no, seriously...

THIS IS ONE BIG HOMEBUILT!

The Ellison brothers' original scratch-built Gweduck

"WHAT'S THAT...A FIBERGLASS WIDGEON? No, it's a Gweduck. What's a Gweduck? It's a clam." — That humorous exchange started virtually every conversation the Ellison brothers, Ben and Marty, had with attendees at EAA AirVenture Oshkosh 2009 where they exhibited their ambitious amphibian for the first time.

BY BUDD DAVISSON

PHOTOGRAPH BY TYSON RININGER

The Gweduck (say "gooey duck" really fast) is a much-bigger-than-average homebuilt, twin-engine, six-place, 600-hp amphibian that lit the imagination of all who saw it.

"The enthusiasm for the airplane," Ben, EAA 72406, the elder says, "was huge, but only a small number of onlookers had serious aspirations. However, those who had amphibian and bush flying backgrounds were very serious because they recognized what we had done: We had designed a corrosion-proof, difficult-to-damage but easy-to-repair amphibian that avoids all the bad flying characteristics amphibians have possessed almost since the dawn of aviation."

The Gweduck sprang from the imagination of the Ellison brothers and a friend, Ross Mahon, EAA 215408. All three can boast of enormously long and varied aviation pedigrees. Ben was the first pilot in the family, soloing at 16 and eventually working for a crop duster while getting his degree in engineering. Ben taught younger brother, Marty, EAA 1008402, to fly, and he wound up doing two tours in Southeast Asia flying A-6s before working his way up to the left seat at a major airline. You read about their friend Ross and his restoration of the Wickham B in the November issue ("Preserving the Past, Homebuilt-Style"). His father, Brian Mahon, was the Gweduck design team's mentor.

When Ben and his wife started boating, they bought a Cessna 180 on floats for transporting family and friends from their home near Seattle to Roche Harbor in the San Juan Islands, where the boat was moored. Eventually they traded the 180 for a de Havilland Beaver on floats. After the Beaver, a Widgeon was going to be Ben's next airplane. At least it was until he looked closely at buying one and realized it had a serious skeleton in its closet. "Given enough time, saltwater would literally dissolve the airplane. That's when I started designing an amphibian of our own," says Ben.

Although he recognized the Widgeon's faults, he nonetheless used it as a comparative design guide of sorts, or maybe a design non-guide, because he designed the Gweduck around the Widgeon's shortcomings and, one by one, eliminated them. "We put together a matrix of the flying characteristics, good and bad, of the better-known amphibians, kept the good characteristics, and worked to avoid all the others."

They started designing the airplane in 1990 and quickly realized they didn't know enough about amphibians. "But we were fortunate to know the people who not only knew the questions but had the answers, many of which could only come from years and years of operating amphibians and floatplanes."

Ben continues, "One of our greatest sources of knowledge was Ross' dad; he taught us the realities of operating on the water. For instance, he said you don't design an amphibian that's going to be operated in the bush with a nose gear because you won't be able to beach it without it digging its nose into the sand. And the tail has to be enormously strong because it's going to get bashed into tree branches and dock pilings. The hull has to be almost entirely boat, not airplane. You need to be able to walk on any part of the airframe, and it has to be able to bounce off docks, and smash into oncoming waves and the occasional log, and suffer no structural damage. Lastly, landing on the water can be much, much harder on an airplane than landing on a runway. Virtually every rough water landing is a crash."

With those lessons "in hand," design work began in earnest. But designing an amphibian means designing a vehicle that must work in two entirely different fluid mediums: one, the air, is compressible and extremely well understood and documented, while the other, water, is very incompressible and not well documented at all. In effect, Ben was designing an airplane that sat on top of a boat. But before doing that, he had to first set his goals, then decide how to best meet those goals.

"Right up front we knew we wanted to have an airplane with a 400-nautical-mile range that could easily carry three 185-pound men, three 160-pound females, and 300 pounds of cargo. This automatically says we're not talking about a small airplane, and there were a lot of design parameters concerning water operations that aren't commonly known." Again, Brian came to their rescue. In his aviation collection were lots of little-known National Advisory Committee on Aeronautics and United States Navy reports on amphibians. "He even had some from the United Kingdom," Ben adds.

"One of the first things we learned from the reports is that building scale models for testing works extremely well. In fact, much of what was learned in the 1930s, '40s, and '50s in this field was learned empirically from models, so we built a quarter scale, 11-foot model with two chainsaw engines that had interchangeable 'slippers' on the bottom, allowing us to easily change hull shapes. It was one of the smartest things we did. Duplicating the Widgeon's hull, for instance, clearly showed us the well-known Widgeon problem of porpoising and how the airplane had a very narrow stable region between nose-up and nose-down porpoising limits. You had to be in that range or risk getting a very exciting roller coaster ride when landing on water.

"We kept fine-tuning the model until we had an extremely benign hull shape. And that's

SIDENOTE

About That Name... Grumman had taken all the really cool bird names, so we named it after a local deep-digging clam. —*Ben Ellison*

GWEDUCK BUILD

The wing center section showing the starboard aileron bellcrank. The long white bearing support is to carry the flap actuating through shaft.

The hull jigged up for the installation of the horizontal tail. The vacuum-formed cabin windows were covered prior to painting.

The harmonic drive gear housing as well as clutch and limit switch mounting brackets for one of the main landing gear legs.

Checking visibility past the engine nacelles. The hull is still jigged in position for the wing installation, which had just been completed.

PHOTOGRAPHY COURTESY OF **ELLISON AIRCRAFT**

Ross Mahon flies the Gweduck with its twin Lycoming IO-540 engines cruising along at 120 mph.

exactly how the real airplane flies. If you start bouncing or aren't happy with what it's doing, just bring the yoke all the way back and it'll take care of itself. On takeoff in lightly rippled water, if you have the Gweduck trimmed correctly, it'll literally fly itself off the water with no help."

Ben says prop spray is one of the defining factors of amphibian design because the higher the gross weight, the more difficult the spray becomes to control. "You may find you're limited to a given weight for the hull design because too much water is getting into the props. This has dogged every amphibian designer in history. Somewhere we saw some photos of the huge Japanese post-war flying boat, the Shin-Meiwa, and noted that it had ducts running inside both sides of the hull that appeared to capture water as it was about to blow out from under the chine and ducted it back behind the step. We searched but could find nothing written about it anywhere. So, using the photos as guides, we started experimenting with ducts on the model and were amazed at how well it worked. We had no idea why other amphib designers hadn't stumbled on this little 'secret' long ago. It really cleans the water out of the air around the props."

Ben says that although he's an engineer, they aren't professional amphibian designers. However, being based in Seattle, they had a lot of retired Boeing design talent looking over their shoulders, not to mention some world-class composite gurus. They hired a structural engineer to tell them how much beef to put where and even had some critical coaching from David Thurston, the man behind a long series of amphibians beginning at Grumman and continuing through the Lake series, whom Ben calls "Mr. Amphibian."

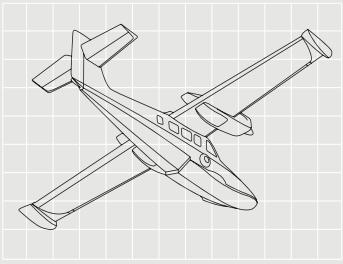
COMPOSITES, OF COURSE!

Ben says the choice of material for their airplane was obvious from the beginning: composites. One of the reasons amphibians have such limited life spans is that they can't be totally protected from the very element they are landing on, especially if that element is saltwater. "Composites don't corrode. We decided on fiberglass and vinyl-ester resin, rather than epoxy, and some kind of space-age carbon fibers, mostly because fiberglass is easier to repair in the field. Amphibians get beat up a lot, so we used the same things used in the marine industry, knowing it would be available almost anywhere. Also, epoxy isn't as stable as vinyl-ester in hot, humid conditions."

All of the Gweduck's skins are glass-foam-glass sandwiches of varying thicknesses. The fuselage sides and the wing skins, for instance, are 3/8-inch thick with the closed-cell, polyurethane Last-A-Foam. "That's commonly used in the boating industry, but it has an interesting characteristic: When you hit it and make a dent in it, the application of heat brings the dent back out. And it doesn't slowly crumble to powder

Specially designed ducts on the underside of the fuselage keep water spray out of the prop arcs.

AIRCRAFT DATA



Aircraft Make & Model:
Ellison-Mahon Gweduck

Certification: amateur-built experimental

Length: 34 ft., 6 in.

Wingspan:
51 ft., 6 in. (48 ft. w/ wing tip floats down)

Height: 10 ft., 10 in.

Maximum Gross Weight: 6,000 lbs.

Empty Weight: 4,200 lbs.

Fuel Capacity:
200 gal. plus 180 gal. auxiliary tank

Seats: 6

Powerplant Make & Model:
Two Lycoming IO (LIO)-540-M1B5

Horsepower: 300 hp (each)

Propeller Make & Type: MTV-9, full feathering, reversing, neutral thrust shut down

Cruise Speed/Fuel Consumption: 120 knots @ 19.5 gph total (economical cruise)

Power Loading: 10 lbs/hp.

Wing Loading: 20 lbs/sq. ft.

Price: 20 years of our lives…kits TBD.

For more information: *info@gweduck.com*

Ben and Marty Ellison.

PHOTOGRAPHY BY **TYSON RININGER AND JIM RAEDER**

The front and back "office" of the Gweduck.

under repeated poundings as most rigid foams do. This was important in our application because of the pounding a floatplane or amphib takes when landing on an even slightly choppy surface."

Ben described the process: "The lay-ups are done dry in female molds. The foam is perforated with thousands of pin-sized holes (900 holes per square foot) to let the resin flow freely. Then they'd compress the sandwich in the mold, draw a vacuum through the mold, and infuse the resin in from the edges, which soaks through the lay-up like ink through a blotter. The result is that the wet-out is complete and the amount of resin left in the sandwich is minimal and therefore lighter than a normal hand lay-up would be."

The fuselage basically uses three molded parts: the sides, the aft bottom, and the forward bottom ahead of the step, which is a full three-quarter of an inch thick. The front portion has to be tough to survive in the rough water environment. Even the windshield is 3/8-inch thick, not only to survive the landings but also because it is used to transfer some of the bow loads up to the top of the hull.

The Gweduck's landing gear borrows heavily on Grumman concepts with machined billet A-arms pulling the oleo struts up into the fuselage sides and the sealed landing gear wells. The entire hull is totally sealed, with none of the usual drains and access panels associated with amphibs. And the interior seen at Oshkosh was bare-bones fiberglass, so the internal structure was clearly visible.

"Many people thought the airplane wasn't finished, but it actually was closer than they thought. We built this airplane to do what we like to do—fish and hunt—and the interior was designed so we can hose it out with salt-water because there's no more efficient way to remove moose blood and fish guts. That's why there is no metal in the airplane from your shoulders down, and everything drains into the bilge and is pumped overboard."

The wing has two molded-sandwich skins, top and bottom, and the molded ribs are bonded to the lower skin while it's still in the mold. The same thing with the spar, which is two C-sections back-to-back with carbon-fiber caps. Ben explains, "We bolt the C-sections together and insert 3/8-inch aluminum plates between the webs where the wings bolt into the fuselage. Once the top skin is bonded on, the bolts joining the spar halves are superfluous.

"The main spar is at 39 percent, which is really far back, but we have another one right up front at 10 percent. That looks kind of odd, except we wanted the leading edge to be non-structural, so it could be easily repaired. With that spar so far forward, we just bond the leading edge to it, and if it gets damage, we saw that section out and bond in a new one. A very easy repair."

Ben is quick to point out that all of the fuel is out in the wings with no fuel at all in the fuselage. It has a normal capacity of 200 gallons, but with the outboard auxiliary tanks filled, the Gweduck holds an amazing 360 gallons. However, even though it looks as though the switching valves are in the cockpit roof, which would require fuel lines to be in the fuselage, those are just actuators because the valves themselves, and the attendant fuel lines, are all out in the engine nacelles.

"We're coming up on 150 hours on the airplane now, with more than 200 water landings, and we came really close to meeting our goals. At 4,200 pounds, it's a couple hundred pounds heavier than we wanted, and it's a little draggy because we still have unfaired float strut gaps in the wings, as well as way too much cooling air, but we're still cruising at 140 knots with 70 percent power. We have 300-hp Lycomings—the right one is counter-rotating—and we love the fact that we can throttle back to 120 knots and be burning only 19.5 gallons/hour total while carrying that much load."

They also love the MT props. Besides having a reverse position for water maneuvering, Ben says what makes them so great is that they have a zero-thrust position when started. "With a twin-engine amphibian on the water, you're always embarrassing yourself because you'll get one started and then you're making slow circles while you try to get the other one going. Having zero thrust on the running engine is terrific, plus we can use differential beta for maneuvering.

"The really satisfying part to its handling is that it's as gentle as a baby buggy when taking off or landing because it is so terrifically forgiving. And we're landing at only 61 mph. The airfoil is a 15 percent thick Ribblet airfoil, and the ailerons are linked to the flaps, exactly the same way a Beaver's are, so they go down 15 degrees as the externally hinged Fowler flaps come down 30 degrees, and it really hangs on and is solid as it comes over the shoreline slow with some power on."

"We had designed a corrosion-proof, difficult-to-damage but easy-to-repair amphibian that avoids all the bad flying characteristics amphibians have possessed almost since the dawn of aviation."

So, the big questions remain: will they make a kit out of it and how will it fit in with the new 51 percent rule, considering that it's such a complex airplane? "If we decide to kit the airplane, it will be with an experienced kit manufacturing partner. To support kit builders, we'd make our assembly jigs and fixtures available at our site and provide whatever technical supervision a builder would need, but the builder would put everything together."

In the meantime, they're going to continue fine-tuning the airplane, but mostly, they want to enjoy it. "There are a bunch of salmon and some moose meat that really need to find their way to our freezers. So that's what we're going to do." EAA

Budd Davisson is an aeronautical engineer, has flown 300 different types, published four books, and more than 2,500 articles. He is editor-in-chief of *Flight Journal* magazine. Visit him on *www.AirBum.com*.

For videos, photos, and more content about the Gweduck video, visit *www.SportAviation.org*.