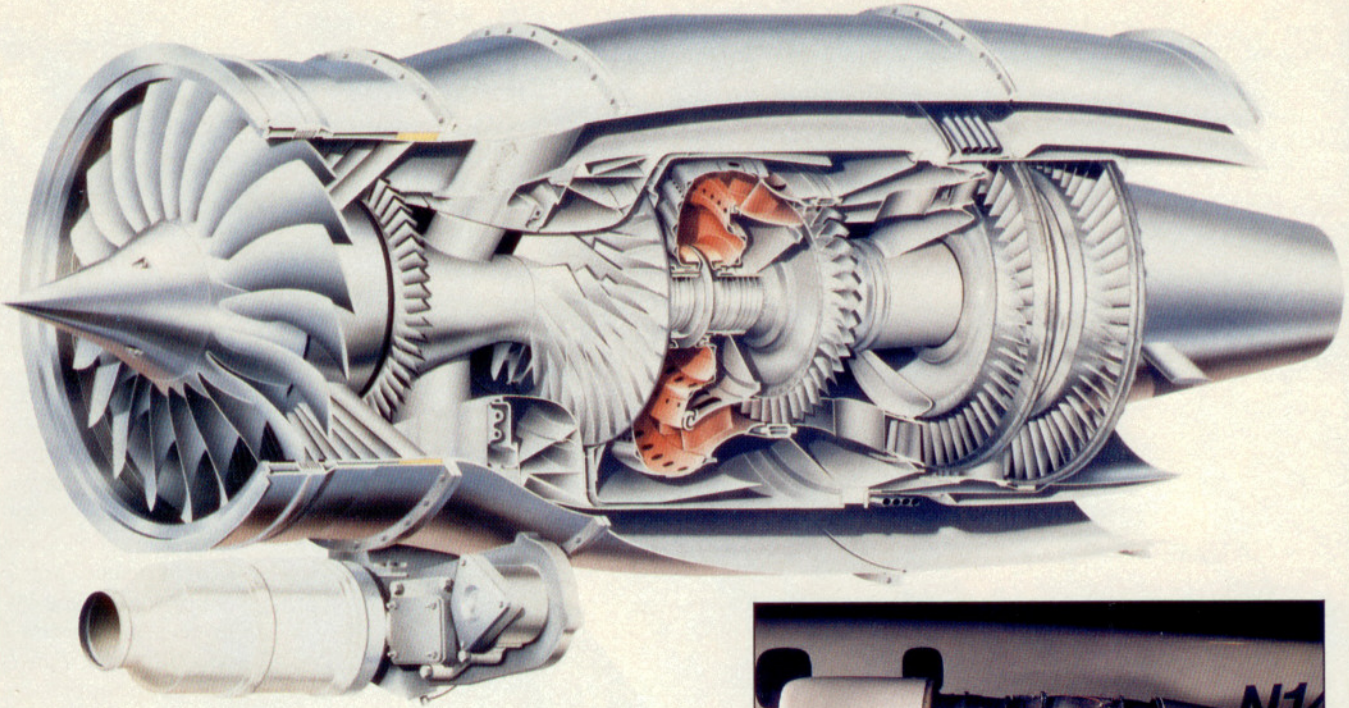
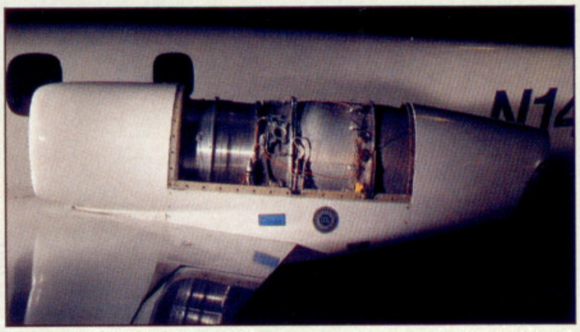
THE TRIUMPH OF TECHNOLOGY

The first of a new breed—the super-efficient business jet.

BY BARRY SCHIFF

General aviation is a laggard, the poor stepchild of the aerospace industry. It forever and eagerly awaits useful morsels of technology to trickle down from its more affluent brethren, the airlines and the military. ■ This certainly has been true with respect to powerplant technology. Turbine (turbojet) engines, which largely have been





Williams International and Rolls-Royce are jointly developing a 1,900-pound-thrust turbofan engine—the FJ44.

superseded by turbofan (fanjet) engines, are the domain of corporate aviation because jet engines are prohibitively expensive and have an insatiable thirst for fuel. But it will not be like this for long.

Williams International and Rolls-Royce are jointly developing a 1,900-pound-thrust turbofan engine. The compact Williams-Rolls FJ44 is the key to a new genre of entry-level business jets that will operate not only faster, but more efficiently than turboprop aircraft.

Williams International has developed 30 different types of small turbine engines and has manufactured 9,000 of them for U.S. cruise missiles and a variety of other military uses. The FJ44, however, is a new design under development since 1983, according to Williams' president and founder, Dr. Sam Williams. It is not a modified cruise-missile engine, as has been reported.

The FJ44 represents a design breakthrough. "This engine will have very low operating and maintenance costs. One reason is that it has only seven hundred parts compared to larger engines, which have fifteen to twenty thousand parts." It is noteworthy that the dry weight of an FJ44 is 445 pounds, which is less than the dry weight of a 250-horsepower Textron Lycoming IO-540 piston engine (excluding the propeller).

Rolls-Royce is sharing in the engineering of the engine and will be manufacturing the turbine rotors and low-speed turbine shaft. The Williams-Rolls partnership assures that support for the FJ44 will be available through Rolls-Royce's worldwide facilities. Williams will be manufacturing all other parts and assembling the engine in Ogden, Utah.

Certification is expected in early 1992. Three aircraft currently are being developed to take advantage of the compact Williams-Rolls turbofan.

One is the Cessna CitationJet Model 525, which is intended to succeed the original Citation 500 and its replacement, the Citation I. The new Cessna reportedly features the first supercritical airfoil on any business jet to achieve laminar flow.

The Model 525 will have a six-place cabin and is designed to operate from 3,000-foot runways. With a maximum cruising speed of 380 knots and a gross weight of 10,000 pounds, the CitationJet is faster, more efficient, and weighs almost a ton less than the Citation I.

Cessna reports that the first flight of the prototype is scheduled for May 1991, and certification is expected in October 1992. The CitationJet, like other aircraft of the same genre, probably will be certified for single-pilot operation.

Another aircraft incorporating the diminutive Williams-Rolls turbofan engines is the Swearingen SJ30, which is described as a miniature Boeing because the wings have 30 degrees of sweepback and less area (165 square feet) than a Cessna 172's. (The smallest Learjet has a wing area of 234 square feet.) This will enable the SJ30 to have a maximum cruise speed of Mach 0.77 and a redline (Mmo) of Mach 0.82.

Like a Boeing, the wing features exotic high-lift devices: full-span, leading-edge slats and genuine Fowler flaps. These reduce stall speed to just 80 knots.

The SJ30's designer, Ed Swearingen, says that the aircraft will be pressurized with a 10-psi differential, which is more than that of a Boeing. This means that a sea-level cabin can be maintained to 28,000 feet; at its maximum operating altitude of 42,000 feet, the SJ30's cabin altitude will be only 4,200 feet.

Swearingen anticipates that the $2.6-million SJ30 will make its maiden flight by the end of June. Certification is expected 30 months later.

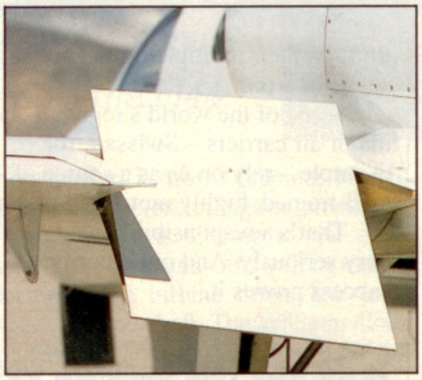
The only flying example of an aircraft powered by the Williams-Rolls FJ44 turbofan engine is Scaled Composites' Triumph Model 143, which was designed by Burt Rutan of *Voyager* fame. Scaled Composites designs and builds proof-of-concept aircraft. The company is hoping to sell the rights to the Triumph design to a manufacturer that will certify and produce it.

The Triumph's airframe consists of composite materials, carbon fiber where stiffness is critical and fiberglass elsewhere. Rutan claims that it has only 10 percent of the parts that the airframe would have if it were constructed of conventional materials.

Another Rutan trademark is the canard, which gives the aircraft three types of lifting surfaces (including the wings and horizontal stabilizer). The wings and canard each incorporate single-slotted flaps. The Model 143 appears to have a pair of rudders, but the lower control surface is an electrically operated trim tab.

The design of the Triumph also allows piston or turboprop engines to be mounted on the wings. This explains the purpose of the ventral fin: It is provided to prevent propeller damage in case of excessive takeoff rotation or landing flare. This is why the aircraft has such long legs and sits so high, which gives it a uniquely handsome appearance.

The cabin has the same dimensions as a Cessna 414's and presumably can carry eight (including pilots) in a high-density seating configuration.

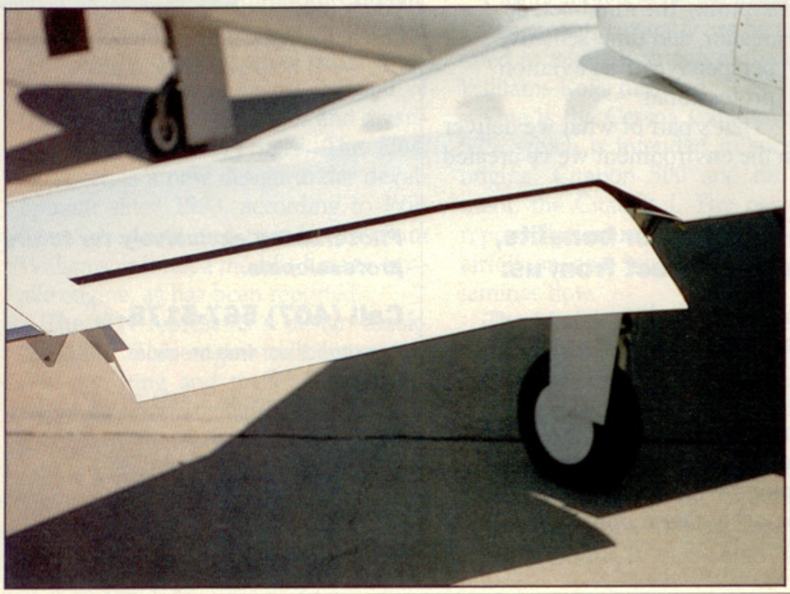


The Triumph is equipped with speed brakes and thrust "attenuators," but thrust reversers were deemed unnecessary because of the airplane's short landing rollout capability.

Unless you know what to expect, a takeoff in the Triumph is startling. I had just advanced the thrust levers when it was time to rotate (88 knots) and lift off (98 knots). But then, how many jets use less than 1,500 feet of runway?

Subsequent climb performance is also swift: 4,500 feet per minute at 5,000 feet msl, 3,000 fpm at 15,000 feet, and 1,750 fpm at 25,000 feet. (Like piston engines without turbochargers, jet engines are normally aspirated and lose power with altitude. That's why the climb rate of jet aircraft also decreases with altitude.) The aircraft can take off at its maximum-allowable gross weight of 9,000 pounds and climb uninterrupted to 41,000 feet.

The Triumph's handling qualities are conventional and predictable except that roll control requires a somewhat heavy hand on the control wheel, and the electric pitch trim operates much too slowly. Also, the aircraft tends to roll during accelerated, flaps-up stalls. It is otherwise stable, responsive, and a joy to fly (even



during engine-out stalls).

The only difficulty I had with the aircraft was losing altitude; it does not come down easily. I had to slip the Triumph to prevent drifting above the glideslope while approaching the runway at 100 knots with the engines idling and the gear and flaps extended. This is the result of a combination of aerodynamic cleanliness and approximately 100 pounds of idle thrust from each engine. The aircraft has thrust attenuators that can be deployed to block half the tailpipe area and eliminate most of the idle thrust. Speed brakes are available to help in the descent. The aircraft does not have thrust reversers because, with a landing roll of less than 2,500 feet, they are not needed.

The seeds for the Triumph were planted in October 1984 when Scaled Composites began to develop a cabin-class twin to compete with Cessna's 400-series aircraft. Such a design, Rutan was advised, also should be capable of incorporating turboprop engines. As the new aircraft began to take shape, Rutan recognized that it "was also just the right weight and size to accommodate Dr. Williams's new turbofan." So Rutan optimized the design to use the FJ44 engines, even though this could result in a slightly less efficient aircraft if piston or turboprop engines were used.

The Rutan Triumph cannot accommodate significantly larger jet engines (such as Pratt & Whitney turbofans) because these would make the aircraft too tail heavy. Also, the additional power that such engines provide would be wasted because each engine inlet ingests air from above the upper surface of each wing. Too powerful an engine would accelerate the local velocity of air flowing over the wing so much that it would become transonic—it would approach the speed of sound. This would create an unacceptable increase in drag due to the formation of shock waves along the upper surfaces of the wings. The Williams turbofans, therefore, are a good match for the airplane.

Most existing business jets obviously are faster but typically can claim only half the fuel efficiency of Rutan's fuel miser.

The combination also is extremely efficient. When the Triumph operates in long-range cruise at its maximum operating altitude of 41,000 feet, it has a true airspeed of 295 knots and covers 0.9 nautical miles for each pound of fuel consumed. Using maximum cruise thrust (still at 41,000 feet), it zips along at 375 knots while boasting an impressive specific range of 0.7 nm/lb.

By way of comparison, most turboprop aircraft are much slower and typically cannot travel more than 0.65 nm/lb. The outstanding exception is the Piaggio Avanti, which comes closest to matching the Triumph's efficiency/speed combination. Most existing business jets obviously are faster but typically can claim only half the fuel efficiency of Rutan's fuel miser. When operating at long-range cruise at their most efficient altitudes, the Cessna Citation II and the Learjet 31, for example, can fly only 0.47 and 0.51 nm/lb, respectively.

The turboprop airplane has been successful largely because it is less expensive than a business jet to purchase and operate. But with the arrival of entry-level turbofan aircraft that are faster and more efficient, one must question the future of turboprop aircraft.

Perhaps of greater importance to most *AOPA Pilot* readers is whether the evolution of the compact FJ44 turbofan points toward the development of even smaller, more efficient engines for use in a wider variety of general aviation aircraft. Experts are unwilling to go on record with a prediction, but they concede that turbine power for light aircraft is becoming less of a dream and more of a possibility. In the meantime, the Williams-Rolls FJ44 is a giant step in the right direction. Our direction. □