will also allow the engines to be upgraded to the latest CF34-8C quick engine change (QEC) kit configuration. As the upgrade progresses, customers will be able to operate the CF34-8C1 and CF34-8C5B1 model engines in an intermix configuration on the CRJ700 regional jet that will help to maximize the operational readiness of their fleet.

According to Rod Williams, vice president, Aircraft Programs, Bombardier Regional Aircraft,

“The introduction of a common engine for the CRJ700 and CRJ900 aircraft increases the overall parts commonality between the two aircraft types to a very high level. This represents a considerable savings in spares and maintenance costs.”

Currently, almost 60% of the CF34-8C1-powered CRJ700 regional jet fleet is signed up for the upgrade program. The upgrade will enable GE to focus its development efforts and resources on a single engine type to continue to introduce further engine improvements.

Contact: **André Robert** andre.robert@ge.com

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“We have 30 people who are involved in diagnostics monitoring, affording our customers 24/7 coverage,” says Donaldson. “And 20 researchers are devoted to improving the software and analysis tools here and at GE’s Global Research Center in Niskayuna, N.Y.

“Diagnostics is a component of GE’s full-service OnPoint Solutions. Our customers are automatically connected to GE’s design,

Key Parameters Monitored

- Fuel flow
- Rotational spool speeds of the high- and low-pressure spools
- Compressor discharge temperature
- EGT (exhaust gas temperature)
- Fuel and oil system temperature
- Flight parameters

customer support, maintenance and on wing support teams and their related expertise,” says Donaldson. “Bottom line: OnPoint Diagnostics leverages GE’s OEM databank and expertise, fleet experience and global service network, enabling customers to operate in a proactive versus reactive environment.”

Contact: **Mark Tulino** mark.tulino@ge.com

CF34-3 Upgrade Initiatives Reducing Cost of Ownership

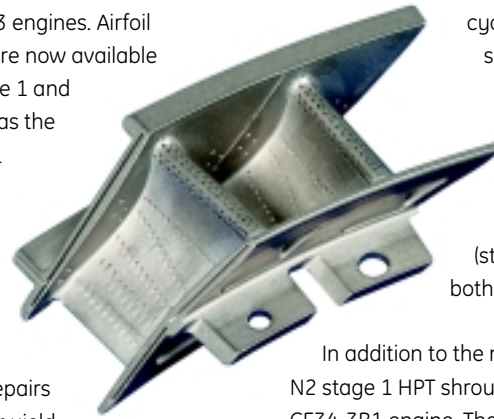
GE - Aviation continues to improve the cost-of-ownership economics of the CF34-3 engine. One of the areas that has had the greatest financial impact on customers involves the high-pressure turbine (HPT). GE - Aviation successfully launched the Set Management Offer (SMO) in 2004, and today, more than 70% of the CF34®-powered regional aircraft fleet is signed up for this program.

Through the SMO program, GE offers CF34-3A1/-3B1 HPT stage 1 and 2 blades and CF34-3B1 HPT stage 1 shrouds in sets over three shop visits at a special price. Customers enjoy the financial benefit independently of where they choose to have their engines overhauled. New hardware is provided in exchange for their old blades and shrouds. Time on wing is enhanced through the use of this program, and customers have typically seen their overhaul invoices reduced by as much as 5% under the SMO.

GE - Aviation now offers additional opportunities to further reduce the cost of ownership of

our customers' CF34-3 engines. Airfoil replacement repairs are now available for the CF34-3A1 stage 1 and 2 HPT nozzles as well as the CF34-3B1 HPT stage 1 nozzle. These repairs replace both leading and trailing vane airfoils, along with the outer band, with new material of the original alloy. These repairs approach 100% repair yield and offer near-new part performance.

Customers may also elect to upgrade their CF34-3B1 stage 1 and 2 nozzles to the latest production configuration. Investing in these nozzles infuses the latest-generation, current CF34 technology into the CF34-3B1 engines in service. These nozzles, manufactured from N5- superalloy, have demonstrated significant durability improvements during a factory-accelerated mission test of 18,000



cycles. GE - Aviation offers several upgrade options for the CF34-3B1 engine, ranging from a combination of airfoil replacement repairs (stage 1) and upgrade by attrition (stage 2) to a full upgrade of both stage 1 and 2 nozzles.

In addition to the nozzle upgrade, a new N2 stage 1 HPT shroud is available for the CF34-3B1 engine. The new design has demonstrated major durability improvement during factory testing. Customers currently signed up under the SMO may revise their agreements to upgrade their fleet to this latest configuration.

Altogether, these initiatives are expected to generate up to an additional 5% of financial benefit on a typical overhaul invoice, depending on the choice of options.

Contact: **André Robert** andre.robert@ge.com

THE AMERICAS

Kevin McAllister
kevin.mcallister@ge.com

EUROPE

Jack Lutze
jack.lutze@ge.com

ASIA

Chaker Chahrour
chaker.chahrour@ge.com

CHINA

Mike Wilking
mike.wilking@ge.com


MIDDLE EAST

Muhammad Al-Lamadani
muhammad.al-lamadani@ge.com

The purpose of *Service Solutions* is to enhance communication with our customers. Please contact us if we at GE - Aviation can be of further service to you. View *Service Solutions* online at www.geae.com/services/information/servicesolutions.

GE
Aviation

General Electric Company
One Neumann Way J4
Cincinnati, OH 45215 U.S.A.
Phone: +1.513.552.3272 (Internationally)
+1.877.432.3272 (Within U.S.)
Fax: +1.513.552.3329
E-mail: servicesolutions@ge.com

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AE-45754 (04/06)

Printed in U.S.A.



imagination at work