Engine development is a three-front campaign to derive more thrust from every atomized droplet of fuel while simultaneously raising reliability, hushing noise and cutting downtime for maintenance. In this special report, we examine how the manufacturers of business aircraft engines are approaching this formidable and perennial quest, and how they are progressing with their product development programs.

**With Passport and H-Series, GE working both ends of spectrum**

GE Aviation is closing in on certification of its flagship turbofan for business aviation—the Passport—and at the same time striving to become a stronger player in the turboprop market with the H-Series.

The 16,500-pound-thrust Passport, destined to power Bombardier's Global 7000 and 8000, entered flight-test late last year and is approaching the first fan blade-out trial. Water ingestion was on the test card last month at GE's facility in Peebles, Ohio. As of early May, eight Passport test engines had accumulated 1,400 hours and 1,700 cycles. The total number of engines involved in the development phase is to be 10, built around eight cores. "We have used eight engines to accumulate the cycles," Shawn O'Day, GE Aviation's senior v-p for business and general aviation, told AIN.

O'Day said the team is happy with the new technologies introduced on the engine. With the fan blisk, for example, "the airflow sees a smoother fan, a smooth front end of the engine as it flows through," he said. Operators will no longer need to lubricate the blades and passengers will feel less vibration. Specific fuel consumption is 8 percent better than that of the Rolls-Royce BR725, according to O'Day. "This turbofan is designed for business aviation–range, low noise and low vibration," he said.

The Passport marks the commercial debut of oxide-oxide (ox-ox) ceramic-matrix composite materials. "The exhaust mixer, the inner cowl duct, the exhaust cone are all ox-ox," O'Day said. This lightweight material resists the high temperatures found in the exhaust area, thus improving durability and fuel consumption, according to its designers.

Also boosting efficiency, said O'Day, is the super-finish surface on high-pressure compressor blades. "On a super-finished blade, because it's so smooth, you have a layer of air that remains over the surface, keeping contaminants from sticking on the blade. The blade remains cleaner and more efficient," O'Day said. The surface of those blades is four times smoother than on conventional blades.

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The CF34-3 program endures with Bombardier’s launch last year of the Challenger 650, a further evolution of the Challenger 600 series. The 650 will be powered by a pair of 9,220-pound-thrust CF34-3BMTOS. The new engine will be able to use its APR rating, normally
activated only when one engine fails, for better takeoff performance. “What we’ve done is make the extra thrust available for takeoff regardless of whether or not an engine is out,” O’Day said. The additional power is pilot-selectable via a new performance thrust setting. The higher thrust setting does not affect engine maintenance, provided it is used on no more than 10 percent of takeoffs, according to Bombardier. The CF34-3BMTO will also offer a reduced takeoff thrust mode to cut maintenance, according to GE.

The GE Honda HF120, rated at 2,095 pounds of thrust, received FAA type certification in December 2013 and an FAA production certificate (for the engines to be built in Burlington, N.C.) this past March. It is getting closer to entering service, as HondaJet won provisional FAA certification for the HondaJet on March 27 and expects full certification “in the next few months,” with deliveries to begin shortly after. GE Aviation itself has ordered two of the aircraft for its corporate fleet and plans to take delivery of them in 2017.

GE Honda last fall announced a joint project with Sierra Industries of Uvalde, Texas, to develop an engine retrofit program for the Cessna CitationJet, CJ1 and CJ1+. The program is known as Sapphire.

**Turboprop Segment**

On the H-Series turboprops, GE continues to develop an electronic engine control unit that is slated to enter service next year on the Nextant G90XT. “A single-lever control will simplify the pilot’s workload,” O’Day said, but he made it clear it will not be on every engine, “because there are aircraft considerations to be taken into account. You need to go from a two-lever cockpit to a one-lever cockpit; it’s not just an engine change.”

Once the new system is certified, it will be offered as an upgrade and possibly for retrofit.

With nine applications for the H-Series so far, GE plans to build more than 100 engines this year. The three models—the H75, H80 and H85 (750, 800 and 850 shp, respectively)—might be joined in future by a more powerful version. “It is at the study stage,” O’Day said.

The most recent first flight of an aircraft fitted with H-Series engines was logged in January, when the Nextant G90XT took to the air. The G90XT is a remanufactured Beechcraft King Air C90A equipped with H75s. Cleveland, Ohio-based Nextant was expecting aircraft certification this spring.

O’Day noted that GE is using additive-layer manufacturing on the H-Series for the fuel injector used in the starting phase.

“With the 1950-rpm gearbox that’s entering service on the G90XT this fall, as well. We’re also offering a 300-amp starter-generator that’s going to be available in all H-series production engines,” he added.

GE Aviation has submitted an application to the EASA for approval to burn S10 diesel fuel in its turboprops. “We received EASA approval to conduct field evaluations in Brazilian agricultural aircraft,” O’Day said, and GE is about to start with these operators, who hope to cut their fuel costs by up to 25 percent. The company is also working with Brazil’s ANAC civil aviation authority.

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New Rolls-Royce Engines Enter Service

Rolls-Royce appears to have no business aviation development program under way but says it is keeping busy with in-production engines.

“The AE3007-C2 has just gone into operations on the Cessna Citation X+,” a spokesman told AIN. The newest version of the AE3007 turbofan features a dual-channel Fadec and provides sea-level static takeoff thrust of 7,034 pounds, flat rated up to 86 degrees F (30 degrees C). Another variant, the 9,020-pound-thrust (ISA+15) AE3007-A2, powers the Embraer Legacy 650.

A recent evolution of the BR725, the 16,900-pound-thrust BR725-A1-12, powers the Gulfstream G650ER.

“It has upgrades on the Fadec, including the fuel management system,” the spokesman said.

Over the last few years, Rolls-Royce has not been chosen for any new major business-jet program. GE, Pratt & Whitney Canada and Snecma were picked for Bombardier’s Global 7000/8000, Gulfstream G500/G600 and Dassault’s Falcon 5X programs, respectively.

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New Bizav Engines

NEW BIZAV ENGINES
Snecma Silvercrest Advances Toward Certification

by Charles Alcock

Snecma is proceeding with the development of the 11,450-pound-thrust Silvercrest turbofan, which is to power the Dassault Falcon 5X and Cessna Citation Longitude twinjets. A number of operability and performance aspects have been validated in tests conducted so far, according to the France-based engine manufacturer.

At last month’s EBACE show in Geneva, Dassault acknowledged that it is now facing the possibility that some delays in the development of the aircraft’s Snecma Silvercrest engine could mean changes to the 5X timetable. “Our engineering team is currently analyzing Snecma’s revised development plan and assessing possible impact for the 5X program,” said Dassault chairman and CEO Eric Trappier. The Silvercrest is now expected to complete certification in next year’s first half.

At an EBACE show press conference on May 18, Snecma’s head of civil engines, Cédric Goubet, mentioned difficulties in modifying the company’s Gulfstream II flying testbed. Although the flight-test campaign is now well under way in San Antonio, Texas, the issues have added several months to the project.

In addition, a technical problem emerged on the oil-fuel heat exchanger. In the context of “a new, more stringent regulation,” the oil-fuel thermal balance fell slightly short of target, Goubet said. A solution is being implemented but it needs new cast parts, which are long-lead items.

Nonetheless, at Dassault’s Bordeaux factory the first Falcon 5X is proceeding with ground testing, including engine run-ups. In Toulouse, ongoing airframe static and fatigue tests have cleared the aircraft for flight-testing.

In total, seven engines are being used for the tests, mainly on Snecma’s indoor test rigs and also on open-air test cells, such as the one at the Istres flight-test center in the south of France. Also under way are partial tests, as well as altitude tests being conducted at the aircraft engine test center of French defense research agency DGA.

In May last year Snecma started a flight-test campaign on the flying testbed at San Antonio in the U.S. The aircraft flies approximately six times each week with one Silvercrest engine and one of its original Rolls-Royce Speys, and has already logged more than 200 hours of tests. Last month Snecma was expecting to begin a fifth series of tests, and these will continue throughout the summer with a view to logging about another 100 hours. Certification by the European Aviation Safety Agency is now expected to be complete in the first half of next year.

To date, complete engines have logged nearly 2,500 hours of ground tests, in addition to a number of hours of partial tests. The company reports that it has demonstrated nominal and maximum takeoff thrust, along with what Snecma describes as “excellent engine operability and very satisfactory dynamic performance.”

The development team has just passed the hail-ingestion tests and has started endurance tests. Snecma said that the test plan is proceeding on schedule and the program is moving toward certification according to its revised schedule.

From the beginning of the Silvercrest design process, Snecma has used sister company Turbomeca’s experience in helicopter turboshaft design for the centrifugal compressor stage. Another sister company, Belgium-based Techspace Aero, which specializes in low-pressure compressors (boosters), has also been involved in the design and production of the Silvercrest.

While testing advances, Snecma is finalizing arrangements for the Silvercrest production facilities. The engine assembly line at Villaroche, near Paris, is now operational. Its Safran sister company Aircelle is ready for propulsion system integration, as well as engine build-up and nacelle installation. The production test stand also has been qualified for use.

At the same time, active production has started for support components, including prototypes of maintenance tools, writing of technical publications and preparation of the initial customer training courses. “We are continuing to set up the support network, with a selection of regional support hubs in the Americas [Dallas], Europe [Paris] and Asia [Singapore], and recruiting local staff,” said a Snecma spokesman. “Our deployment plan provides for the entire system to be ready six months before entry into service.”

Snecma also is moving forward on the development of its real-time ForeVision engine monitoring system. For the Silvercrest, this will track more than 1,500 parameters in flight, calculated on the basis of about 250 physical measurements (mainly from sensors).

This allows the manufacturer to monitor about 30 different functions, including engine performance, and the condition of oil, fuel, engine filters and other systems. ForeVision automatically transmits data several times per flight and sends reports that summarize about 50 performance parameters, calculated by algorithms in the aircraft systems that are common with those in Snecma’s ground systems. Failure messages are transmitted immediately.
Pratt & Whitney Canada’s PW814GA and PW815GA—which will power the Gulfstream G500 and G600, respectively—received type certification from Transport Canada in February. As of late April they had logged more than 3,600 hours/7,600 cycles, including more than 360 flight hours on the engine maker’s Boeing 747SP flying testbed, Michael Perodeau, v-p for corporate aviation and military programs, told AIN.

In addition, the PW800 engine’s common-core technology, used in six PurePower engine applications, has amassed 17,000 hours of testing. “We are now doing post-certification maturation testing—endurance testing—to ensure robustness over a long time,” Perodeau said. Endurance testing is also part of the Etops certification program.

Another routine post-certification activity is developing Fadec updates. “We provide them as needed, as the aircraft flies and the airframer needs modification to the Fadec,” Perodeau explained. The G500 is slated to fly this year, followed by the G600 in 2017. The engines will be rated at 15,144 and 15,680 pounds of thrust, respectively.

The PW814/815GA will introduce a double-digit improvement in fuel burn over the previous generation of engines in this thrust class, according to its designers. Pratt & Whitney Canada is providing the entire integrated powerplant—engine, nacelle and thrust reversers—for the G500 and G600.

On the 5,760-pound-thrust PW306D1 for the Cessna Citation Latitude, the focus will soon be on entry into service, Perodeau said. The Latitude finished FAA certification flight-testing in April. “The PW306D1 is similar to the Citation Sovereign’s engine, so we expect no big issue.”

As of late April, certification of the 6,725-pound-thrust PW307D for the Falcon 8X trijet was said to be imminent. Meanwhile, development of the PW307B for the Learjet 85 is on hold, as Bombardier has “paused” the aircraft program.

Perodeau said that while no development is under way on the PW500 series (2,900 to 4,500 pounds), it is a high-volume program for the company, thanks to the Embraer Phenom 300.

On the PW600, he noted the very light jet market has been relatively soft. “We expect a need for an engine improvement as airframers develop derivatives, but we are not there yet,” he said. PW600 turbosfans have been used so far on the Eclipse, Cessna Mustang and Embraer Phenom 100 at thrusts ranging from 950 to 1,780 pounds.

On the PT6A turboprop, Pratt & Whitney Canada is looking at introducing electronic controls, such as Fadec. Electronic engine control is already aboard PT6As powering some military trainers but there are no civil applications yet. “So far, the cost/benefit ratio was not good enough but, as technology evolves, it becomes more doable,” Perodeau said.

The Fadec would be as generic and modular as possible but some differences between applications would likely be required—for example, on hydromechanical components.

Finally, more power—toward 2,000 shp—is on the agenda. “We have the technology to do it,” Perodeau said. Today’s maximum power in the PT6A series is close to 1,700 shp. Going much beyond 2,000 shp makes less sense for the PT6’s architecture; the PW100, with cooled turbines, is already in that power class, he explained.
Honeywell plans to bring new tech to existing line-up

With no new turbofan or turboprop under development, Honeywell is considering infusing new technology into production engines and refreshing its production processes with new materials and techniques.

The company hopes to announce a new application for the 6,500- to 7,500-pound-thrust HTF7000 turbofan soon and is looking at technologies that could be applied to the engine over the next five to 10 years. The most recent application was the 7,323-pound-thrust HTF7350 that powers the Bombardier Challenger 350, now in service. The new engine provides 7 percent more thrust than the Challenger 300’s HTF7000.

The company is also ramping up production, to 400 engines annually from 300, in large part to accommodate the entry into service of Embraer’s Legacy 450 and Legacy 500, AIN understands.

More than 1,000 HTF7000 engines are in service, with a combined 2.3 million hours and dispatch reliability of 99.9 percent, Nasos Karras, v-p for marketing and product management, told AIN. The most recent in-flight shutdown happened a year ago, he added.

“There is no demand for a new development” of the 5,500-pound-thrust-class TFE731, long Honeywell’s workhorse for business aviation, Karras acknowledged. The company is nevertheless studying technology for upgrades. Approximately 10,000 TFE731s are in service.

Similarly, Honeywell might incorporate new technology into the TPE331 turboprop (575 to 1,600 shp), which was designed more than half a century ago. “We are looking at opportunities in the business aviation and military markets,” Karras said. The TPE331 features a two-stage centrifugal compressor, a compact and erosion-proof design, he pointed out.

Honeywell has taken part in the Continuous Lower Energy, Emissions and Noise (Cleen) program, led by the FAA, since 2010. As part of the program, core and engine testing of a new centrifugal compressor stage, able to withstand higher temperatures, is scheduled for this quarter. Low-leakage air-air seals have been tried over 1,500 engine cycles.

The company has tested new thermal barrier coatings for the high-pressure turbine, on the tip shroud of the first stage and on airfoils. The coatings have been matured to technology readiness level 6, meaning they are ready to leave the laboratory and go to full product development.

Honeywell is also hoping to expand the use of ceramics—already employed in production for some stators and vanes—to raise temperature tolerance and engine efficiency. “The challenge with ceramics remains their unproved reliability and durability, but expect this to change with time as their use and field experience expands,” Karras said.

Separately, the future looks bright for additive layer manufacturing. “This technology has no limit and we are investing heavily in 3-D printing,” Karras said.
Two Williams turbofan programs on track for certification by year-end

Williams International is in a busy period for development, with two engines—the FJ33-5 and the FJ44-4A-QPM—scheduled to receive certification this year.

Since Cirrus restarted the single-engine Vision SF50, the Williams FJ33-5 program has made progress and is on schedule for certification in August, Matt Huff, Williams International v-p for business development, told AIN. “It has passed the most difficult tests for a small engine—ice slab, hail and bird ingestion—as well as blade-out retention,” he said.

Production deliveries of the 1,800-pound-thrust turbofan will begin in the fourth quarter. The third prototype (the second conforming aircraft) of the SF50 first flew last December and Cirrus is aiming to deliver the first aircraft late this year.

Before Diamond terminated the D-Jet program in 2013 that airplane was considered another possible application for the FJ33. The initial version of the FJ33 received FAA certification in 2004.

The “quiet power mode” version of the FJ44-4—the -4A-QPM—is on schedule to receive certification next year, Huff said. It is being developed to power the PC-24, which Pilatus rolled out last August and flew for the first time last month. The quiet power mode can be used on the ground, with the engine acting as an auxiliary power unit (APU) to supply electric power and bleed air. Williams says the noise signature is less offensive than that of typical APUs.

Another feature of the engine destined for the Pilatus is the so-called Exact passive thrust vectoring. It uses a “proprietary fluid dynamic” system. The thrust vector from the exhaust nozzle varies as a function of engine operating conditions: power setting, exhaust-gas temperature, Mach number and altitude. The improvements in performance offset the weight penalty, Huff noted.

On the PC-24, each engine will provide a normal takeoff thrust of 3,435 pounds at ISA+8C, and a new automatic thrust reserve will provide 5 percent more thrust if needed.

Williams has produced nearly 400 copies of the engine’s predecessor, the FJ44-4, which powers the Citation CJ4 (3,400 pounds of thrust) and Hawker 400XPR upgrade (3,230 pounds). “The total population of FJ44s in service is approaching 5,000 and we are now at 10 million hours of service on the fleet,” Huff said.

The 1,800-pound-thrust FJ33-5A, top, and the larger FJ44-4A-QPM, are on track for certification this year.