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B/CA Analysis:® Beech Duke

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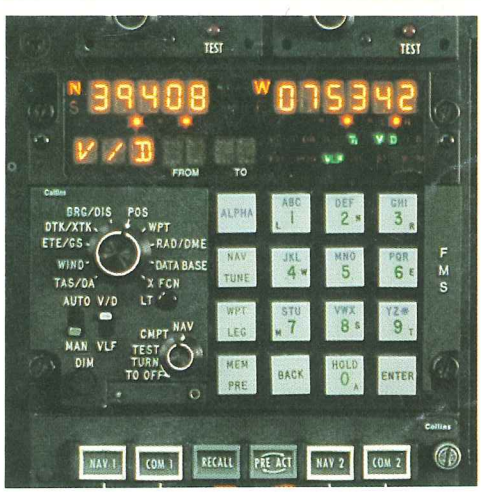

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Business and commercial Aviation November 1981

B/CA Analysis®: Beech B60 Duke

by John W. Olcott and Richard N. Aarons

Aircraft selection involves the analysis and comparison of many quantitative elements, such as performance and operating costs. But for many buyers—particularly owner-pilots—selecting an airplane also involves emotion. An aircraft is special: something with personality and appeal.

The way a pilot feels about an aircraft cannot be underestimated in the selection process.

Beech Aircraft Corporation relies heavily on personality and appeal to sell the Duke, its six-place, pressurized and highly personalized turbocharged twin. Since the 6,775-pound aircraft was introduced in late 1968, it has been identified with entrepreneurs who have "made it" by virtue of their own style and hard work. Beech attributes the affinity between successful individuals and the Duke to something about the aircraft that seems to make a statement about its owner.

Precisely what that statement is cannot be identified easily. Perhaps the rakish, low-slung nose and a ground stance that seems purposeful give the Duke an appearance of determination, as if to say that the person who flys this aircraft knows exactly what he wants and has the muscle to get it.

Possibly it's the half-million dollar price tag that suggests only a special type of owner-pilot can be in the Duke's league. Whatever the aircraft's statement may be, it sounds very appealing to a particular breed of buyer.

The profile of the Duke owner is rather sharply defined for a design that has sold about 580 units. The aircraft usually is purchased by a company that is owned by an individual who will do most of the piloting himself.

Rarely is the Duke sold to a large firm that employs salaried pilots and has a large flight department. The owner-pilot who chooses a Duke usually has been involved deeply in the growth of his company, and he identifies with its success. He typically drives an expensive car that attracts attention, such as Mercedes 450SL or a Ferrari as opposed to a Cadillac. Only last year did the owner of a Chrysler join the ranks of Duke owners, but he also fit the mold: His Chrysler was a 1956 model and, therefore, was bordering on classic status.

When asked, the buyer of a Duke often will admit to a longing to own this particular Beech model that began when he first started flying. For some, apparently, the aircraft has taken on the role of being the ultimate owner-flown recip. Generally the Duke prospect is flying a Beechcraft, typically a Baron or possibly a Bonanza. While the pressurized Baron 58P might appear to be the logical step-up aircraft, for the man who has image on his mind the choice is clear—the Duke definitely exudes a distinctive style.

Behind the Facade

There is more to a Duke than just distinctive styling and a macho image, however. The aircraft is nicely configured for the owner-pilot. It handles well, and its flight deck is thoughtfully arranged to ease the workload associated with single-pilot operations.

Good handling qualities are a characteristic of the Duke, both at normal cruise and at slow approach speeds. In pitch, with the center of gravity at a typical position (two pilots, and one passenger in the aftmost seat), the aircraft's long-period or phugoid mode is nicely damped. This characteristic causes the airspeed to return nearly to the original, trimmed value within about two oscillations of the nose above and below its level-flight position when the aircraft has been displaced from its trim position (either by a gust or by pilot action) and left to return to its original airspeed without further control input.

Such good damping makes the aircraft fairly easy to hand fly at a given airspeed during climb and approach, and it aids in altitude-holding tasks. Beech engineers apparently have found a nice blend between just enough downspring force in the Duke's longitudinal control system to

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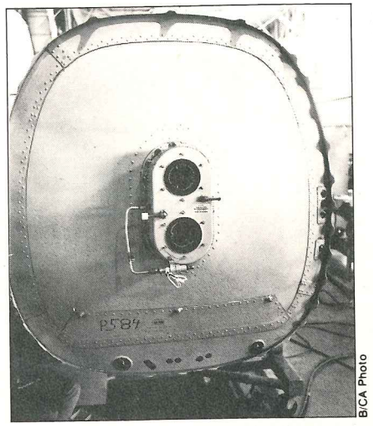
With stylish looks and good handling qualities, the Duke continues to appeal to a special type of owner-pilot.



B/CA Photo

These outflow valves are located on the rear of the Duke's aft pressure bulkhead to minimize air noise. Maximum differential is 4.6 psi.

provide good static stability and yet not so strong a downspring that the phugoid becomes wildly oscillatory.

The Duke's short-period longitudinal mode, which is the aircraft's initial pitch response to a control input or gust, is quick and very heavily damped, with no pronounced tendency to overshoot its final pitch attitude.

These short-period characteristics enable the Duke to respond smartly and precisely in pitch when its pilot makes a control input.

In its lateral/directional mode, the Duke is not particularly well damped. It took over five yaw cycles (back and forth) of the nose before the aircraft's Dutch roll subsided after the rudder was kicked. But the Duke's autopilot does have a yaw damper, which suppresses any tendency the basic aircraft may have toward Dutch roll oscillations.

Adverse yaw from using the ailerons while applying no coordinated rudder pressure is minimal in cruise. If a wing is deflected 10 degrees in bank and then left unattended, the aircraft is very slow to bank further into a steep spiral. Thus the aircraft is fairly benign when being hand-flown on instruments. The Duke maintains its heading nicely and doesn't have a pronounced tendency to fall off on one wing.

Pitch changes with gear and flap deflection are minimal, despite the Duke's relatively high gear and flap operating speeds. The gear and approach flaps can be lowered at 174 knots CAS, and full flaps can be applied below a speed of 140 knots.

In the landing flare the Duke's downspring is somewhat noticeable, for a healthy pull is needed to rotate the nose and effect a nice landing. But using nose-up trim, which is easy to apply with the Duke's electric pitch-trim, facilitates glass-smooth landings. And there is nothing like a good landing to make an owner-pilot feel as if he has found the right aircraft for his flying.

Competitive Performance

The Duke's performance is highly competitive with other pressurized twins that are typically owner-flown. The aircraft's maximum payload of 1,638 pounds and useful load of 2,019 pounds are the highest of the five aircraft included in the Comparison Profile shown on the opposite page, and the Duke's runway requirements rank it second among its peers. At 55-percent power, the Duke is the fastest of the aircraft selected for B/CA's comparison, but it yields to the Pressurized Baron at 65-percent cruise, according to published AFM data.

In the areas of all-engine climb gradient, passenger-miles per pound of fuel consumed, fuel flow and specific range, the Duke takes a back seat to other owner-flown pressurized twins, however. As can be seen from reviewing the Comparison Profile, the aircraft's numbers in these areas are noticeably below average.

Duke operators state that the aircraft matches its published performance figures quite nicely, but that recommended piloting techniques should be followed, particularly if the published takeoff ground roll is to be obtained at maximum gross weight.

Beech calls for lifting off at 94 knots, nine knots above VMC but 16 knots below blue line and five knots below best single engine angle of climb speed. If the pilot chooses to remain on the runway until reaching a speed higher than 94 knots, possibly waiting until the aircraft accelerates above its 99-knot VXSE, the Duke appears to consume considerable real estate before becoming airborne, although the distance to reach a safe altitude in the event of an engine failure probably is not affected significantly.

Because of the aircraft's relatively high power loading (each horsepower from the Duke's two turbocharged 380-hp Lycoming TIO-541-E1C engines is responsible for 8.9 pounds) and high wing loading (there's one square foot of wing area for every 31.8 pounds of aircraft), the Beech Duke will respond with noticeable yawing moment and loss of performance if one of its engines fails as the pilot rotates at 94 knots.

Although Beech has demonstrated that a pilot with moderate skill can correct for the yaw, retract the gear, identify and feather the dead engine, accelerate to VXSE and achieve book performance without undue problems, some owner-pilots choose to give themselves a greater margin between VMC and their liftoff speed. This explains the tendency for some Duke pilots to consume more run-

No aircraft can be all things to all people; each must be a compromise or tradeoff between the options that are available to the designer. But if it were possible to combine the capabilities of all the aircraft within a given class, the resultant vehicle might represent the closest thing to a no-compromise aircraft. At least the hypothetical aircraft would incorporate the average capabilities for its particular performance class.

In its Comparison Profile, B/CA constructs the hypothetical "no-compromise" aircraft for a particular class of vehicles by averaging the characteristics of all relevant aircraft within that class. By comparing a specific airplane with the average, we can see where and to what degree compromises were made. Such an analysis is important in deciding whether the airplane satisfies a particular set of operational needs.

We have constructed the average line on a purely objective basis from hard data taken from flight manuals or from engineering projections.

The Profile line indicates the percentage by which each parameter exceeds or falls short of the average for the category.

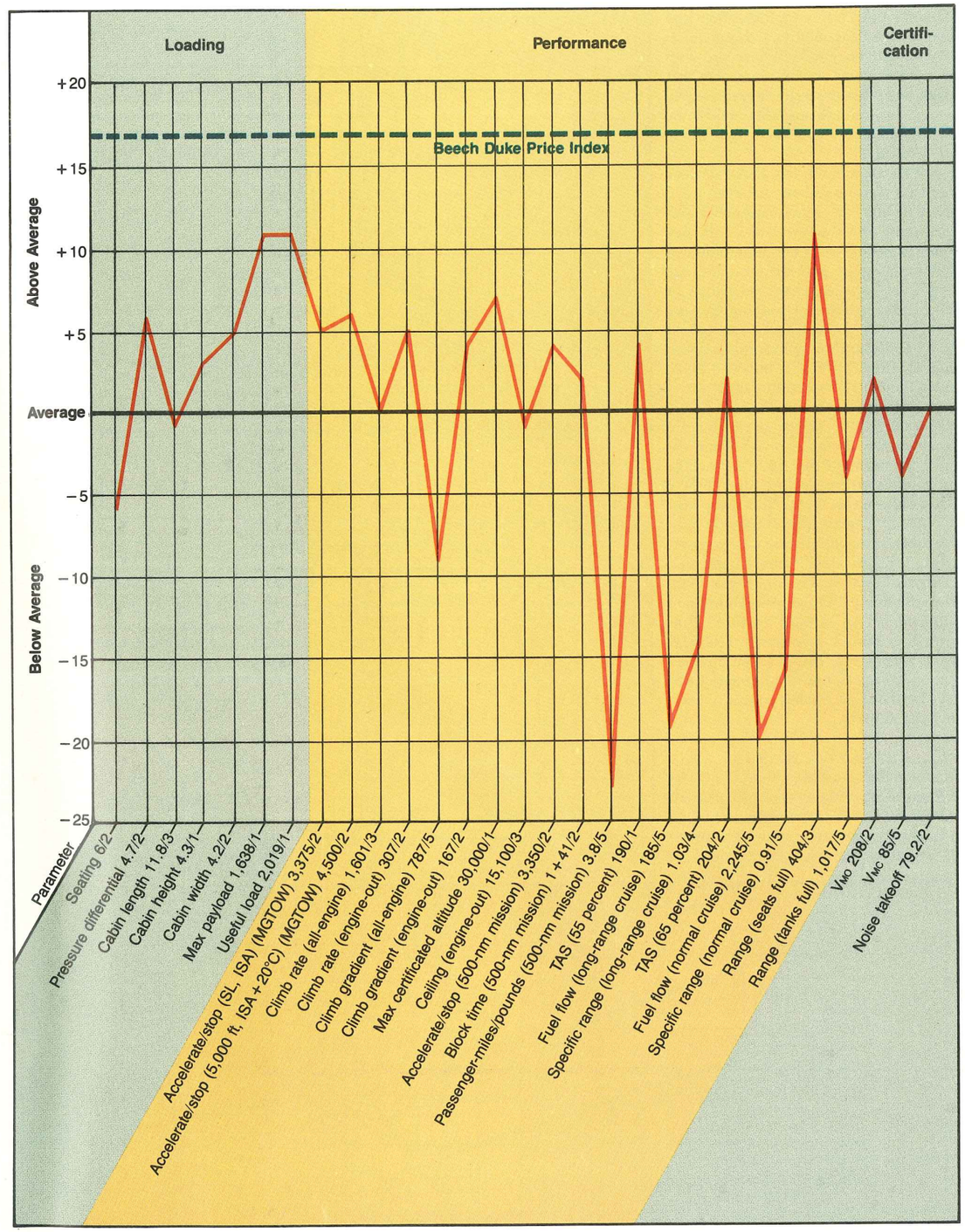
The dashed Price Index line indicates how much of a particular parameter the purchaser gets for his dollar relative to the average price for the feature or performance within the category. Where the Profile extends above the dashed line, the airplane offers more in that parameter per dollar of acquisition cost than the average for the category. If the Profile falls below the Price Index, the airplane offers less value per dollar in that parameter.

For this Profile, the category comprises the Beech Duke and those airplanes most likely to be considered along with the Duke — the Beech Baron 58P, the Cessna 414, the Cessna 340A and the Piper Sequoya 602P.

The actual specifications and performance numbers for the Duke are included along the bottom of the Profile so that readers can easily make comparisons. The number for the Duke is followed by a slash and the aircraft's standing in the particular category relative to the other four.

It must be understood that this Profile was not created as a tool for directly comparing the subject airplane with any other single airplane in the category. This is possible only if a Profile for the other aircraft based on identical criteria is available. This Profile compares the subject airplane with the average and thus establishes areas in which it is strong relative to the competition or in which it is compromised. Therefore, the Profile must be studied with the prospect's own needs and preferences in mind.

B/CA Comparison Profile
% Relative to Average



B/CA Art Dept.

way distance than the 2,100 feet that Beech says a Duke at maximum gross weight will roll before becoming airborne on a standard day at sea level.

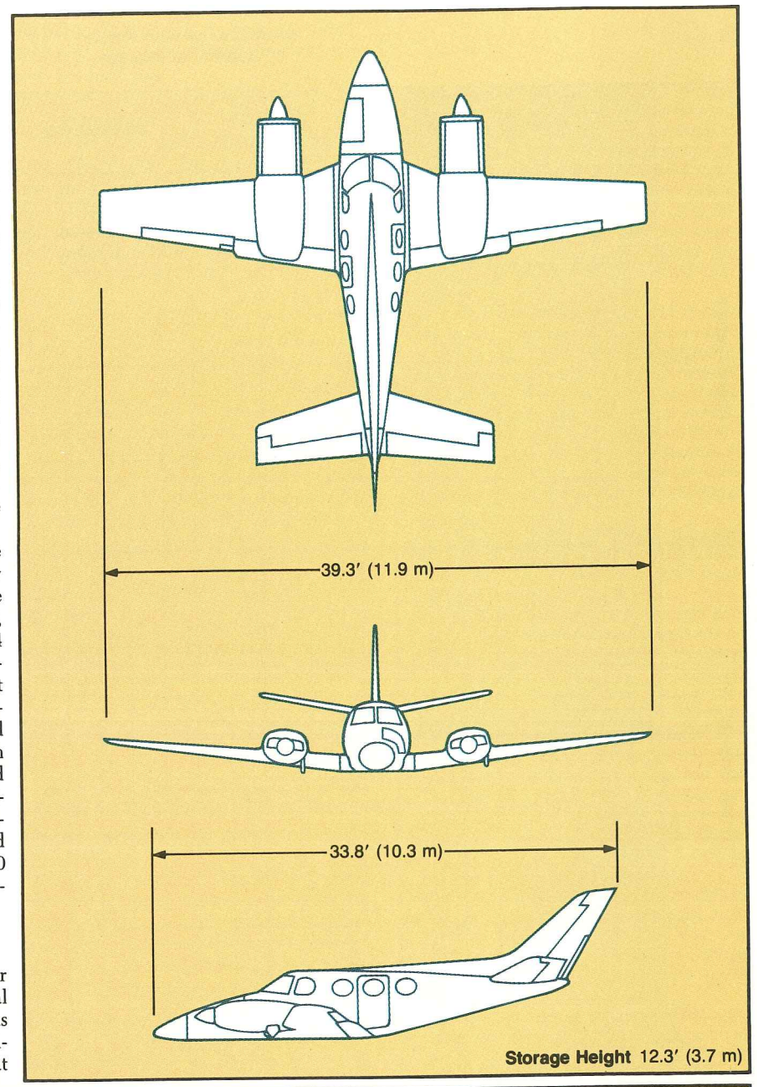
Despite the Duke's sophistication and performance capabilities, owner-pilots enjoy a relatively good safety record with the aircraft. One reason may be that Dukes, like other pressurized twins, rarely are used for training, and they tend to be flown by devotees who take their flying very seriously.

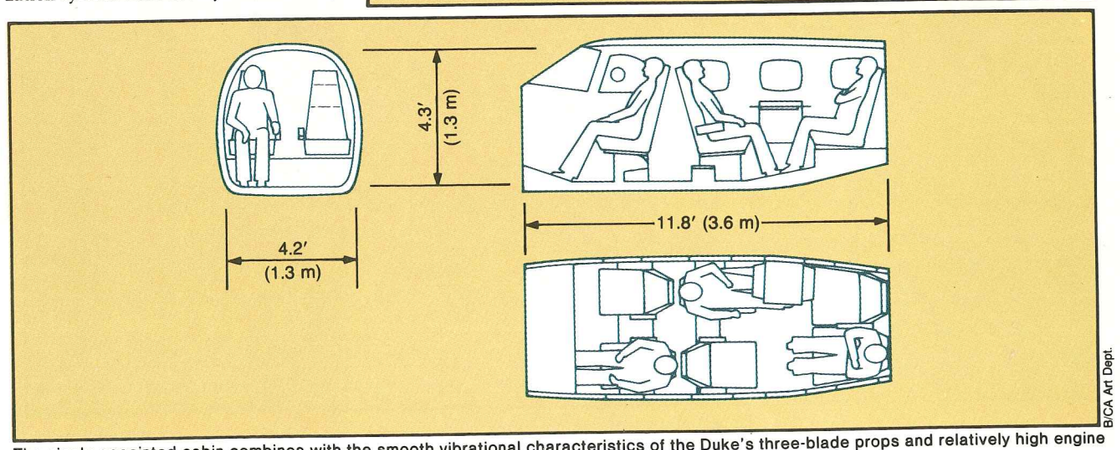
Another reason for the Duke's safety record (10 fatal accidents between 1970 and 1979) may be good transition training. Beech offers a two-and-a-half day ground school plus about four hours of flight training as part of the purchase price. Pilots who acquire used Dukes or wish to take additional training for any reason also can do so at Beech's school for $350. The program is sufficiently personalized that the differences between Duke models can be addressed in detail.

Most of the significant changes in the Duke occurred during the aircraft's early history as the design evolved from the Model 60, through the A60 to the B60, which appeared for the first time in 1974 with serial number P-247 and is the current model. Engine improvements, most noticeably in the installation of a more efficient, stainless steel turbocharger and redesigned exhaust system, began with serial number P-144 (an A60 Duke) and continued as the aircraft matured. Initially, the Duke's Lycoming TIO-541-E1A4 powerplants had a recommended TBO of 800 hours, but that figure is 1,600 hours for the -E1C models currently powering the aircraft.

Consistency the Key

Despite the doubling of the TBO for the Duke's powerplants and the continual evolution of the aircraft's systems, such as replacing the aircraft's original pressurization system with one by AiResearch (at





The nicely appointed cabin combines with the smooth vibrational characteristics of the Duke's three-blade props and relatively high engine revs to give the recip powered aircraft a comfortable interior environment, somewhat akin to that of a turboprop.

Beech Duke

These graphs are designed to be used together to determine how the Duke would fit into your operation.

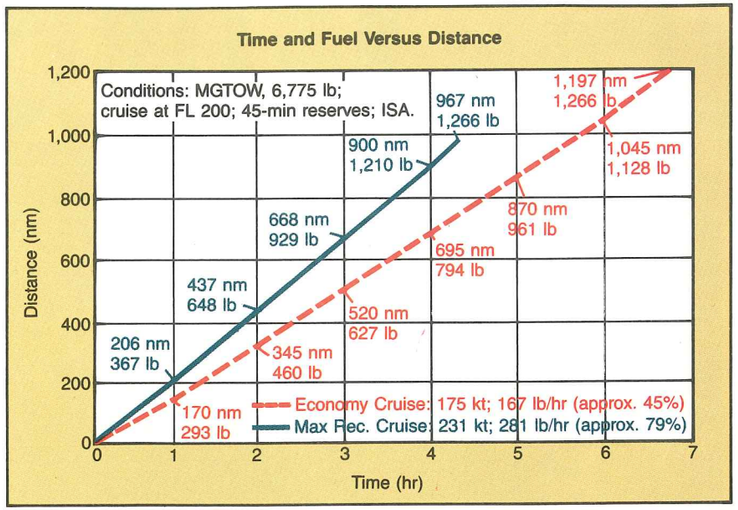
Time and Fuel Versus Distance — This graph can be read from either axis to determine how far you will go in a specified time or how much time is required to travel a desired distance. For example, if you expect your typical mission to be about 900 nm, you can see that the Duke will take about four hours to complete such a trip and will use about 1,210 pounds of fuel at max cruise.

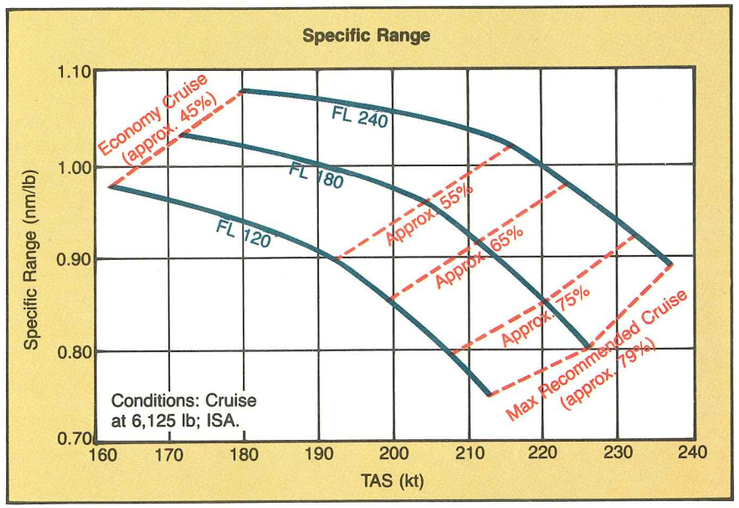
Specific Range — The specific range of an aircraft, a measurement of its fuel efficiency, is a ratio of nautical miles flown per pound of fuel burned. Relatively large specific range numbers indicate high mileage yield on the fuel investment; small specific range numbers suggest less efficient fuel burns.

This graph shows specific range values at three altitudes for the Duke. For example, at max-cruise power, FL 240, the Duke will provide a specific range of 0.89 nm/lb while truing out at 236 knots. If you reduce power to economy cruise, your speed will drop to about 180 KTAS but specific range will improve to 1.08 nm/lb.

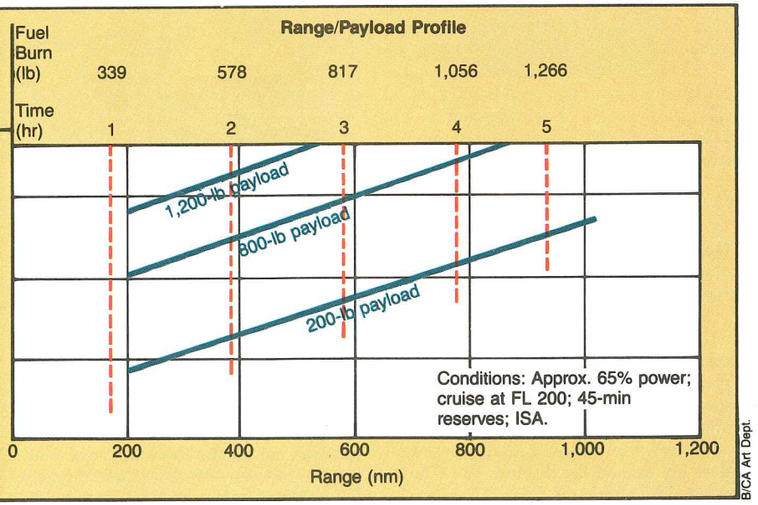
Range/Payload Profile — This graph enables you to simulate trips under a variety of payload and airport restrictions. For example, if you want to simulate a 600-nm trip with an 800-pound payload, you can see that the Duke will require just over three hours to complete the trip and will require about 3,300 feet accelerate/stop distance on a standard day. You also can see that a maximum, no-wind trip with a 1,200-pound payload would be about 525 nm.

Numbers are approximate. Not for flight planning purposes.





Accelerate/Stop (ft)		Gross Takeoff Weight (lb)
SL ISA	5,000 ft ISA + 20°C	
3,375	4,500	6,775
3,300	4,200	6,500
3,100	3,900	6,000
2,800	3,600	5,500
2,700	3,400	5,300



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The Beech Duke features an uncluttered instrument panel that is nicely configured for single-pilot operations. This Beech demonstrator is equipped with King Radio's latest panel-mounted package, including its new KWX 56 stabilized radar.

serial number 308), the key to operating a Duke successfully is consistency. Rough use of the engines, without careful attention to heat management, can lead to turbocharger problems and overhauls prior to the recommended TBO. ("Heat Management is the Key to Turbocharger Operation," B/CA, August 1980, page 54).

But if a pilot carefully plans his descents (even if that planning means an occasional prodding of ATC for clearances to lower levels) and if he uses the Duke's 174-knot gear extension and approach flaps speed to provide sufficient drag for descending with near-cruise power settings, the turbocharged Lycomings will stay at comfortable operating temperatures, thereby avoiding the damaging effects of shock-cooling. With overhauls of each Lycoming TIO-541 costing close to $16,000, each hour that the powerplant falls short of its TBO costs the operator about $10.

Pilots must beware, however, that the Duke's maneuvering speed is 160 knots at full gross weight, thus a descent at 174 knots should be accomplished only in smooth air.

One key to consistent operations in a Duke (or any aircraft) is careful attention to flight planning. The aircraft's Pilot's Operating Manual presents convenient charts for determining range profiles and fuel requirements.

The charts show quite vividly the advantages of flying high, where the aircraft performs at its best. Generally speaking, the Duke achieves its maximum speed for typical cruise-power settings at about FL 260, but as a rule of thumb operators often select a flight level that does not exceed the distance to be flown divided by 10 (that is, for a 150-mile trip, an altitude of 15,000 feet).

The performance charts on page 53 present a capsule picture of the Duke's performance capabilities. Although not to be used for flight planning purposes, these three performance graphs do provide a way of estimating what the Duke will do in terms of range and payload during particular missions.

With its 4.7-psi pressurization plus the ability to depart at full gross weight and reach 25,000 feet in 28 minutes (although going from 25,000 feet to the Duke's certificated ceiling of 30,000 feet requires an additional 12 minutes), flying in the mid-200 flight levels is quite practical for the Duke.

At FL 250, for example, the aircraft's cabin level is 10,000 feet. Setting the cabin-altitude controller at the planned cruising altitude (plus 500 feet to assure that the outflow valve does not ride against its limit setting), the Duke's pressurization system will regulate the rate, up to 500 fpm, at which the cabin's altitude will change as the aircraft approaches its assigned flight level. If the cabin differential pressure reaches its maximum value of 4.7 psi and the aircraft is still climbing, the cabin altitude will climb with the Duke's altitude.

With the ability to operate near the aircraft's optimum altitude routinely, achieving consistency comes easily in a Duke. And with consistent operations come a degree of predictability and professionalism that adds safety to owner-flown aircraft.

Its Own Appeal

Because of its style, comfortable handling qualities and performance, the Duke can be particularly appealing to the owner-operator.

But the aircraft's pleasures are only for those few individuals who are willing and able to accept the Duke's half-million dollar (plus) price tag and operating costs that include rather thirsty engine fuel flows.

If owning something distinctive—and with Duke production running now at about 30 units per year, something that might even be classified as a limited edition—is your style, the Beech Duke may be the answer. □

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Although not strictly classified as a cabin class aircraft, the Duke's club seating, sturdy foldout table and center aisle give the owner pilot a special cabin-class feeling when he flys the six-place Beech. Most Dukes are owner-flown.