TWIN & TURBINE®

FOR THE PILOTS OF OWNER-FLOWN, CABIN-CLASS AIRCRAFT

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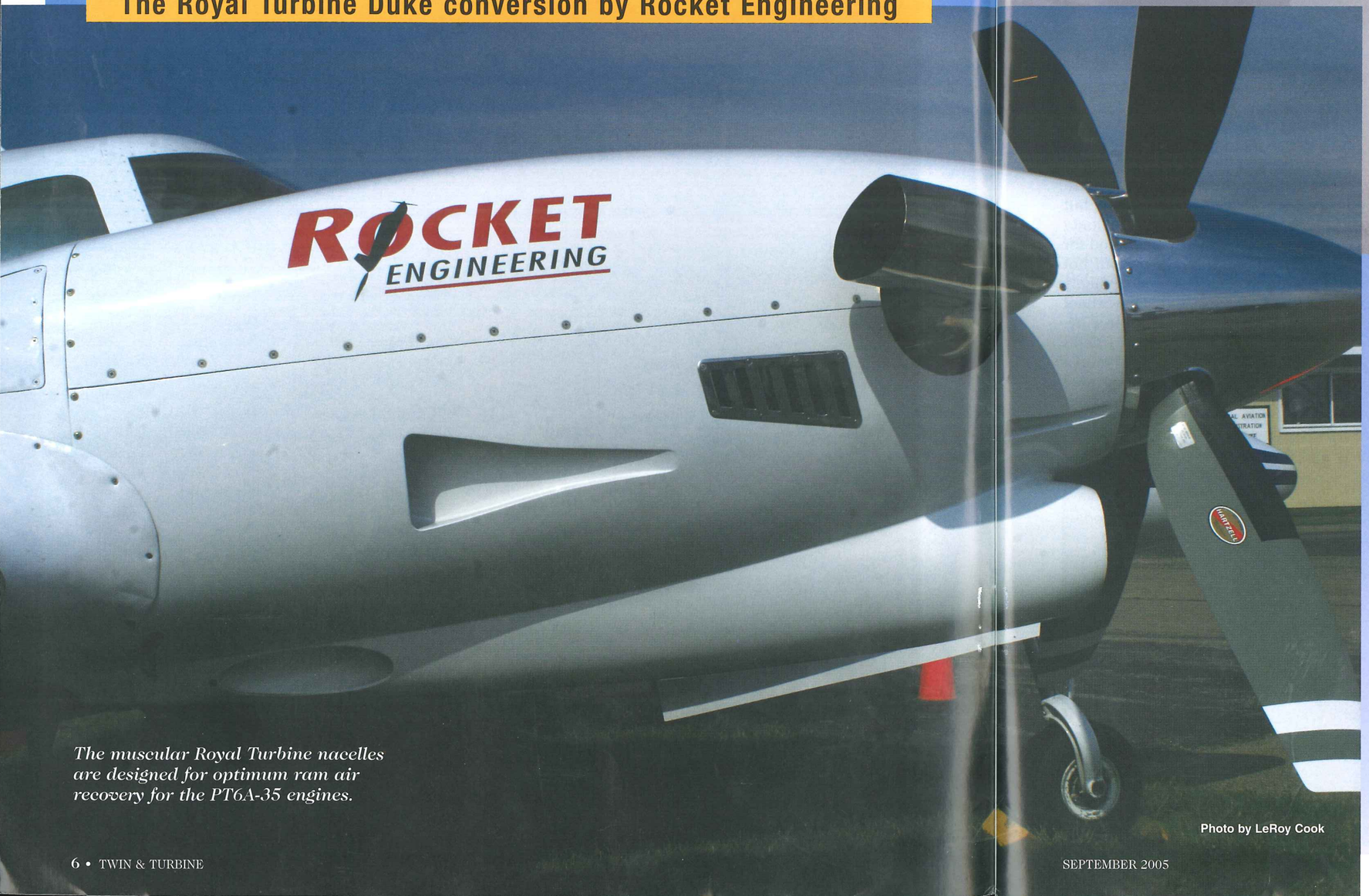
The Royal Turbine Duke

Rocket Engineering Conversion Gives Popular Twin More Speed & Capability

The Beechcraft Duke Becomes a Baby King Air

The Royal Turbine Duke conversion by Rocket Engineering



The muscular Royal Turbine nacelles are designed for optimum ram air recovery for the PT6A-35 engines.

Photo by LeRoy Cook

Photo by Rocket Engineering

by LeRoy Cook

If ever there was an airplane exhibiting "ramp presence," the Beech Duke would be a first choice. Styled like a pair of Italian sunglasses, the Beechcraft model 60 was introduced in 1968 as a gap-filler, pressurized-cabin airplane for the owner-flown market. It was a blatant move to keep move-up Baron pilots firmly in the ranks of Beechcraft owners, yet its appeal was almost universal.

Built through 1982 (it was briefly included in the 1983 line-up), the Duke used a time-honored formula; put the biggest possible engines on a sleek airframe and present it in a way to make people want it. Beech was good at these marketing efforts, as shown by the success of the Baron and King Air lines. At the time of the Duke's appearance, Beech had no pressurized piston twin, other than the hulking Queen Air 88 with a mechanical cabin supercharger; the Baron 58P was introduced eight years after the Duke.

And so, Duke ownership quickly became a cachet of the fortunate few who could possess the ultimate personal twin. Only the mighty Lycoming TIO-541-E14C engines added a sour note to the symphony; called upon to produce 380 horsepower at 41 inches m.p. and 2900 rpm, the Duke powerplants were often overhauled early, despite having been built integrally with their turbochargers. Careful handling could get them to last 1,200 hours, but the 1,600-hour rated TBO was an elusive target.

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Photo by LeRoy Cook

The Duke panel is still recognizable, but the engine switches at the left and turbine instrument stack are new. The power quadrant looks the same, but functions differently.

Enter Rocket Engineering, the long-established successful turbine conversion company from Spokane, Wash., that brought us the JetProp modification of the Piper Malibu and the Turbine Air Bonanza B36TC. With around 200 conversions in the field, Rocket Engineering has an excellent depth of experience in putting Pratt & Whitney Canada PT6As in piston-powered airframes. When considering a twin-engine project, president and CEO Darwin Conrad realized the potential in Beech's Duke B60, the definitive version that came out in 1974, and specifically those with extended-range fuel tanks, first offered in 1976 at serial #365.

Because prices vary widely, depending on condition and equipment, there are some bargains to be had. In researching the asking prices, we found a 50 percent range from a median price of around a quarter-million, mostly for relatively low airframe times.

To create the Royal Turbine, as Rocket calls its new hot-rod, the hand-grenade 380-hp piston engines are replaced by either P&W PT6A-21's or -35's, flat-rated to 550 shp. That's a significant increase on an already-powerful airplane, enough to push it to over 300 knots and climb at 4,000 fpm. Because the B60's optional wet wingtips provided 232 usable gallons, only a slight increase in fuel tankage was necessary, achieved by putting bladder tanks in the aft nacelles for an extra 30 usable gallons. Weight savings achieved by installing the lightweight turboprops permits carrying a heavier fuel load.

How much is all of this going to cost? Depending on starting and ending parameters, a straightforward conversion could be flying for under $1 million, while a very complete Royal Turbine will represent an investment of $1.1 to $1.2 million. For what it offers, that's very competitive.

You could buy a new Baron and cruise 100 knots slower, or an older, slower turboprop with engines of questionable health, but Rocket Engineering uses only brand-new PT6A engines, good for a TBO of 3,600 hours without hot section inspections and a likely prospect for extended overhaul times with trend monitoring. Beech's legendary tough airframes hold up well; the Duke is not a cabin-class Baron. Flush riveted throughout, it rides on a wing with

Photo by LeRoy Cook

The finely-crafted interior has all the amenities expected of this class of aircraft.

chem-milled skins, makes extensive use of bonding and honeycomb stiffeners, and it has a heavier landing gear and an entirely different empennage. Maneuvering speed at the original 6,775 gross weight is 161 KIAS.

Rocket Engineering takes full advantage of existing Duke aftermarket enhancements, like yaw-damping strakes under the tailcone and an array of vortex generators and winglets that allow gross weight to be increased to 7,000 pounds. These items will be added during the conversion process if not already installed. The aft wing-root fairings have been lengthened to pick up a few knots. To improve boarding and deplaning access, Rocket added sturdy grab handles beside the doorframe. And of course, the instrument panel acquired a new set of analog/digital power gauges. We were invited to share a short ride in N157JT, the first Royal Turbine off the completion line, and it was indeed an eye-opening experience.

Juliet-Tango was a beautiful 1982 B60, one of the special edition airplanes marking Beech Aircraft's 50th anniversary, built only eight units from the end of production in Beech's Salina, Kan., plant. Sitting low and poised in that perpetual crouch only Dukes have, it appeared to be moving at 100 mph while standing still. Up forward, the nose opens on the left side to allow 385 pounds of baggage to be stowed. The batteries have been relocated from the left nacelle to the lower portion of the nose; Rocket Engineering uses gas-mat spillproof lead/acid batteries. The 45,000-BTU Janitrol combustion heater is converted to Jet-A use.

The composite nacelles are optimally shaped for their job, adding ram air inlet recovery to boost performance. Electrically-heated intake lips forestall ice accretion and, like all PT6A installations, the rear inlet screens make it difficult for FOD to enter the compressor section.

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Royal Turbine Duke Conversion by Rocket Engineering

PRELIMINARY SPECIFICATIONS

Base price, less airframe	$887,000 ($787,000 with PT6A-21 engines)
Certification basis	FAR Part 23, STC'd
Powerplants	Pratt & Whitney Canada PT6A-35
Power output, flat rated (each)	550 shp
TBO	3,600 hours
External Dimensions:	
Length	33 ft 10 in
Height	12 ft 4 in
Wingspan	39 ft 3 in
Landing gear wheelbase	9 ft 2.37 in
Landing gear span	11 ft .24 in
Internal Dimensions:	
Seats	5 pax plus 1 pilot
Cabin length	11 ft 10 in
Cabin height	4 ft 4 in
Cabin width	4 ft 2 in
Baggage capacity	385 lbs/32 cu. ft
Weights:	
Maximum takeoff weight	7,000 lbs
Maximum landing weight	6,775 lbs
Maximum fuel capacity	1,755 lbs
Basic operating weight	4,480 lbs
Useful payload and fuel	2,520 lbs
Payload with full fuel	765 lbs
Performance:	
Maximum certified ceiling	30,000 ft
Maximum service ceiling - 1 engine	27,000+ ft
Takeoff distance (SL,ISA, MTOW)	1,200 ft
Landing distance (SL, ISA, MLW)	1,000 ft
Two-engine climb rate	4,000+ ft/m
Single-engine climb rate	1,600+ ft/m
Maximum speed	301 KTAS @ 27,000 ft
Typical cruise speeds	285 KTAS @ 27,000 ft
Maximum operating limit	208 KIAS
V_{ref} (SL MLW)	95 kts
Stall speed (landing config.)	73 kts
Range:	
IFR range (two crew, 2 pax)	1,241 nm
IFR range (2 crew 6 pax)	1,043 nm
Pressurization differential	4.6 psi

For more information:
Rocket Engineering Corporation, Darwin Conrad, President and CEO, Jeanie Sadler, Executive Vice President, 6427 East Rutter Road, Spokane, WA 99212, phone (509) 535-4401, fax (509) 534-2025, www. rocketengineering.com

Photo by LeRoy Cook

The Royal Turbine conversion of the Beech Duke B60 is a standout on any ramp. Its sleek, purposeful look spells speed and comfort for the person on the go. Small enough to be a personal airplane, it's big enough to hold its own in any company.

Manually-extended ice vanes can be deployed in the induction path if conditions warrant. Hartzell's 82-inch, four-blade reversible propellers run at a maximum of 2170 rpm, so the powerful Royal Turbine leaves a quiet footprint. The 14,000-BTU vapor-cycle air conditioner is retained in the right nacelle.

The fuel system has three filler ports per side, allowing for selective loading by the line crew. Using the inboard wing caps gives 202 gallons, topping off the outboard fillers brings the load up to 232 gallons and with the nacelles filled 262 gallons are on board. Sight gauges read out partial fuel levels up to 60 gallons in the main tanks. All of this is transparent to the pilot, since the tanks are interconnected and are managed as simply on, off or crossfeed.

The wing's planform is similar to the NACA 23000-series layout of the Baron but is structurally different, with a dihedral of 6 degrees. An adjustable trim tab is on the left aileron and the electrically-actuated flaps have increased chord to aid in slowing the speedy Duke. The electric Beechcraft landing gear fully stows in 4.5 seconds behind sequencing doors, but to preserve the Duke's stiletto profile the nosegear rotates 90-degrees to lie flat under the baggage compartment.

Main gear tire size is 19.5 x 6.75-8 and the nose tire is a 15 x 6.00-6.

Landing lights are mounted on the main gear struts and a taxi light articulates with the nosegear.

The vault-like cabin entrance door is immediately above the left wingroot, allowing the wing to be used as a walkway, and a retractable step is provided to facilitate entry. Four static ports are on the aft fuselage sides, for independent pilot and copilot systems, and the standby oxygen cylinder is in the tailcone. The pressurization outflow valves are on the aft side of the pressure vessel for quieter operation.

There's no mistaking the rakish Duke vertical stabilizer, with a dorsal fin that runs forward to the cockpit, originally designed to hide the ADF sense antenna. The aftermarket strakes under the aft fuselage increase yaw stability. The horizontal stabilizer has 10 degrees of dihedral to clear the propeller wake. To meet FAR 23 certification requirements, dual actuators are installed on the trim tabs found on the rudder and left elevator.

The door is 47.5 by 26.5 inches, easily negotiated with Rocket Engineering's new handles. Inside, there are no bad seats in a Duke;

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Photo by LeRoy Cook

The Duke wing featured extended-chord flaps and a generous aileron gap.

Photo by LeRoy Cook

The Duke empennage sets it apart from any other Beechcraft; the strakes under the tailcone are an aftermarket add-on to enhance damp yaw response.

spacious club seating in the cabin is supplemented by a foldaway worktable on the right sidewall, with cup holders, reading lights, lighters and ash trays at each seat. The plug-type emergency exit includes the window aft of the copilot's position.

Darwin Conrad had nearly 100 hours in the Royal Turbine at the time of our visit; the STC work was largely done and certification was expected by the fall of 2005. Because the stowable rudder pedals on the right side were not equipped with brakes, Conrad took the left seat, which is conveniently configured for single-pilot operation. The extra eight inches of width over the Baron interior is put to good use in the sumptuous six-place cabin. Most electrical switches are on and forward of the left armrest area, with circuit breakers on the right. Earning the gratitude of bifocal wearers, nothing is overhead but ventilation outlets and reading lights.

The six-lever power quadrant is retained, but the former mixture controls are now condition levers used as fuel cocks. The propeller knobs include negative torque lights, so if an engine fails, the pilot has merely to pull the illuminated knob all the way back.

Engine operation is entirely new, of course. Instead of magneto/starter switches, there's now a pair of starter/generator switches, engaged after fuel and ignition go on. The left engine's Ng spooled up in typical effortless PT6A free-turbine fashion; at 15 percent fuel was introduced and acceleration proceeded with ITT rising no higher than 700 degrees, well under the 900-degree operating limit, let alone the 1,090-degree transient redline. The Hartzell propeller began working itself out of feather and with the charge rate declining after the starter became a generator, the right engine was brought to life. The welcome breath of A/C wafted through the cabin while the avionics aligned.

Avionics will no doubt be commensurate with the performance upgrade, although no RVSM certification is planned, capping cruise at FL280. The demo airplane had

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The assist handles developed by Rocket Engineering for the Duke door.

Boarding the Duke cabin is a two-step affair onto the wingwalk, using the Rocket Engineering-designed handles.

Photos by LeRoy Cook

the now-normal Garmin GMA 340 audio panel, GNS 530 and GNS 430 comm/navigators and GTX 327 transponder, plus a Garmin AT MX-20 MFD, Bendix RDR radar and Bendix/King KR 87 ADF, KN 63 DME and KFC 200 autopilot with yaw damper, along with Shadin fuel flow/air-data and Argus moving map boxes. All up empty weight was reported as 4,480 pounds, so with five persons on board and half fuel we were departing at roughly 6,200 pounds. Full tanks would have required voting half a person off the island.

Taxiing the Royal Turbine requires little brake use because the throttles can be lifted over the Beta-mode gate to gain direct propeller pitch control for modulating taxi speed. Turboprop simplicity greatly eases the converted-Duke pilot's chores. There are no cowl flaps (manual oil cooler shutters are provided for extreme conditions), no warm-up wait, and no worries about balky wastegate controllers. Instead, there are just daily governor checks and pretakeoff feather tests; the Pratts run dependably and smoothly as long as the fuel keeps flowing.

Photo by LeRoy Cook

Ignition and boost pumps came on for takeoff and Conrad stood the power levers up until the prop governors had full rpm control, then fed in the 1100 horsepower for a most satisfying rush of acceleration toward the 95-knot rotation.

Flat rating means the Royal Turbine will seldom be temperature limited; the climb torque reading was 1,330 foot pounds, although the engines, Conrad said, were good for 1,600. At 150 knots the VSI was pegged out beyond 4,000 fpm, and with power at 1,315 ft/lb, ITT was a cool 770 degrees. Even with propeller rpm maxed out at 2,170, the no-headsets noise level was conversational. Conrad says the installed prop sychrophasers have proved unnecessary and won't be on the standard conversions.

Cruise-climb rate out of 12,500 feet was 2,500 fpm, with more available by simply slowing down. We leveled off at 17,500 feet to remain VFR and with propeller rpm reduced to 2,050 and torque at roughly 1,280 ft/lb, we were soon indicating 193 knots, a TAS of 257 knots, which is Mach .4! The airplane's 300-knot-plus top speed comes in the upper twenties.

Fuel flow was approximately 90 gph at 17,500, where our fully-fueled range would have been about 750 nautical miles, but climbing to FL270 would have reduced the flow to 68 gph and extended the range to 1,000 miles, and going to long-range power would have brought the range up to 1,200 miles.

Changing from turbocharged pistons to turboprop power means learning to get as high as possible as quickly as possible; fuel burn can drop to 48 gph at altitude, while maintaining a cruise speed of 250 knots or more.

The optional PT6A-21 engines have a 1,150 ft/lb torque limit, so Conrad says they are actually operating in long-range mode all the time.

However, for Part 135 operators seeking maximum economy with still-spectacular performance, the -21s are a valid option. Asked about engine-out capability, Conrad brought the right engine to idle and we slowed to 170 knots IAS on the power of the remaining engine, a TAS of 220 knots on one engine! Vmc is 91 knots with the Royal Turbine modification.

Coming back down is much simpler than with the piston-powered Duke. The PT6A-35's don't mind being chopped back to flight idle and the nose can be pointed down at the 208-knot redline which, in accordance with certification rules, was formerly the beginning of the Duke's yellow arc.

We were looking at a 3,000-fpm descent rate while leaning into the propeller discs. With typical Beechcraft toughness, the landing gear and approach flaps can be lowered at 174 knots or less, requiring little trim change. The full 30-degrees of flaps are allowed below 141 knots. We swung onto a five-mile final at 120 knots, slowed to 110 with the addition of full flaps and crossed the fence at 90 as the stall warner began to chirp. Touchdown came at 85 knots and pulling the power levers back into reverse until reaching 40 knots had us turning off in about 2,000 feet of runway.

The Royal Turbine conversion solves a host of problems for Duke owners and offers a unique airplane that fits neatly between turboprop singles and King Air/Commander ownership. The Duke has always been just big enough for a personal airplane, yet with full amenities for high-altitude cruising. By going to the PT6A engines, with 200 million hours of experience behind them, the engine management chores are reduced and there's performance to satisfy the Walter Mitty in anyone.

As Darwin Conrad says, "When you take a flight in it, it'll probably be a very costly ride." T&T