A star is born

Diamond's diesel should shake up the light-twin market

BY THOMAS A. HORNE

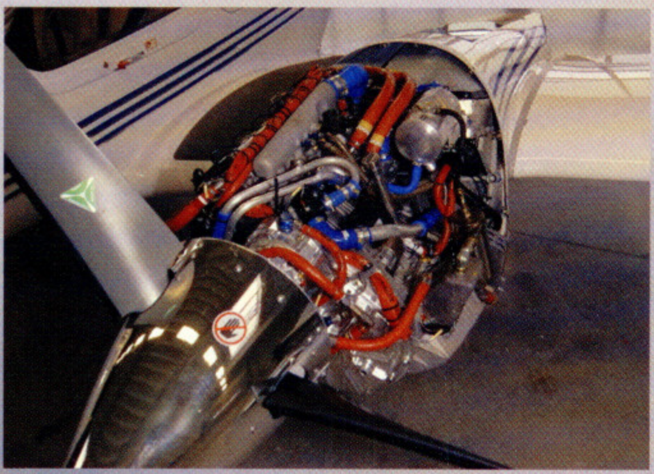
PHOTOGRAPHY BY MARK WAGNER

With its needle nose, wasp waist, and bulbous nacelles, the Diamond DA42 Twin Star is among the most dramatic new entries to the general aviation market. It's also the first new light twin introduced since 1982, when Cessna brought out its T303 Crusader. The Twin Star has attracted a lot of attention lately—mainly because of its liquid-cooled Thielert TAE 125, 135-horsepower turbodiesel engines and the fuel economy they demonstrated on an August 16 trip across the Atlantic Ocean. A Diamond test pilot flew at 42-percent power for 1,900 nm nonstop—from St. John's, Newfoundland, to Porto, Portugal—in 12 hours, burning fuel at a rate of just 2.8 gph per engine. The airplane's two-tube Garmin G1000 glass cockpit—standard equipment, and the first original-equipment installation of this large two-display system—has also garnered crowds at major airshows.

The Twin Star's all-carbon-fiber airframe is basically the same as that used in Diamond's DA40 Diamond Star, but with a nose baggage compartment and, of course, beefed-up center spar sections to support the weight of the two engines. There's also more legroom for the front-seaters, the seats are set one inch lower than the Diamond Star's, and the instrument panel is located farther away from the pilot—a change made possible by the G1000's comparatively narrow depth.

The Twin Star received its European certification from the EASA (European Aviation Safety Agency) in May and United States certification should follow in mid-2005, Diamond says. The company says it has racked up some 458 orders for the Twin Star; more than 200 are destined for American owners.

To get a better look at this promising new design, I went to Diamond's home factory in Wiener Neustadt, Austria, where the first 14 Twin Stars were rolling out the doors. They're being built at a rate of 16 airplanes per month.



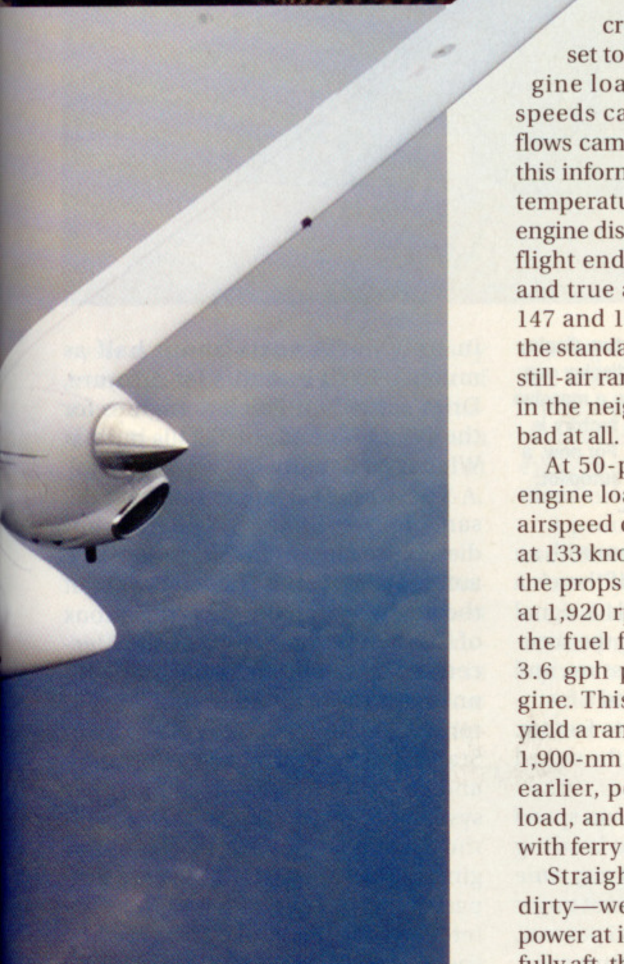
Flying impressions

My right-seat minder on my familiarization flight was Diamond's managing director, Michael Feinig, who spent many hours flying in the DA42 flight-test program.

Strap into the Twin Star and you feel like you're wearing the airplane. Seat position is fixed, so you have to adjust the pedals to fit. After lowering and latching the huge forward-hinged canopy it's time to take in the instrument panel and controls. The G1000 and its many display subsets dominate, but your attention is quickly shifted to the starting procedure. This amounts to turning on each engine's engine control unit (ECU) toggle switch, waiting for the TAEs' glow plugs to warm up (an annunciator extinguishes when the plugs are ready), then turning the keys. The TAEs instantly jump to life, emitting slight puffs of black exhaust in the process.

Taxiing is conventional, but the pretakeoff engine "runup" is simplified. You press and hold the ECU test buttons while the units go through a self-test procedure lasting a few seconds.

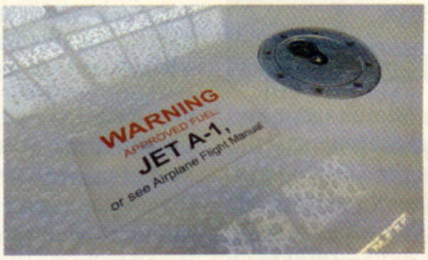
For takeoff, it's full throttle, release the brakes, and wait for 69 knots to rotate and lift off. With turbocharging, a



Above, left to right: The DA42 has its DA40, single-engine stablemate's cabin and entry doors; Thielert turbodiesels have three cooling systems, and large cooling outlets on the upper nacelles; when the autofeather system senses a power loss, the affected engine's propeller immediately feathers (note the prop in the far right photo). Restarting is a matter of flipping on the ECU's toggle switch. The engines run on Jet-A (facing page), and engine instruments show fuel temperature as a precaution against fuel icing in very cold temperatures.

takeoff manifold pressure of 76 inches, and MT three-blade, composite-construction constant-speed propellers this doesn't take long, and soon you're in an 83-KIAS V_{YSE} (best single-engine rate-of-climb speed, the speed used in climbout to ensure best performance in case an engine fails). Climb rates were in the area of 1,500 fpm (it was 62 degrees Fahrenheit/17 degrees Celsius at the 896-foot-elevation Wiener Neustadt airport); the engines are remarkable in their smoothness, and the visibility out that huge canopy is excellent. In cruise at 6,500 feet, power was set to 85 percent (measured as engine load) and the resultant prop speeds came out to 2,200 rpm. Fuel flows came out to 6.3 gph per side. All this information, plus coolant and fuel temperatures, is listed on the G1000's engine display. So is wind direction and flight endurance. And so is indicated and true airspeed, which came in at 147 and 164 knots, respectively. With the standard 89-gallon fuel system, our still-air range that day would have been in the neighborhood of 1,050 nm. Not bad at all.

At 50-percent engine load, true airspeed came in at 133 knots, with the props turning at 1,920 rpm and the fuel flows at 3.6 gph per engine. This would yield a range of some 1,450 nm. For the 1,900-nm Atlantic crossing mentioned earlier, power was set at 42-percent load, and the airplane was fitted out with ferry tanks.



Straight-ahead stalls—clean and dirty—were almost nonevents. With power at idle and the control stick held fully aft, the airplane shook and bucked slightly, but never exhibited a clean break or sharp roll-off on either wing.

The Twin Star is designed with both cruising and training in mind. Embry-Riddle Aeronautical University and other large flight schools in the United States have expressed great interest in adding Twin Stars to their training fleets.

This leads us to the Twin Star's single-engine behavior and performance. To start off the single-engine performance demonstration, the airplane was slowed to approximately 80 knots with the gear and flaps retracted, simulating a post-takeoff condition. Then the left throttle was closed and the right throttle advanced to full power. At V_{YSE}, the climb rate at 6,000 feet showed as 400 to 500 fpm.

The Twin Star's V_{MC} (minimum control speed with the critical engine inoperative) is listed as 68 knots in the pilot's operating handbook. It's important to note that the Thielerts, for all their advanced design concepts, both drive clockwise-rotating propellers (as viewed from the pilot's seat). This means that the Twin Star is a bit unusual in that it has a critical engine—in this case, the left. The critical engine is a function of several variables, one of them being the asymmetric thrust produced by the differing p-factors of each propeller. Because of p-factor, a propeller's descending blades develop the highest thrust levels. The right propeller's descending blades create thrust farther outboard along the wingspan, where there's much more of a moment arm from the airplane's center of gravity. This means the right prop generates more yawing force when the left engine gives out than vice versa. Therefore, losing the left engine is more critical to yaw control in engine-out situations. Other modern light-twin trainers don't have a critical engine; they have counterrotating propellers, which means that each engine has equal engine-out asymmetric forces.

In any event, Feinig said that with the left engine windmilling, the right one going full blast, the left wing raised slightly to create the recommended zero-sideslip configuration, the right rudder shoved full forward to the stop, the gear retracted, and airspeed dropping through 65 knots, an uncontrollable yaw will begin. This signals the onset of a loss of directional control, and therefore V_{MC}. The yaw and its accompanying roll isn't abrupt or scary, Feinig emphasized. It's more of a lazy rolling-off to the left. I didn't elect to perform a full-blown V_{MC} demonstration on this flight. Mainly because of aft CG concerns, what with our photographer in the backseat.

However, I did fly multiple V_{MC}-like demonstrations with the left—then

The avionics package features a two-display Garmin G1000. Its mutifunction display can be zoomed in or out (left) to show a massive moving map. Diamond's Austrian factory is in the dead center of the screen. For now, a Bendix/King KAP 140 serves as autopilot; a Garmin unit will soon replace it.

right—propellers feathered, gear and flaps up, and the opposite engine at full power. In most cases the airplane buffeted and stalled before there were any signs of an uncontrollable yaw or roll. The loss of directional control took place nearer 50 knots, and was as docile as Feinig advertised. In two demonstrations configured with full flaps, the airspeed was almost pegged at the low end of the scale when simultaneous stall buffeting and V_{MC} yawing and rolling took place. Heading control resumed the moment power was reduced by as little as 10 percent on the operating engine.

Diamond says that the Twin Star's winglets explain the airplane's single-engine manners. They help directional stability, keep rolling and yawing moments to a minimum, and enable quick recoveries from single-engine drills, the company says.

Feathering is accomplished by simply flipping the ECU switch to the Off position. Within a couple of prop revolutions the blades feather and come to a halt. Dubbed an "autofeather" system, the Twin Star's feathering works via an electro-hydraulic system with an unfeathering accumulator. If there's a loss of power, the ECU sends a signal that closes a valve controlling the accumulator (which stores oil pressure, and is normally on all the time) and a feathering spring drives the prop to feather. Cycle the ECU back on, and the stored pressure unfeathers the prop.

Landings are easy. There's no speed limitation for lowering the landing gear, so it can be dropped at any time to help in slowing to the 80-knot target speed on final. Set power to 35 percent, extend full flaps and landing gear, come down final, then reduce power to 20 or so percent as you near the runway. Trailing-link landing gear makes for graceful, face-saving arrivals, even in gusty crosswind conditions.

Powerplants

"I can see the day when there will be no avgas at all, and the only fuel will be Jet-A," said Christian Dries, chief executive officer of Diamond Aircraft Industries. "Already we see avgas prices of five to six dollars per gallon in Europe, and as much as eight dollars per gallon in Italy. Jet-A costs about half as much." To fit into this Jet-A future, Dries settled on Thielert engines for the Twin Star and the DA40s built at Wiener Neustadt.

These engines are essentially the same four-cylinder, 1.7-liter turbodiesels used in certain Mercedes-Benz automobiles. Frank Thielert, owner of the engine company, adds a gearbox of his own design, replaces the Mercedes crankshaft and camshaft with ones of his own, and installs a customized ECU—the heart of the Twin Star's single-lever power controls—and an electro-hydraulic autofeather system for the propellers. To deal with the extra heat put out by diesel engines, four cooling radiators are also part of the TAE engine package: an intercooler for the intake air heated by the turbocharger; a radiator for the glycol-based liquid engine coolant; an oil cooler; and a heat exchanger for cabin heating.

Diesels get their fuel economy because they always run lean. A full explanation gets complicated, but suffice it to say that they have comparatively high compression ratios, get high-pressure fuel injection, always run at full throttle (when the pilot moves the throttle control, this only changes the duration of the fuel-injection pulses), and therefore develop high torque at low rpm. Unlike a spark-driven ignition

SPECSHEET

Diamond Twin Star
Model DA42
Standard price: $439,000

Specifications

Powerplants ....2 Thielert TAE Centurion 1.7-liter, 135-hp
Current recommended TBR..........1,000 hr
Propellers ....2 MT V-6-A, three-blade, constant-speed, full-feathering; wood-composite with stainless leading edge cladding, 6 ft, 2 in dia
Length ....27 ft 11 in
Height ....8 ft 8 in
Wingspan ....44 ft
Wing area ....177.2 sq ft
Wing loading..........20.52 lb/sq ft
Power loading ....13.8 lb/hp
Seats 4
Standard empty weight ....2,400 lb
Maximum takeoff weight ....3,748 lb
Maximum useful load..........1,348 lb
Payload w/full fuel ....778 lb
Maximum landing weight ....3,560 lb
Fuel capacity, std ......89 gal (85 gal usable)
Baggage capacity,
Nose ....66 lb
Aft cabin ....100 lb

Performance

Takeoff distance, ground roll ....951 ft
Takeoff distance over 50-ft obstacle....1,542 ft
Rate of climb, sea level ....1,730 fpm
Single-engine ROC, sea level ....500 fpm
Projected cruise speed/range w/45-min rsv (fuel consumption)
@ 84% power, 12,500 ft....183 kt/1,235 nm (12.2 gph total)
@ 60% power, 12,500 ft....157 kt/1,442 nm (8 gph total)
Maximum operating altitude..........18,000 ft
Landing distance over 50-ft obstacle....1,640 ft
Landing distance, ground roll..........950 ft

Limiting and Recommended Airspeeds

V_{MC} (min control w/critical engine inoperative) ....68 KIAS
V_{SSE} (min intentional one-engine operation) ....83 KIAS
V_X (best angle of climb) ....76 KIAS
V_Y (best rate of climb) ....76 KIAS
V_{YSE} (best single-engine rate of climb) ....83 KIAS
V_A (design maneuvering) ....127 KIAS
V_{FE} (max flap extended) ....131 KIAS
V_{LE} (max gear extended) ....197 KIAS
V_{LO} (max gear operating)
Extend ....197 KIAS
Retract..........197 KIAS
V_{NO} (max structural cruising) ....159 KIAS
V_{NE} (never exceed) ....197 KIAS
V_R (rotation) ....69 KIAS
V_{S1} (stall, clean) ....62 KIAS
V_{SO} (stall, in landing configuration)..56 KIAS

For more information, contact Diamond Aircraft, 1560 Crumlin Sideroad, London, Ontario N5V 1S2; telephone 800/359-3220; Web site (www.diamondair.com); e-mail sales@diamondair.com

All specifications are preliminary, subject to change, and based on manufacturer's calculations. All performance figures are based on standard day, standard atmosphere, sea level, gross weight conditions unless otherwise noted.

system, diesels ignite their (already lean) fuel-air mixtures with the heat of compression generated in the cylinders. It all adds up to an engine that's force-fed huge amounts of air, and that makes the most out of a gallon of Jet-A.

Lycoming power

The Thielerts may be efficient, but Diamond knows that their service support in the United States—almost nonexistent now—will be a big, big factor in America's acceptance of the Twin Star. This prompted Dries to pursue a Lycoming option for the American market, which is now in flight test. Service and parts for Lycoming engines are everywhere in the United States, and every mechanic worth his salt knows them inside out.

A proof-of-concept airplane with two 180-horsepower Lycoming IO-360s is now flying in Austria. Feinig offered me a ride in the Lycoming Twin Star, and it proved to be a hot rod of the highest order.

And why not? It's got 90 more horsepower than the Thielert-powered DA42. The Lycoming Twin Star stood out on the ramp because of its engine cooling inlets—large vertical slits in the engine cowlings. Thielert-powered cowlings have single horizontally oriented cooling inlets.

You notice the extra power as soon as you advance the throttles on takeoff. I could barely keep the Lycoming Twin Star on the runway by the time liftoff speed came. During climbout I had to reduce power to keep the thing from getting into the yellow arc. We had the vertical speed indicator pegged at

Lycoming 180-horsepower IO-360 engines are being tested on this proof-of-concept Twin Star. Designed with the American market in mind, this airplane burns avgas and has conventional engine controls. Certification should come by mid-2005, and performance should be impressive.

2,000-plus fpm—and we were flying 40 knots faster than V_{YSE}.

For a demonstration of cruise flight, the throttles were pulled back to 20 inches, and the props set to 2,100 rpm. That's about 55- to 60-percent power in a typical IO-360 installation in a typical airframe. But in this airframe—limited to the DA40's 161 KIAS V_{NE}—the result was 155 KIAS. Six knots below redline!

Works in progress

Although the DA42 is certified in Europe, it's still very much a project in evolution. Diamond expected European IFR certification by mid-October 2004, and certification for known icing using the TKS weeping-wing system by December 2004. But before the anticipated U.S. certification, Diamond faces other big challenges.

One centers around the heat generated by the Thielert engines. The intercoolers haven't been able to keep up with engine intake heat rises at altitudes above 12,000 feet. This overheating in turn causes the ECUs to automatically limit power in order to prevent engine damage. Engineers are talking about redesigning the cowlings to boost airflow over the intercoolers. Keeping the liquid coolant sufficiently under control to prevent cylinder hot spots is another concern. So far, Diamond has achieved success by pressurizing this cooling system.

The Thielerts also need their TBRs (time between replacements) upped from the current 1,000 hours to 2,400 hours. The TAEs aren't overhauled; they're replaced with new engines when their times are up—at a cost of $25,000 per engine. Diamond is confident this TBR increase will happen, based on encouraging test results.

Expanding the speed envelope is another issue. At this writing, Diamond is seeing maximum cruise speeds of 172 knots for the Thielert-powered Twin Star. By tweaking the airframe, a boost to the goal of 183 knots is anticipated. This could involve a re-rigging of the flaps and stabilator, a change of propeller pitch, and changes to the shape of the nacelles to eliminate cooling drag.

Then there's the Lycoming option. There's much work to be done with this project, and meeting the projected U.S. certification date of summer 2005 will be a daunting task indeed. When it's finished, though, customers can look forward to what promises to be one of the best-performing light twins in general aviation history.

But in spite of what it sees as temporary setbacks, Diamond remains unfailingly confident in the future. Ducking in and out of Diamond's "Katana Kafe" on the cold September day I visited, Dries recounted the company's steady progress. How 400 airplanes a year leave the factory. How one year ago there were 100 employees; now there are 400. How a new composite production facility was recently completed. How the Canadian factory in London, Ontario, builds one airplane a day. How more than 3,200 Diamond airplanes have been manufactured over the years. And how the D-JET, a low-cost, 315-knot single-engine business jet will go to market in 2006. You get the feeling that this is a company on the move, riding the crest of a new wave of entrepreneurship that's rising in central Europe. It will certainly be interesting to watch the Twin Star program unfold in the United States. It has the potential to rekindle the static light-twin market. AOPA

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