AIRCRAFT PERFORMANCE REPORT

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GlaStar SH-4

BY BRIEN SEELEY AND THE CAFE BOARD

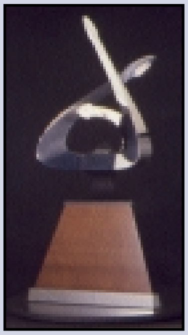
Early last year Tom Poberezny suggested several kit-built planes as candidates for testing by the CAFE Foundation based on their popularity. High on his list was the very popular Stoddard-Hamilton GlaStar. The folks at S-H thought this was a great idea, but couldn't free up their prototype for some time due to its strong demand for demo flights across the country. Finally a time was arranged when the plane would be available for three weeks in December, 1997.

Riding high on the success of the Glasair series, Stoddard-Hamilton sought to appeal to a broader market with its next kit plane. The high-wing GlaStar combines a wide range of features into a versatile aircraft that is fun to fly, easy to reconfigure, and pleasing to the eye. Its design was intended to fit in a niche between the Kitfox/RANS Courier and the RV series of aircraft.

The GlaStar design includes a provision for folding its wings. Its tricycle gear can be converted to conventional landing gear or converted to floats. The eleven foot span horizontal tail is also removable making storage or trailering another option. FAR Part 23 certification of the design is being considered at S-H. as are a variety of fast-build options.

HISTORY

The origin of the design derived many years ago from the ideas of Tom Hamilton and a friend, whose plans were subsequently undertaken by S-H. The S-H plan for an all-composite version of the aircraft ran into weight and cost problems. A group of six including Tom Hamilton, Ted and Tom Setzer, Bud Nelson and others resumed the project under a company called Arlington Air-



TRIAVIATHON TROPHY

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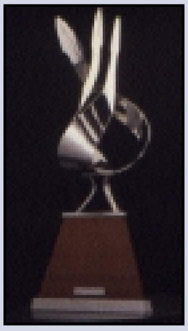

The CAFE flight data is displayed digitally by LCD boxes taped atop the glare shield.

craft Development. The prototype, N824G, was largely built by this group in a small building on the Arlington Airport, with Ted Setzer doing most of the hands-on construction.

After much consideration they reasoned that a welded steel-tube cage cabin structure to which everything was bolted would make the plane more efficient and easier to build. Hence, the engine, seats, tail cone, wings, flap handle, control sticks, rudder pedals, landing gear, pulleys, seat belts, etc. all bolt directly to this steel tube roll cage.

The pre-formed composite outer shell allows for the sweeping compound curves that give the GlaStar it's distinctive profile. The wings and tail surfaces do not have any compound curves and readily avail themselves to being made out of aluminum. These parts of the kit come machined, pre-punched, pre-stamped, and pre-drilled with pilot holes to greatly accelerate assembly. Wing skins are pre-drilled along the rib locations. The spar and each rib are match-drilled to facilitate Cleco pre-assembly.

The GlaStar was first displayed as a nearly-completed prototype at Oshkosh in 1994. Even before the first flight took place in November 1994, 100 builders had placed orders for the kit. Complete kits were being shipped by the fall of 1995 with the first customer-built GlaStar flying after only three months. There are over 36 flying examples as of April 1998 and many more are expected at Oshkosh this summer.

Originally powered by a 125 HP Continental IO-240 engine, the GlaStar met the designers' goals. In 1996, after about 400 flight hours, the prototype was fitted with a 160 HP Lycoming O-320 and constant-speed propeller. The rationale for the change in engine was the ready availability of used, reliable O-320 engines. The difference in price of a new IO-240 and a used O-320 is negligible and this engine increased its performance in all categories, from short-field takeoffs and landings to cruise speed and climb out rates. Some kits are now being outfitted with a 180 HP engine which adds just seventeen pounds to the empty weight but greatly increases the 'fun envelope.' Most kit builders who are going to mount floats or plan IFR capability are finding the twenty extra horsepower desirable. Sensenich is developing a new fixed pitch metal prop for 180 hp Lycoming users.

During 1997 the GlaStar prototype was fitted with floats and tested with both Aerocet 2200 straight floats and Wipline 2100 amphibs. The Aerocet is the float of choice for the aircraft. The floats entailed an increase in the GlaStar's gross weight from 1960 to 2100 pounds. According to S-H literature, changing from gear to floats takes about a day, while converting from tricycle to conventional gear takes about half a day .

N824G was flown to the CAFE Foundation's test facility in Santa Rosa by CAFE Secretary Cris Hawkins. This prepared Cris to assume the duties of flight engineer on the CAFE test flights. Cris, who is 6'3" tall, reported that he had ample room in the GlaStar cabin.

ACKNOWLEDGEMENTS

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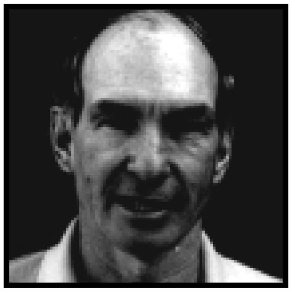


SUBJECTIVE EVALUATION
GlaStar SH-4, N824G

by

Otis Holt and C.J. Stephens

INTRODUCTION

Compared with most CAFE APR's, flight testing the GlaStar was a fairly relaxed project. Typically, APR subjects arrive on Thursday or Friday afternoon, and with good luck we might get in one subjective evaluation flight before the CAFE team descends upon the aircraft to install all of the sensors and equipment used for measured performance testing. The balance of the weekend is filled by an intense series of flights for data collection, subjective evaluation, and air-to-air photos, with the aircraft departing sometime on Sunday. Fortunately N824G, the normally very busy GlaStar prototype, was made available to us for a period of three full weeks in December. Between us, CAFE Chief Test Pilot C.J. Stephens and I logged more than twenty hours of flight time during that period. In flight, the GlaStar has an interesting range of capabilities and behavior, so we were grateful to have some extra time for exploration.

FIRST IMPRESSIONS

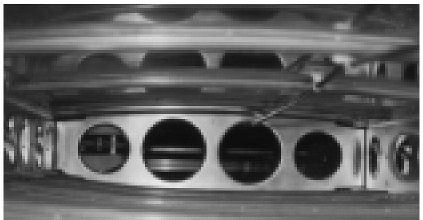
Our first impressions of N824G actually date back three years, to a brief visit the GlaStar paid to the CAFE Test Facility in March, 1995. The prototype was still in active development at that time, making it a bit premature for a CAFE APR; but each of us flew the aircraft briefly, and were favorably impressed. At that time she was powered by a new 125 horsepower Continental turning a fixed-pitch prop, and tipped the scales at about 1150 pounds empty. This time, N824G came to us a very different creature, with 160 horsepower, a constant speed prop, and a truly "splashy" paint job. The empty weight had increased to 1274 pounds.

The prototype had also been modified in other significant ways since the previous visit. She now sported the very powerful Fowler flaps, carried on a massive set of tracks, that come standard with the production kit. Perhaps as significant, the wings' leading edge was fitted with four large vortex generators, one at each wing root and one ahead of each aileron's mid-span. Also, a large plate-like strake was fitted at the root of the horizontal stabilizer on each side of the fuselage. We were assured by the factory that, although the wing differed structurally from the kit version, N824G was aerodynamically identical.

N824G had by now logged more than 1,000 flight hours, comprised almost entirely of hundreds of short demo hops with as many prospective customers at the controls. Every switch, knob, and control surface had seen countless cycles at the hands and feet of the curious, and the wing-folding feature had been demonstrated innumerable times. It is doubtful that any customer-built GlaStar will see this much use and abuse in its entire lifetime, but N824G appeared to have handled it well.

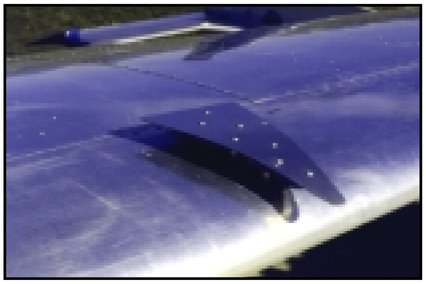
THE DESIGN

The GlaStar airframe is comprised of three major elements. Inside is the rugged, TIG-welded steel-tube cage that carries most structural loads and provides ready attach points for all other major components, including all configurations of landing gear. Wrapped around this is a two-piece composite fuselage shell incorporating the vertical stabilizer. Finally, there are the all-metal wing and horizontal tail. The long-span, constant-chord metal wing represents a major departure for Stoddard-Hamilton but the airfoil section remains identical to the

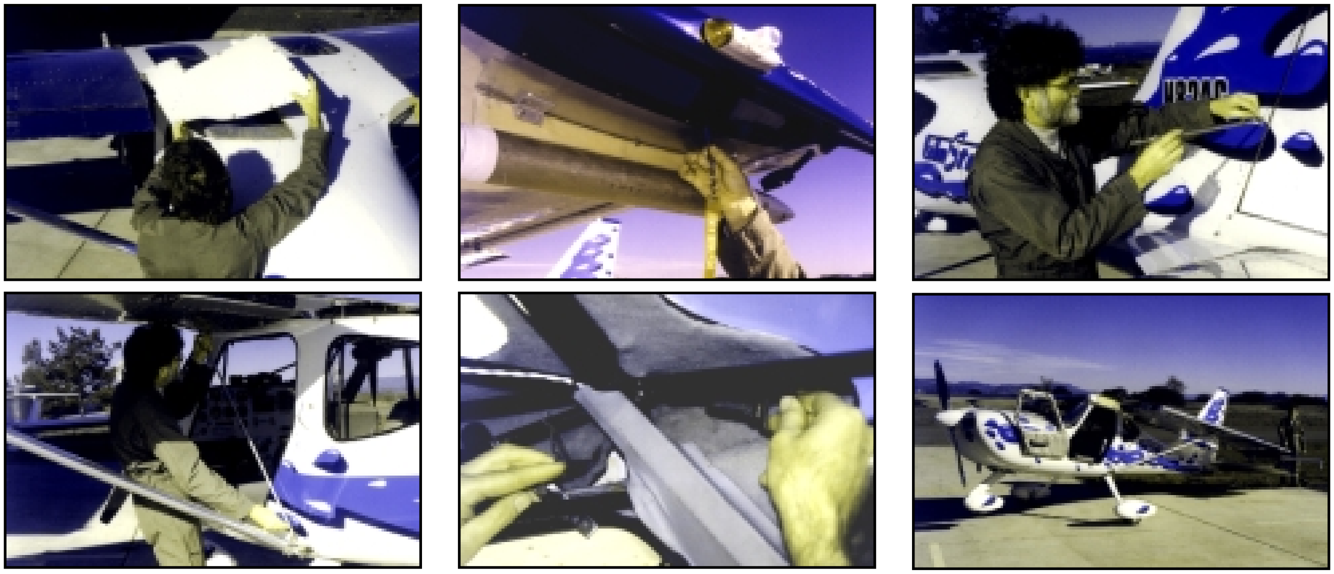


Internal wing structure shows the use of hat-section stiffeners.

Larry Ford photos



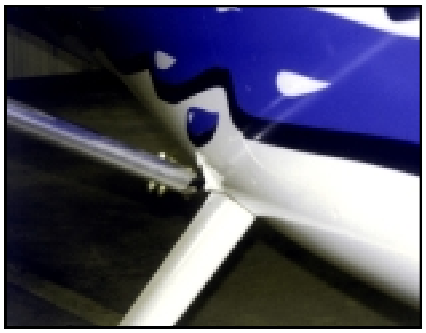
Glasair's. The designers are to be commended for their flexibility and willingness to seek the most appropriate solutions to each of the GlaStar's elements, even though some involved major changes in methods and tooling for the company.



CAFE photographer Larry Ford documents Otis Holt's procedure to fold the GlaStar's wing: Clockwise from the top left are the removal of the fuselage roof panel and the placement of the wingtip fuel tank drain plug, the attaching of the tail and wing strut fixation rods, the removal of the wing spar pin and the final position of the wingfold.

It can be argued that most successful aircraft designs are optimized to excel at some narrowly defined mission. By contrast, the GlaStar's success and appeal rest largely upon its diverse mission and broad utility. The kit features folding wings and supports numerous landing gear, power plant, and equipment options. At the same time, it is designed to be easy to build and, once built, easily converted from one configuration to another. This diversity inevitably carries with it a significant weight penalty, but it also contributes to the GlaStar's affordability by greatly broadening its market.

The Glastar's spacious baggage compartment is an important element in the design's utility. There is a 180 pound capacity of the forward portion



and additional 70 pound capacity of the aft portion of the compartment. With a little imagination, an aft-facing third seat could probably be devised that would accommodate an averaged-sized adult passenger without violating c.g. loading limitations. Certainly, two persons travelling cross-country will be able to bring along all they need to support backpacking or other outdoor activities along the way. The large access door allows a person to duck the upper part of their body into the baggage area and reach all parts of it.

Our tendency to look askance at complex extras gave way to appreciation for the GlaStar's ingenious wing-fold feature. We found it very convenient to be able to fold one wing repeatedly during its stay in the CAFE hangar. With a little practice, I was able to fold a wing in less than three minutes working alone and using a screwdriver as my only tool. Reversing the process took about a minute longer. The only structural element removed in the folding of a wing is a 1/2" diameter steel pin at each main spar root. Fortunately, both pins are clearly visible to the pilot from inside the cabin, making this important pre-takeoff checklist item easy to verify. As C.J. put it, it might actually be possible to fly "a short distance" with the pins removed.

When folded, two small snap-on rods position each wing so securely that you can use the wing tip as a grip to easily move the GlaStar about. The aircraft rests lightly on the nose wheel with one wing folded, but sits on its tail when you fold both. Fuel in the wing tanks can be at any level, but it is necessary to plug the wing-tip fuel vents to prevent fuel from flowing out. The possibility of failure to unplug the fuel vents before flight argues that some type of automatic check valve system should be devised to make this step unnecessary. We also observed that fuel can stream out of the vents during taxiing turns and uncoordinated flight with full tanks, and check valves would remedy this problem as well.

As is usually the case with added amenities, the wing fold feature does extract a price. The lift-strut lower attachment must be located in the same vertical axis as the rear spar, so it ends up in a less than ideal region where the fuselage cross section is contracting abruptly. This aft location also dictates a longer strut, and the resulting oblique structure is less efficient and therefore heavier. Although there is no need to disconnect the flap or aileron controls during wing folding operations, the control cables do go slack, so their positions are maintained by guide blocks that would not otherwise be necessary. These may contribute to the excessive aileron break-out force and control friction that we observed in flight.

Ferry pilot Cris Hawkins commented upon these traits after delivering the aircraft, stating that he tended to make his heading changes with rudder rather than with aileron.

ERGONOMICS

The lift-strut's aft attach point does make possible the GlaStar's huge doors, which are hinged so as to pivot forward more than 180 degrees until they come in contact with the engine cowling. This is a real plus for GlaStars on floats. Few aircraft could be easier to get in and out of; you simply sit down and swing your legs into position. The sheer volume of the cabin and its abundant window area, including a windscreen that wraps all the way up to the main spar carry-through, contribute to a sense of spaciousness and light. For a high-wing aircraft, the pilot's field of view is relatively unrestricted in level flight, with the bulging side doors and windows permitting a nearly straight-down view. Two overhead skylights, though small, are useful during steep turns. An exposed structural tube does pass a bit too directly through the pilot's straight-ahead line of sight, but one quickly grows accustomed to looking around this obstacle.

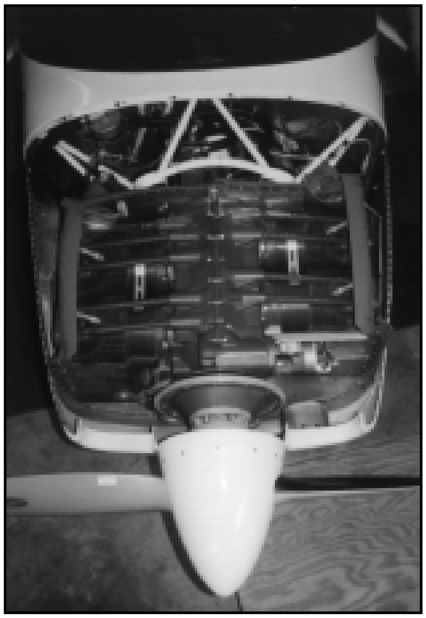
C.J. and I were both somewhat critical of the GlaStar's seats. They do score points for simplicity, as fore and aft repositioning is achieved by sliding only the backrest portion along a pair of tracks. However, to accommodate this, each stationary seat-bottom consists of a long, dead-level padded plank, so the only thigh support is provided by thick auxiliary foam cushions once they have compressed under the occupants' weight. An increased recline angle and the superior thigh support of a bucket-style seat would improve comfort considerably, especially on longer flights. Like most other light aircraft available today, the seats have no special provision for energy dissipation in the event of a crash landing. The shoulder harnesses get high marks for being attached to the steel cage well above and slightly behind the passenger's shoulders, so they cannot contribute to spinal compression, but the level seat-bottom increases the challenge of passenger restraint during extreme deceleration.

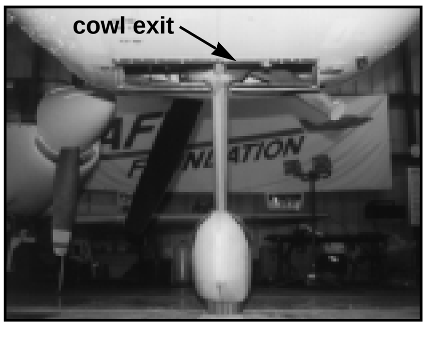
Flight engineer Cris Hawkins, left, ran the Barographs and Digital Acquisition Device for all of the performance flights. Test pilot Otis Holt is at the controls.

The GlaStar's panel has ample space for almost any configuration of avionics and instrumentation the builder desires. N824G's modest panel is efficiently set up for VFR flying, with all switches and controls clearly marked and within easy reach of the pilot. We would have preferred that the ELT switch and the switch deactivating the electronic-advance component of the LASAR magnetos be located off by themselves, and not grouped together with the frequently used switches. The panel also features well thought out checklists and a calibrated airspeed chart which proved to agree closely with values derived from the CAFE Barograph. On-board navigation is provided by a King KLS 135 GPS/Comm. Our only complaint about this popular unit is that you have to wait for the GPS to "boot" and scroll through a four-item list of acknowledgments before the comm frequencies are displayed; a bit frustrating when you merely want to obtain ATIS and call ground control.

Dual flight controls are well located for both seats, and require no awkward contortions on the part of either pilot. The control columns on the GlaStar have a fairly long throw, requiring that pilot and passenger to be prepared to accommodate large control deflections. Given the modest control forces required in the GlaStar, slightly tighter ratios, limiting the stick's range of travel to a smaller "box", might have been preferable. On N824G, the throttle and mixture controls are located on a center console within the stick's range of travel, and can actually snare the stick if it is moved in a certain fashion. According to Stoddard-Hamilton, all kit builders will be placing their engine controls higher in the panel, well above the stick's airspace, so this potentially hazardous condition should be unique to the prototype.

Ideally, it should be possible to maintain basic control of an aircraft with little conscious effort, but we observed two minor problems with N824G's control system which interfered with our ability to achieve this sense of linkage. In addition to the excessive aileron break-out force and control friction mentioned previously, we observed a significant amount of lash in both elevator and aileron controls. This allowed more than an inch of stick travel in either axis when the





stick was rapidly oscillated out of phase with the control surface movement while seated in the stationary aircraft. (In flight, the aileron's trailing edges were observed to reflex upward about 3/4" relative to their relaxed position on the ground.) These problems could be partly attributable to poor rigging or to the heavy use seen by the prototype, but even several thousand airframe hours should not alter the control system significantly.

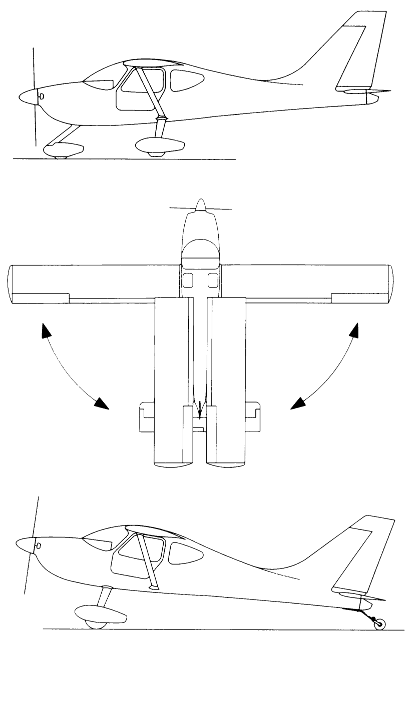
GROUND OPERATIONS

The GlaStar's ground handling qualities are superb. Thanks to the free-swiveling nose wheel, the aircraft can be pivoted easily about either of the main wheels by engaging that wheel's brake and giving a small burst of power. Taxiing is secure and straightforward, with the large window area providing an unobstructed field of view when on the ground. Steering is easy using various combinations of rudder, power, and differential braking. The GlaStar is quite easy to move about manually as well, although care must be exercised when pushing it backwards, as the nose wheel can strike its stops violently if it is not prevented from castering by a firm grip on the towbar.

Preflight checks are very basic. The only unusual items are to check that the wing spar pins are secure and the fuel vents unplugged. Fuel management is simple, as the system consists of two coupled wing tanks, gravity feeding the engine-driven fuel pump on the carbureted Lycoming through a simple on/off valve well located just below the throttle. The Mac servo-driven elevator trim is set to takeoff position by reference to an indicator on the panel. After a routine run-up, flaps are set to the one-half position for takeoff and the GlaStar is "good to go".

TAKEOFF AND CLIMB

The more powerful engine and constant speed prop have shifted N824G into the high performance utility class, and provide brisk acceleration and healthy climb rates. The rudder becomes effective immediately and has ample power to control tracking



CAFE MEASURED PERFORMANCE

Propeller max. static RPM	2695 RPM
Vmax, TAS, 2071’ density alt., 1950 lb, w.o.t..	158.7 mph
Vmax, TAS, 6001’ dens. alt., 1935 lb, 23.8”, 2692 rpm, 9.9 gph	157.3 mph
Stall speed, 1935 lb, 14 in M.P., full flaps, CAS	40.5 kt/46.7 mph
T.O. distance, no wind, 1914 lb, 38° F, 125 ft MSL, full flaps	400 ft
T.O. distance, no wind, 1916 lb, 38° F, 125 ft MSL, 1/2 flaps	475 ft
T.O. distance, no wind, 1651 lb, 38° F, 125 ft MSL, full flaps	310 ft
Liftoff speed, by Barograph, 1914 lb, full flaps, CAS	58.2 mph
Touchdown speed, Barograph, 1915 lb, full flaps, CAS	52 mph
Minimum sink rate, 1875 lb, 66 mph CAS, 76 mph TAS	661 fpm
Glide ratio, coarse pitch, idle, 93 mph CAS, 103 mph TAS	10.6
Noise levels, ambient/idle/full power climb/75% cruise	62/74/101.7/103.1 dBA

throughout the ground roll, with plenty left over for control during crosswind takeoffs. The GlaStar lifts off almost immediately after rotating gently at 40 knots indicated (only panel indicated airspeeds are listed here. See the measured performance section for calibrated equivalents). With one-half flaps left in for the initial climb out, comfortable deck angles and good climb rates were found at 60-70 KIAS. With flaps retracted, a good range of cruise climbs occurs at 80-100 KIAS. Flying solo with full fuel (about 300 pounds below gross), I typically saw ground roll distances around 400’ and maximum climb rates in the neighborhood of 1300 FPM near sea level. At the same loading, a 90 KIAS cruise-climb still produced nearly 1000 FPM at low altitude. Numerous data collection flights made later at the GlaStar’s published maximum gross weight of 1960 pounds confirmed this to be a reasonable value for N824G with this prop/power plant combination.

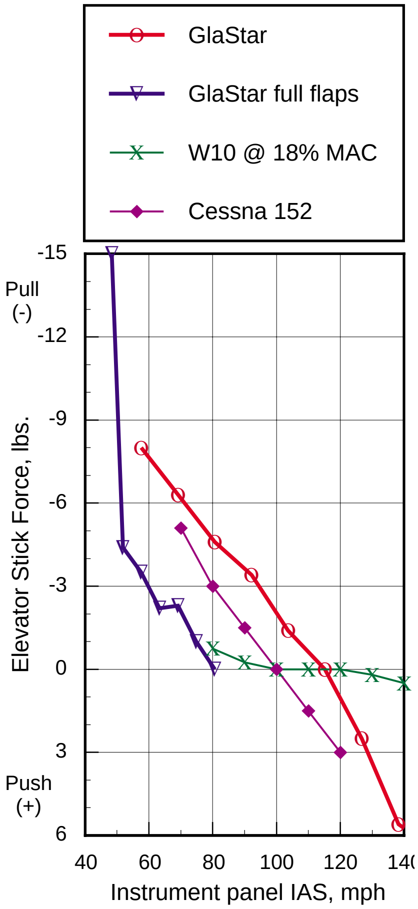
Due perhaps to the great width of the cowling and instrument panel, deck angles during the climb out are perceived to be greater than they actually are, so visual estimates voice-recorded during early flights proved to be erroneously high when later checked against measured values. Depending upon the speed, each notch of flaps reduces the deck angle by a very significant three to five degrees. During the initial climb out, deck angles begin to feel uncomfortably high at about 70 KIAS with no flaps, but that threshold drops closer to 60 KIAS with one-half flaps, and to just above 50 KIAS with full flaps. N824G did show a tendency toward rapid increase in cylinder head temperatures during any sustained climb at lower airspeeds and full power, making it advisable to reduce power and enter a cruise climb as soon as obstacles are cleared for normal operations.

STABILITY AND CONTROL

The GlaStar’s basic handling qualities and stability were examined at a forward c.g. (15% MAC) and moderate loading. It should be noted that variations in construction, rigging, or loading could change the stability and control characteristics of other aircraft of the same design.

LONGITUDINAL STABILITY

The GlaStar returned to the trim condition with moderate speed and no overshoot after elevator doublets in all configurations, demonstrating deadbeat dynamic and good static stability in pitch. Static longitudinal stability was also quantified by measuring the stick force required to hold airspeeds above and below the trim speed of Va (100 KIAS). The results can be seen in the graph to the right. In the clean mode, the absolute values for stick force are light for a utility aircraft, but they do progress in a healthy fashion as you deviate further from trim speed. The sharp increase in stick force observed when approaching



Static longitudinal stability

Trimmed to zero pounds with stick- free and flaps up at Va. Trimmed to approach speed with full flaps.

the stall should help prevent stalls from occurring unintentionally.

DIRECTIONAL STABILITY

Although the GlaStar demonstrated good static yaw stability in response to rudder doublets, it overshot about three and one-half cycles before returning to trim with the pedals free and about two cycles with the pedals held fixed, indicating poor dynamic stability. Likely contributing factors include the relatively large portion of the GlaStar’s profile flat plate area located forward of the c.g. and its long wing span. Although the vertical fin is fairly large, the movable control surface comprises most of its area. The rudder controls on N824G were fitted with centering springs, but pedal forces remain sufficiently light to permit an increase in the strength of these springs. This might further reduce the rudder’s float and increase its contribution to yaw stability. It would also be interesting to fly a GlaStar with dorsal and/or ventral fins added to see if these might improve yaw stability.

DIHEDRAL EFFECT AND DUTCH ROLL

Being located almost entirely above the roll axis, the GlaStar's tall vertical fin contributes to the strong dihedral effect observed. Nearly thirty degrees of left bank was required to hold a constant heading against full right rudder, and about twenty degrees of bank was required in the opposite direction at Va. It was also possible to raise either wing with rudder, but again this tendency was stronger with right rudder.

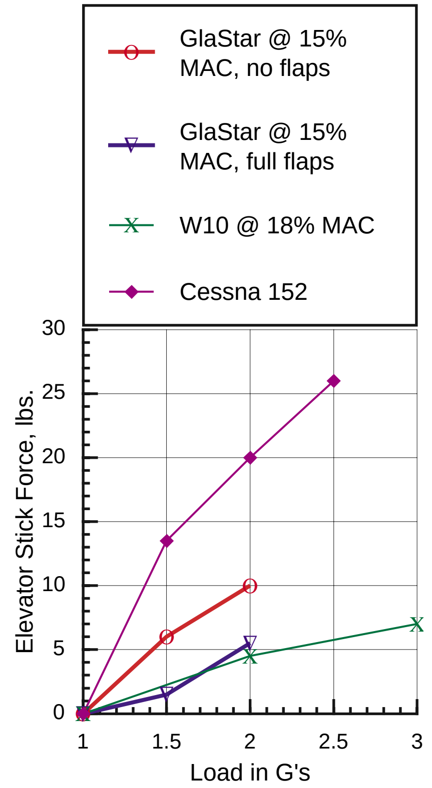
Strong dihedral effect often combines with any yaw instability to produce a Dutch roll tendency, but control-induced Dutch rolls quickly decayed into more of a "snaking" tendency in N824G before damping within about three cycles, so yaw instability is the dominant concern. The effect is mainly felt when flying the GlaStar in turbulence. With the previously mentioned control lash and aileron breakout force thrown in, you soon find yourself chasing the airplane in all three axes. For example, during the air-to-air photo flights we encountered considerable light chop, and C.J. commented that formation flight in those conditions was challenging in the GlaStar. This behavior is not a major problem during normal VFR flying, but it would complicate life for the pilot flying in turbulent IMC. N824G was easy to trim and fly in a coordinated fashion in smooth-air conditions.

ADVERSE YAW

The GlaStar displayed very little adverse yaw in either direction after full aileron deflections with the rudder held neutral. The tendency was to hesitate briefly after a slight reversal of no more than a degree or two before turning to the desired direction, regardless of speed or configuration. Gentle rudder inputs easily overcome any tendency toward adverse yaw.

MANEUVERING STABILITY

The prototype N824G was flown under a much more stringent g-load limitation than production kit GlaStars due to differences in internal wing structure, so we were not able to explore the stick force per g-load relationship fully during these tests. We did, however, establish that the GlaStar exhibits a healthy progression within this more limited range, as shown in the accompanying graph.



Maneuvering stability

SPIRAL STABILITY

The GlaStar displayed neutral spiral stability in all configurations, showing no natural tendency to deviate from an established fifteen degree bank in either direction with neutral aileron.

ROLL RATES

The standard technique for measuring roll rates for CAFE APRs is to establish the aircraft in a coordinated 60 degree bank and then time a roll to passage through a 60 degree bank in the opposite direction, so as to include the time required for control input and roll acceleration. The rate for a sustained roll would be higher. Rates and control forces were measured in the GlaStar at Va and at 1.3 Vso with one-half flaps. Stick forces achieved during these maneuvers were within the range of 13-14 pounds for rolls to the right, and 17-19 pounds for rolls to the left.

STALLS

Stall behavior was benign in all configurations tested in N824G. All stalls were performed at forward c.g.'s by decelerating slowly while holding precise altitude as long as possible to eliminate the possibility of any ballistic component. If the deceleration rate was much less than one knot per second, the GlaStar tended to mush gradually into a fairly steady sink upon reaching full aft stick. With a higher deceleration rate, a gentle break occurred at panel-indicated airspeeds of about 51 knots clean, 44 knots with one-half flaps, and 43 knots with full flaps when flying solo with full tanks. See the measured performance section for calibrated stall speeds at near-gross weight. Recovery was aided by a forward nudge on the stick, and there was

ROLL RATE, degrees/second, includes input time	Va	1.3 Vso
RV-6A	80	36
Tailwind	47	45
Cessna 152	47	34
RANS S-7C	61 Rt./63 Lt	50 Rt./53 Lt
GlaStar	52 Rt/50 Lt	47 Rt/43 Lt

Stall speeds	Flight/Clock	Mode	Manifold Pressure, in. Hg.	Weight, lb	Panel IAS, kt/mph	CAS, kt/mph
GlaStar N824G	#3--09:46:21	Clean	13.6	1942	52.0/59.9	49.5/57.0
at various M.P.	#3--09:51:39	Clean	9.1	1939	54.0/62.2	51.3/59.1
and weights	#3--09:55:20	1/2 flaps	14.4	1937	45.0/51.8	43.0/49.5
with forward c.g.	#3--09:55:52	1/2 flaps	10.0	1937	47.0/54.1	44.7/51.5
gross wt. = 1960	#3--09:59:15	Full Flaps	14.0	1935	42.5/49.0	40.5/46.7
	#3--10:00:25	Full Flaps	9.6	1935	45.0/51.8	42.7/49.2

no tendency toward excessive nose rise afterward. The GlaStar would benefit from some type of stall warning device or angle of attack indicator, as noticeable airframe buffet precedes the stall by no more than about one knot.

We were impressed by the GlaStar's aileron authority during stalls. Regardless of the configuration, it was possible to continue flying with full aft stick and confidently perform coordinated gentle maneuvers using normal control inputs. Rudder authority was also ample during stalls with zero or one-half flaps, but diminished significantly with full flaps. Flying straight ahead with the stick full aft, the GlaStar would descend and bob gently as the airspeed fluctuated by one or two knots. It should be noted that N824G's ailerons were rigged to reflex upward , with their trailing edges about one inch above neutral. It is possible that their low speed authority would be affected by alternative rigging.

APPROACH AND LANDING

The GlaStar has sufficient airframe drag to produce a comfortable descent with a modest power reduction, so no extra planning is required when descending from cruising altitude. A light pre-landing workload frees the pilot to concentrate most of his or her attention to the outside world during pattern entry and the approach to landing. Along with the aircraft's ample field of view, this contributes to what should be a good safety record for the GlaStar.

Landings are another area where the GlaStar really shines. The standard approach calls for 65 KIAS and one-half flaps. The flaps produce a very comfortable deck angle in this configuration, with the touchdown point in view all the way to the flare. Equipped with a constant speed prop set to flat pitch, the sink rate and descent angle do increase dramatically when the throttle is closed, but 65 KIAS leaves plenty of energy and tail power to negotiate a power-off landing. Forward slips are effective but generally unnecessary in the GlaStar. Speed over the fence can be comfortably reduced to around 60 KIAS if a few inches of manifold pressure are carried into ground effect. A bit more power managed into the flare can also produce feather-light soft-field landings with a little practice. In normal landings, over-rotating slightly during the flare enables the pilot to hold the nose wheel off the ground much longer so as to maximize aerodynamic braking. Although braking and directional control during the roll out are generally excellent, the pilot must be ready to bring in a bit of differential braking as the rudder looses authority near the end of the roll-out. Those accustomed to steerable nose wheels might be caught off guard by this during their first few landings.

GLASTAR N824G

Prototype from kit manufacturer.
Construction: Aluminum wing and tail, tubular steel cage for cabin to firewall, fiberglass composite shell fuselage.
Equipment: King KLX 135 A GPS-Comm, KT-76A transponder, G meter, PS Engineering Intercom PM1000 II, VisionMicro engine instruments.

SPECIFICATIONS

Empty weight/gross weight	1274 lb/1960 lb
Payload, full fuel	494 lb
Useful load	686 lb
ENGINE:	
Engine make, model	Lycoming O-320 D1F
Engine horsepower	160 BHP
Engine TBO	2000 hr
Engine RPM, maximum	2700 RPM
Man. Pressure, maximum	30 in Hg
Turbine inlet, maximum	na
Cyl head temp., maximum	500° F
Oil pressure range	60-90 psi, 100 psi max. on startup
Oil temp., maximum	245° F
Fuel pressure range, pump inlet	2 psi normal, 0.5 psi min., 8 psi max.
Weight of prop/spinner/crank	na
Induction system	NACA inlet, rt. side of cowl, MS-4SPA carb (Facet)
Induction inlet area	5.5 sq in
Exhaust system	1.75 in O.D. ss, 4 into 2 into 1 muffler, 2.25 in exit
Oil capacity, type, cooler	6 qt., 15W-50, S.Warner 10599R cooler
Ignition system	LASAR electronic advance magnetos
Cooling system	2 pitot inlets, downdraft
Cooling inlet area	63 sq in (stock cowl)
Cooling outlet area	50 sq in, fixed, no cowl flap
PROPELLER:	constant speed
Make	HartzellHCFZYL-1F, F7663-3 blades
Material	aluminum
Diameter	73 in, 2 blades
Prop extension, length	3 in, integral with hub (7.187 in to blade center)
Prop ground clearance, half fuel	8.2 in
Spinner diameter	11.75 in
Electrical system	12V Electrosystems alternator, B&C regulator
Starter	Sky-Tec 31A22100
Fuel system	2 wing tanks to a common firewall header tank
Fuel pump	gravity to engine driven pump, no boost pump
Fuel type	100 LL
Fuel capacity, by CAFE scales	31.93 gal
Fuel unusable	7 oz
Flight control system	aileron, rudder and elevator by cable, flaps manual
Governor	Woodward, B210-776A
Tire size, main/tail	5.00-5 6PR mains, 11x4.00-5 nose
CABIN DIMENSIONS:	
Seats	2 abreast
Cabin entry	2 doors, each 31.3 in H x 44.6 in W
Width at hips	42.2 in
Width at shoulders	46.2 in
Height, seat to headliner	36.5 in to roof tube without extra cushions
Baggage capacity, rear cabin	45.5 in L x 35 in W x 27 in H
Baggage door size	12.5 in H x 22.5 in W
Lift over height to baggage area	36.5 in
Rear baggage capacity	250 lb forward area, 65 lb rear area, 315 lb total

The GlaStar's sure handling and ample control authority with one-half flaps also make this configuration the best choice for most crosswind landings. No-flap approaches were found to be uncomfortably nose-high at speeds less than 75 KIAS on the downwind leg, and the sink rate rises sharply when the speed decays to around 70 KIAS with the throttle closed. I would tend to reserve the no-flaps option for extreme crosswind situations where the first attempt to land at one-half flaps had resulted in a go-around.

With full flaps deployed, most approaches and landings in the GlaStar would be classified as high-performance because energy and power management become critical, so demands on the pilot's skill are greater. Thanks to the GlaStar's positive aileron control at very low airspeeds, it is possible to extract some impressive performance in this mode. Short-field landings were explored using full flaps and approach speeds of 50-55 KIAS. At a forward c.g. loading (15% MAC) about 300 pounds below gross weight, 55 KIAS requires full-aft trim. A significant amount of power is needed to control the sink rate in this configuration. The resulting steep approach and the brevity of the subsequent roll out are impressive. The view of the runway was good and control remained very positive throughout the approach. It should be noted that loss of engine power during the final fifty or so feet of this type of approach would result in a very hard landing with damage likely.

GlaStar N824G Sample c.g.

Forward sample item	Weight, lb	Arm	Moment
Main gear	899	113.3	101845
Nosewheel	375	45.1	16926
Pilot, front	200	101	20200
Co-pilot, front	140	101	14140
Fuel, wing tanks full	192	108.0	20687
Oil, included	0	0.0	0
Baggage, fwd (cap. 250 lb)	90	136.0	12240
Baggage, rear (cap. 65 lb)	64	113.7	7300
TOTALS	1960		193338
c.g. this flight, in.	99		
c.g., % MAC	21%		
c.g., % aft of fwd limit	39%		
Gross weight, lb	1960		
Empty weight, lb	1274		
Useful load, lb	686		
Payload, lb	494		
Fuel capacity, gallons*	32		
Empty weight c.g.	93		
c.g. range, inches	95.6-		
c.g. range, % MAC	14% -32%		
*as weighed by CAFE			

Datum used is 89.378" forward of wing leading edge.

KIT SUPPLIER

Stoddard Hamilton Aircraft, Inc.
18701 - 58th Avenue, N.E.
Arlington, Washington 98223.
(360) 435-8533 FAX 435-9525
www.stoddard-hamilton.com

OWNER/BUILDER N824G

Arlington Aircraft Development
Serial No. 01-P Model SH-4
Contact Stoddard Hamilton Aircraft for more information.

DESIGNER'S INFORMATION

Cost of kit, no engine, prop, avionics, paint	**$23,590**
Kits sold to date	**650**
Number completed as of 4/10/98	**36**
Estimated hours to build, from prefab kits	**1200 hr without fastbuild options**
Prototype registration date	**12-6-94**
Normal empty wt., IO-240 f.p.---O-360 c.s.	**1150---1200 lb**
Design gross weight, lb	**1960 lb/2100 lb with floats**
Recommended engine(s)	**O320 or O360 Lycoming**
Advice to builders:	**Get started and enjoy the building process.**

CAFE FOUNDATION DATA, N824G

Wingspan/wings folded and tail removed	**35 ft/8 in**
Wing chord, root/tip	**43.9 in**
Wing area	**128 sq ft**
Wing loading	**15.3 lb/sq ft**
Power loading	**12.25 lb/hp**
Span loading	**56 lb/ft**
Airfoil, main wing	**GAW-2 (LS-0413) (Modified)**
Airfoil, design lift coefficient	**0.4**
Airfoil, thickness to chord ratio	**13 %**
Aspect ratio, span^2/ sq ft wing area	**9.6**
Wing incidence	**1.0 °**
Thrust line incidence, crankshaft	**1.5 ° right and 1.8° down**
Wing dihedral	**4.5 °, (2.25 ° per side)**
Wing taper ratio, root/tip,	**none**
Wing twist or washout	**0 °**
Wing sweep	**0 °**
Steering	**Differential braking, castoring nosewheel**
Landing gear	**Tricycle, fixed**
Horizontal stabilizer span/area	**128 in/32.2 sq ft, incl. strakes**
Horizontal stabilizer strakes	**2 ea. @ 21.5 in L x 13.5 in W**
Horizontal stabilizer chord, root/tip	**34 in/34 in**
Elevator: total span/area	**126 in/14.4 sq ft**
Elevator chord: root/tip	**16.5 in/16.5 in**
Vertical stabilizer: span/area incl. rudder	**60 in/16.5 sq ft**
Vertical stabilizer chord: root/tip	**61.5 in/17.5 in**
Rudder: average span/area	**60 in/5.8 sq ft**
Rudder chord: bottom/ top	**21.5 in/6.2 in**
Ailerons: span/average chord, each	**na**
Flaps: span/chord, each	**110.3 in/11.2 in root/11.0 in tip**
Flap area	**16.8 sq ft**
Tail incidence/airfoil	**-1.25 °/NACA 0010**
Total length	**22.3 ft/25 ft with wings folded**
Height, static with full fuel	**9 ft 1 in**
Minimum turning circle	**45 ft**
Main gear track	**87.4 in**
Wheelbase, nosewheel to main gear	**67.5 in**
Acceleration Limits per factory:	**+3.8/-1.5G (+2G , prototype only)**
AIRSPEEDS PER FACTORY, IAS N824G	
Never exceed, V_{ne}	**140 kt/ 162 mph**
Maneuvering, V_a	**98 kt/ 113 mph**
Best rate of climb, V_y	**78 kt/ 90 mph**
Best angle of climb, V_x	**50 kt/58 mph**
Stall, clean, 1960 lb GW, V_s	**47 kt/54 mph**
Stall, dirty, 1960 lb, GW, V_{so}	**39 kt/45 mph**
Flap Speed, full 45°, V_f	**75 kt/86 mph**
Gear operation/extended, V_{ge}	**na**
Not approved for spins	

Panel IAS, kt/mph	Cabin Barograph, kt/mph	CAS, kt/mph
44.5/51.3**	42.9/49.4	42.5/49.0
54.0/62.2	53.5/61.6	51.9/59.8
60.0/69.1	59.8/68.9	59.5/68.6
70.0/80.6	69.7/80.3	69.6/80.2
80.0/92.2	81.0/93.4	79.0/91.0
90.0/103.7	89.8/103.4	87.8/101.2
100.0/115.2	99.6/114.7	97.4/112.2
110.0/126.7	109.5/126.2	107.2/123.5
120.0/138.2	119.5/137.7	117.4/135.2
130.0/149.8	130.6150.5	126.3/145.5
140.5/161.9	141.0/162.5	136.2/156.9

GlaStar N824G
Airspeed calibration

Cabin Barograph shows the airspeed indicator's instrument error and CAS shows total pitot-static system error.
Full flaps.

Touch and goes in N824G are just that, as the airplane literally leaps back into the air with the application of full power. With the aircraft still trimmed for the approach, very substantial for-

FLIGHT TEST DETAILS

10 flights were made over the course of 3 weeks in December 1997, during VFR conditions. A FlowScan fuel flow transducer was used for the gph determinations and was calibrated by measuring the weight of fuel burned on each flight. A PropTach digital tachometer was used. Performance data flights were conducted with pilot and flight engineer aboard and flying qualities were assessed with solo flights.

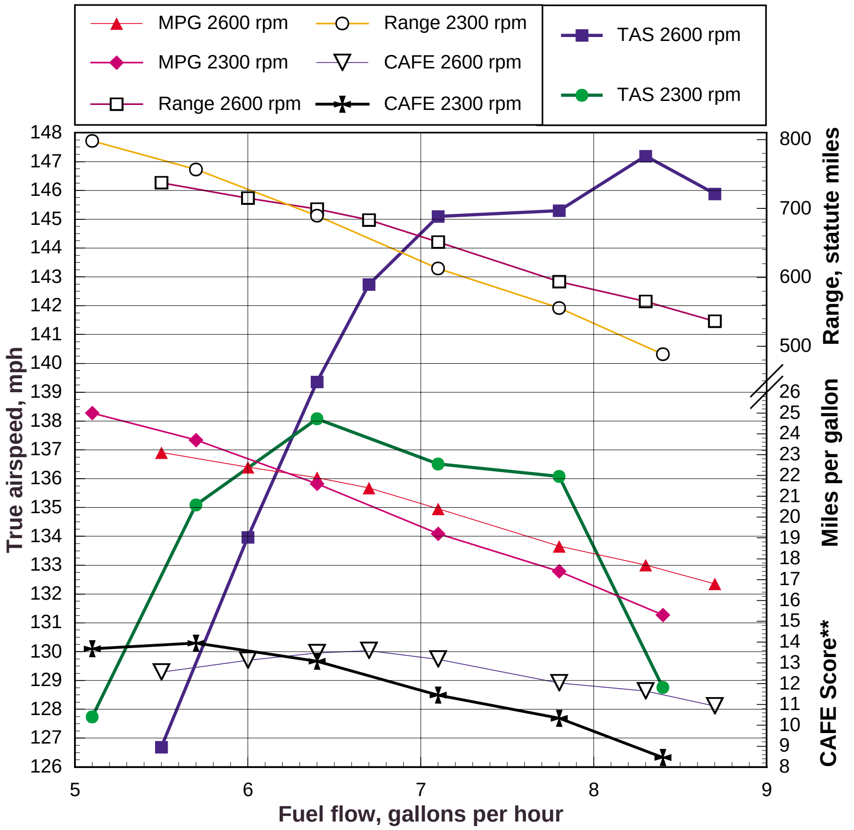
Cruise flight data was obtained with both the wingtip Barograph (#3) and the cabin Barograph (#1) and these were correlated to produce the airspeed correction table shown here. Our data suggest that Vy is 90 mph CAS and Vx is 67 mph CAS. No Triaviathon climbs were performed.

Total energy monitoring was used in selecting cruise data points.

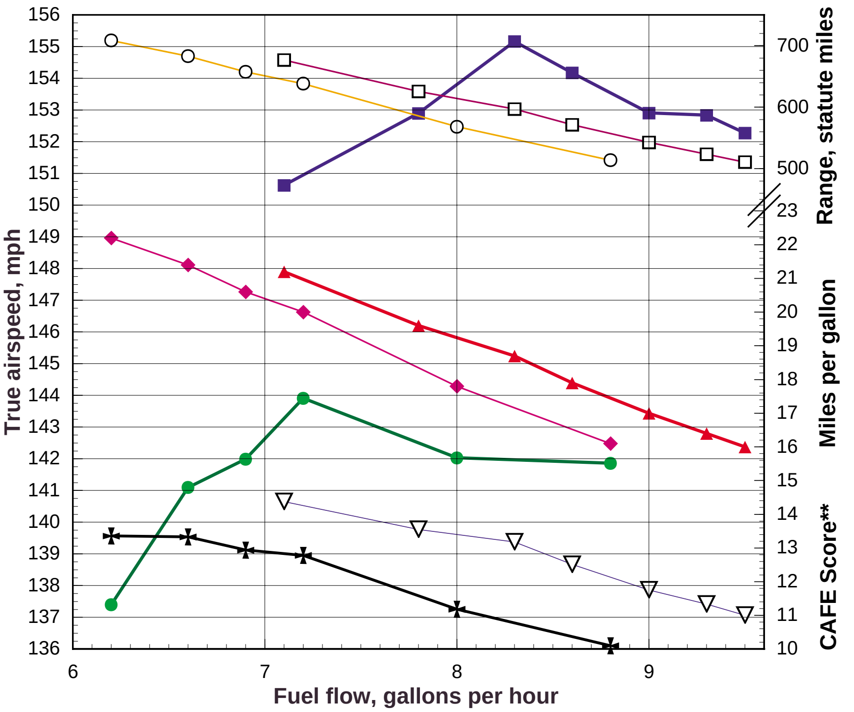
CAFE HONORARY ALUMNI

Steve Barnard--RV-6A
Jim Clement--Wittman Tailwind
Jim Lewis--Mustang II
Ken Brock--Thorp T-18
Larry Black--Falco F.8L
Chuck Hautamaki--Glasair III
Jeff Ackland--Legend
Jerry Sjostrand--Express
Randy Schlitter--RANS S-7C
Stoddard Hamilton Aircraft, Inc.--GlaStar

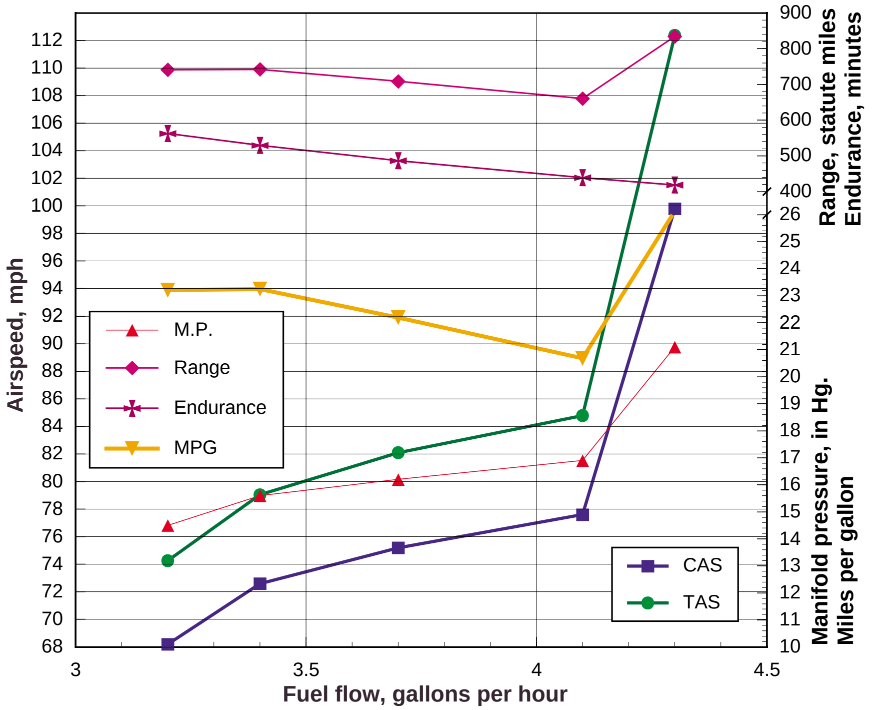
The graphs below use a Power-Performance data plotting technique developed by Klaus Savier. The peak CAFE score occurs at the fuel flow and cruise velocity, V, which optimize the trade-off between speed and MPG and is typically lean of peak EGT. The relative CAFE scores shown here, scaled to fit the graph's Y axis, are based on the computation ($V^{1.3}$ x MPG), which is part of the CAFE Challenge formula.



GlaStar N824G: 12000' density altitude, w.o.t..
****Comparative aircraft flight efficiency score**



GlaStar N824G: 8000' density altitude, w.o.t..
****Comparative aircraft flight efficiency score**



GlaStar N824G: low power settings. All data at 6000' density and 2080 rpm except the 112 mph TAS data point which was at 8000' density and 1800 rpm.

ward stick pressure is required to hold attitude for the subsequent climb out. Because the electric trim is slow to respond, this forward pressure must be maintained for an extended period of time.

CONCLUSIONS

The GlaStar is an aircraft that will be immediately easy to fly and safely enjoy. As owners gain experience they will discover its deeper capabilities. Benign stall characteristics, good slow speed handling, and the rugged steel cage structure all contribute to making the GlaStar an intrinsically safe aircraft, and a good candidate for the low-time pilot. At the same time, its affordability and versatility offer something to a much broader range of pilots. The aircraft would benefit from some improvement in yaw stability, but it's a safe bet that there will soon be many happy GlaStar fliers among our ranks.

GlaStar N824G	Flight/Date	Start time	Pressure altitude, ft.	Density altitude range	Weight, lb	Panel IAS, kt.	CAS, mph	TAS, mph	Rate of climb, fpm
	Climbs								
Climbs at various altitudes using	#3--12/11/97	09:19:25	78	<1153>-1297	1961	72	83	84	987
wide open throttle (w.o.t.) at	#3--12/11/97	09:24:04	71	<1046>-1325	1958	81	92	93	1013
various weights and airspeeds.	#3--12/11/97	09:39:06	46	<1197>-1307	1947	86	97	98	1055
Gross Wt = 1960	#3--12/11/97	09:29:10	92	<977>-1350	1955	90	102	104	976
All climbs without flaps	#3--12/11/97	09:34:05	40	<1034>-1361	1950	100	112	114	890
	#5--12/13/97	11:14:46	4543	4900-5939	**1647**	85	96	103	1029
	#5--12/13/97	11:15:42	5488	5922-7919	**1646**	85	96	106	945
	#4--12/13/97	09:46:31	5636	6000-8012	1930	87	98	108	712
**turbulence	#3--12/11/97	10:50:48	10775	11496-12011	1900	80	91**	109	483
	#3--12/11/97	10:58:46	10904	11499-12003	1895	80	90	108	418
**turbulence	#2--12/10/97	12:15:56	6357	6502-7004	1913	90	102**	113	596
	#2--12/10/97	12:19:53	6378	6500-7007	1909	82	92	101	712
¢¢ Best angle of climb with 1/2 flaps gave	#1--12/09/97	18:00:09	7	<273>-357	1891	71	82¢¢	82	1097
328 feet horizontal per 50 foot rise.									
	Descents								**Rate of sink, fpm**
All descents at idle throttle	#3--12/11/97	11:27:39	9729	10338-9965	1875	60	69	81	-813
using coarse pitch and no flaps.	#3--12/11/97	11:28:15	9223	9813-9606	1875	63	72	83	-812
	#3--12/11/97	11:29:28	8407	8811-8482	1875	57	64	73	-721
	#3--12/11/97	12:02:41	6391	6911-6655	1850	82	93	103	-854
	#3--12/11/97	12:07:16	1382	1487-1033	1849	126	140	143	-1395
°°with 1/2 flaps	#3--12/11/97	12:01:32	7439	8001-7458	1851	60	69	78°°	-716
	#3--12/11/97	11:26:09	10762	11406-10874	1875	95	108	128	-1114
##Vx	#3--12/11/97	11:28:43	8898	9413-8956	1875	58	66	76##	-661