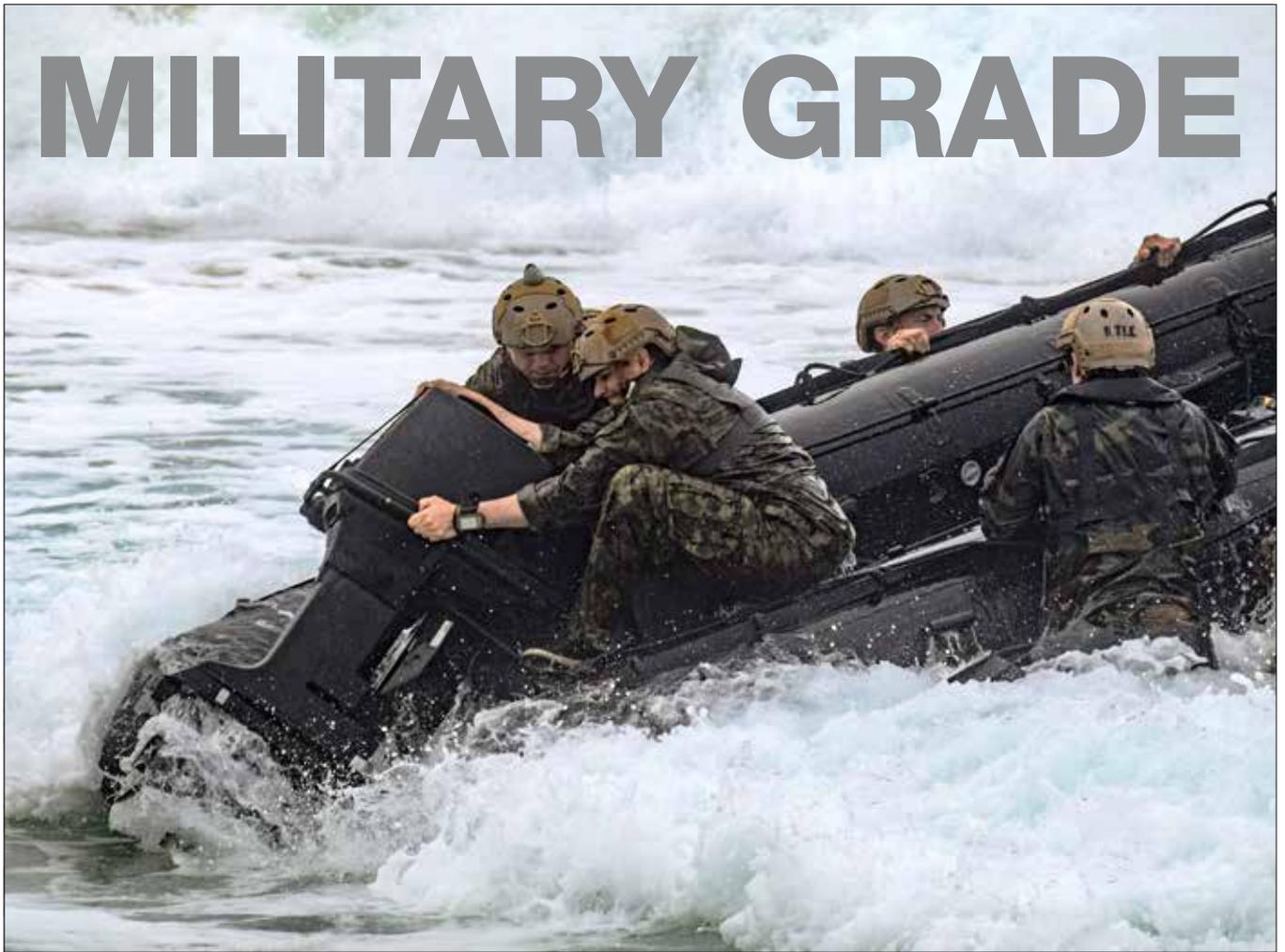


MILITARY GRADE



A small family firm in Florida builds submersible multifuel outboard engines for tough missions.

by Dieter Loibner

The High Speed Boat Operators (HSBO) Forum in Gothenburg, Sweden, is a gathering unlike any other. Uniforms are part of the ambience, as 370 delegates including search-and-rescue, police, customs, special forces, and navy converged on this biannual event to exchange information, to learn about new techniques and technologies, and, above all, to sea trial the boats on display, putting the hammer down on test runs along the skerry-strewn coast. Par for the course is 60 knots and more on these craft with shock-absorbing seats and supersized engines. In this high-octane crowd, a small tiller-steered

outboard motor that looks like it had escaped a 1980s time warp certainly stands out as an oddity.

“Well, this might not be the biggest or the fastest motor here,” explained Chris Woodruff, 51, “but it can do a few things that nobody else can.” That motor was the Raider 50, a two-stroke, multifuel, submersible outboard built exclusively for the U.S. military. Strictly speaking, these motors are government issue, but Woodruff said he’s at HSBO because he has permission to shop this product to governments on “friendly terms with the U.S.” His company website leaves little doubt about its niche:

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“Raider builds and supports reliable outboard motors for the warfighter.”

These motors are heavily modified versions of the 40-hp (30-kW) Tohatsu 40C and the 50-hp (37.3-kW) 50D2, with numerous parts swapped out, refined, or added, including a nifty dewatering system patented by the U.S. Navy. Conspicuously, they lack many staples of commercial outboards, like electronic fuel injection or digital shift and throttle controls, features that are either expensive or difficult, if not impossible, to repair in an emergency or in a remote and hostile theater. Raider’s motto is KISS: keep it simple, stupid. “We decided to go back to the basics,” Woodruff said about those two-stroke carbureted outboards with a pull starter. “Our goal is getting the boys back safely.” The downside? These engines don’t run as clean as contemporary hi-tech commercial four-strokes or fuel-injected two-strokes. Still, the U.S. Environmental Protection Agency nodded its approval, but more on that later.

Built for the mission

Raider outboards are intended for service on small inflatables and are knowingly subject to admittedly abusive uses—landing facedown in the surf zone on a beach during training, getting tossed out of airplanes at altitude, or being released from the



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dive-chamber of a submarine for secret operations. Only on rare occasions does the military share details, and if they become available, they most likely concern rescues of civilians (see the sidebar on page xx).

The Raider facility occupies a squat office and manufacturing building a few miles outside Titusville, Florida, a coastal town on the western shore of the Indian River within sight of the Kennedy Space Center. Welcoming visitors from behind the reception desk is a life-size cardboard cutout of a trimmed down Donald Trump, giving a double thumbs-up. It is a family

business run by Chris Woodruff, who, in a prior life, sold boats for Donzi Marine, and by his father, George, a twice-retired executive, who’d worked in government sales at IBM and Lockheed Martin. The Raider crew is a cast of colorful characters with diverse backgrounds (most of them military), but all are fiercely dedicated to building these motors.

Formalities are not a priority here, so it takes only a few seconds before I sit in Chris Woodruff’s office. Although his official title is business development manager, he is really leading R&D, which is why his desk overflowed with 3D-printed ABS plastic samples of an inflatable boat he has been working on and bits for a jet drive that can be retrofitted to Raider outboards. These are but two examples of models and prototype components the company tries out and modifies with the Raise3D N2 printer in his office, since replaced by a F410 3d printer.

Woodruff took two parts off a shelf, an old and a new head, to show what



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kind of value Raider adds when it modifies for the military

“We changed heads, intake, electrical, fuel system, and dewatering components,” he said. “We switched out the throttle cams and moved the shifter to the front of the motor. We use new linkages and a special motor mount that makes it easier to put on the engine at sea.”

Choosing low tech

The company replaced the Tohatsu motor’s original heads with custom ones, to increase compression and improve water flow. They now are made of machined 6061 aluminum and have holes at the bottom of each cylinder. They are equipped with special relief valves to allow water to be removed

after submersion. As an added benefit, Raider says these changes yielded about 5 extra hp (3.7 kW) on the 40 and around 7 hp (5.2 kW) on the 50. To burn multiple fuels, including gasoline, diesel, JP-5, and JP-8, Raider selected a different carburetor, which atomizes No. 2 diesel and mil spec JP-5 heavy fuels to a fine vapor, making it suitable for spark-ignition combustion without preatomization or the need to preheat the fuel.

Dewatering an outboard engine that might have sat on the seafloor in up to 66’ (20m) of water is a process that had to be simplified to several steps that could be carried out day or night, in arctic cold or tropical heat, and, if need be, under enemy fire. Just as important is the question of fuel.

Testing different additives, Raider found that in a pinch, the motor runs as well on a 50:50 mix of diesel and gasoline as it does on gasoline only, which is why Woodruff called this “a fuel of opportunity.”

Spark plugs in submersible outboards must get very hot to evaporate all moisture left in the cylinders after dewatering. These plugs are hard to find, at least ones made in the U.S., as mandated by the Barry Amendment, which guides procurement for the military. Raider worked with Pulstar in Albuquerque, New Mexico, which made several different types of plugs for Raider to improve heavy-fuel ignition. The chosen model is a stainless-steel plug with a patented internal capacitor. It gets much hotter than standard plugs, vaporizing residual water and helping the motor run better, because hot plugs also improve diesel ignition.

Raider orders motors for modification by the container load—60 units of the 40-hp model and 48 of the 50s. The



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goal is to keep about 150 units of the smaller and 100 of the larger motors in stock. Tohatsu likes that volume and helps with favorable payment terms.

“My salvage guy loves me for all the parts we discard.” Woodruff laughed. “In the early days we had to make

changes, but now we are on Generation 2, and the Navy beats the crap out of it. But out of more than 500 engines we sold thus far, not one was lost due to a manufacturing defect. And we have a one-year unconditional warranty.”

Regarding those changes, Raider

quickly learned that electronics are not the best choice to manage the electrical system of their engines when they are on critical missions. Alternator output, for instance, is controlled by a custom voltage regulator, George Woodruff explained.

Initially, when the motors ran for an extended period, the lightweight, powerful, and expensive lithium-ion batteries became unstable and required more charging than the old, heavy AGM batteries. The latter have two advantages: they’re much cheaper, and they are spillproof. Since their sulfuric acid is absorbed by fiberglass mat, these batteries automatically take care of hazmat restrictions for

shipping and storing the engines on planes and submarines.

The user feedback loop

For incremental product improvements, Raider depends on feedback from the troops. “The smartest guy in this scheme is the boathouse mechanic,” Chris Woodruff said with a grin. “He can be a crusty Navy guy, an aged hippie. I want to become friends with all of them, and when they talk I just shut up and listen.” The man who deals with these technicians most often is Mike Waddell, 48, recently promoted from field technician to production manager. A diesel mechanic by training, he grew up on a farm in Illinois and serviced M1 Abrams tanks for the Army.

“Training users in handling the motor is essential,” said Waddell, who was hired straight out of Westland Marina in Titusville, where he worked on boat engines. “If the dewatering

procedure is not handled properly, there’ll be a flame-over with a mushroom cloud at the backside of the engine where the dewatering valves are. Check the clear carburetor bowl for the separation of water and gas, and check the position of the dewatering lever. Start in gear, then close the dewatering lever.”

As a veteran who did a tour in Bosnia in the 1990s, Waddell is familiar with the drill. “Getting dropped in a remote area at 2 a.m. from 12,000’ [3,700m], having to pop the engine and mount it is the same as assembling an M16 rifle blindfolded, or popping the boat out of a submarine’s dive chamber and watching it inflate as it floats to the surface. We have trained 200–300 [military] boat operators, mechanics, and technicians. Thus far, we did it all in the same training session, but now we hold separate classes.”

Waddell says that problems reported

to the company hotline “get addressed within 24 hours.” Common issues are with the electrical system, fuel drainage, and the dewatering valves. “The Tohatsu [engine] is a good base—no other engine is still carbureted, so we have to teach ancient techniques,” he said. “It’s a step back in time.” But there are still plenty of new things to learn. He said, for example, from a test near a desalination plant in Abu Dhabi where the water had extremely high salinity, after 24 hours of use, the engine had a level of corrosion equal to that of ones used for two to three weeks in the U.S.

To combat corrosion in general, Raider sprays its motors with Corrosion Zero and seals vulnerable electrical connections such as the starter solenoid with liquid electrical tape. Despite all the precautionary measures, there are still untold ways of roughing up motors. “Every time I check an engine and ask, ‘How did you



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do that?’ the answer is always: ‘We were training.’” Waddell said.

This feedback loop is the reason the original round carrying handle that bends around the back and the side of the motor was replaced with a square version to prevent the motor from tipping over when it is set down on the ground. Similarly, Raider also was asked to replace the metal carburetor bowls with transparent plastic ones, so a visual check for the presence of water in the fuel would be quick and easy.

The crew

Making this transparent plastic part fell to machinist and toolmaker Chet Barker, who operates a clinically clean

workshop dominated by a milling machine and a workbench he keeps in meticulous order. Barker said he got started in this line of work at 13 in his grandfather’s workshop, and that after 60 years in the trade, he still has his machinist’s mojo. “At age 73, I’m retired, but I still put in 25 hours here,” he said. “Nobody learns anymore the stuff I’m doing, [which is why] I still make parts for antique motorcycles like Simplex, Mustang, and Cushman.”

In 1960 Barker arrived at Patrick AFB, just south of the Cape, and at one point trained to recover Apollo space capsules with a C-130 aircraft dragging a weighted cable. In the 1980s, he got into Jet Skis and dealt with jet drives that sustained damage from rocks and sand when the craft was run up on the beach. “That was an expensive repair, because the impeller and the housing have to fit exactly for the [jet] drive to work. I thought of a



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better fix: I removed the impeller, fitted a polyurethane ring into the stator, and corrected the impeller. It cost much less than buying a new impeller.”

He showed me the tooling for the dewatering valve, the kill switch, and the transparent carburetor bowl. “The kids who come here as interns don’t

know where to turn on the milling machine, but they are big on computer drawings,” Barker quipped. “When they don’t see any in my shop, they

ask, 'Where are your drawings?' Right here," he said, tapping his head.

Around the corner from Barker's shop is the workstation of Jim Ness, 62. "By job description I'm a machinist, but you can call me magician," he joked. A lifelong boater and a live-aboard who hails from Michigan, he's been with Raider for eight years. Like Barker, he came to Florida in the '60s. He chose to follow in the footsteps of his dad, an engineer, and an uncle, who both worked at the Kennedy Space Center. Ness said he worked on the Hubble Space Telescope mission and built launchpads. After the Challenger catastrophe he lost his job and went to the Florida Keys to work in land survey, drywall construction, and pool maintenance. Later he got back into making things and ran CNC machines at Seminole Gunworks.

When I visited, he was busy milling the stator of a new Safety Jet drive on

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a 40-hp engine. Raider is betting big on it, for military *and* civilian markets. In about 10 minutes, Raider says, these jet drives can be retrofitted to the original lower units. The goal is to prevent injury from prop strikes during dangerous surf launches, and to protect manatees in the shallow Florida waters or flood victims rescued by inflatable in the aftermath of hurricanes.



In another area of the shop were two young technicians who graduated from the Marine Mechanics Institute in Orlando before joining Raider



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His colleague, **Christopher Laval-
lee, 33**, who switched careers from the restaurant industry to outboard technician, was getting other motors ready for shipment. Both said they like the creative spirit at Raider and the chance to work with their hands to solve problems.

The latest addition to Raider's staff was **Geri Deal, 57**, to manage inventory. She joined the company just a few weeks prior to my visit.



Outboards. Army veteran **Jon Klein, 31**, who worked at Toyota until he hurt his shoulder, was removing a lower unit from one of the 40-hp engines.

Previously, she'd worked in the semiconductor industry as a procurement manager for circuit boards and other electronic components. "I'm learning.

It's a lot of new stuff for me, so I have to ask many questions," she said as she showed me around her domain—the stockroom chockablock with shelves

and hundreds of bins. Among them are a couple of boxes for rejects or defective parts for recycling. Lest they get pinched, Deal keeps a watchful eye on the waterproof emergency toolkits. These little lifesavers contain pins, sockets, spark plugs, a pull rope, and assorted tools and come with every Raider outboard.

Building Raider

To an outsider, it looks like after more than half a dozen years in business, Raider Outboards has come into its own. But it had to navigate some tricky waters, including the specter of bankruptcy at one point. Chris Woodruff's father, George, 75, steered the company through those turbulent times. He had retired to the area from his careers in government sales at IBM and work on programs for the F22 fighter plane at Hughes Aircraft and an advanced-technology-support

contract at McClellan Air Force Base in Sacramento, California, for Lockheed Martin. "I went to Titusville to go fishing, to visit Disney, and to play golf," he joked. "But that got old after six months, and I had no clue what I wanted to do next."

But George Woodruff, raised on a farm in upstate New York, always knew hard work and how to figure things out. He said that in 1964 he graduated from a two-year college "on a Friday and started at IBM the following Monday," working his way up to senior positions in government sales, before moving on to defense contractors who were former clients. His Rolodex contained useful highly placed contacts he could call on when starting Raider Outboards Inc., which he named in honor of the Marine Corps Raiders, who went behind enemy lines in rubber boats in World War II.

Woodruff: "I work with state officials and congressional people in D.C. You can say I'm my own lobbyist. If it is for the troops, it is easy to get money."

First "I bought a building with a parking lot in downtown Titusville, and in 2005 I won a research contract for \$1 million to build a zipper mast for use with robots in nuclear power plants, and for clandestine [military] applications," Woodruff said. It was a logical step for a man who holds **eight** patents, for infrared technology and electroluminescent lighting for aircraft. ZipperMast, still in business today, was a kind of dress rehearsal for the outboard business.

In 2010, the Naval Surface Warfare Center (NSWC) in Panama City, Florida, received funding from the Air Force to replace the dated Improved Military Amphibious Reconnaissance System (IMARS) motor, aka Enforcer, built by Johnson. The simple, lightweight

two-stroke 35-hp outboard was proven and well liked by the troops, but Johnson and Evinrude were acquired by the Canadian company Bombardier Inc. in 2001. It notified the U.S. it was terminating its support for IMARS, offering the more sophisticated and complicated Evinrude E-Tec 30 and the Evinrude 55 MFE as substitutes. It was a fortuitous time for Woodruff to get involved, because he knew how procurement for the military works. “With my experience at IBM, Hughes Aircraft, and Lockheed Martin, it was clear that a government in-house project would never be capable of production,” he said.

Woodruff submitted a proposal for a nongasoline-burning outboard motor to the Special Operations Command (SOCOM) in Tampa, Florida, and was awarded a \$2.5 million contract to develop a multifuel submersible outboard motor that could burn heavy



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fuel like JP-5 and JP-8 but also gasoline. “We surveyed all the available outboards, looking at reliability, supportability, patent information, rights in data, etc. and selected Tohatsu or Nissan as the outboard motor of choice,” George recalled. But the NSWG, which managed the process, was not **confident in** the Tohatsu/Nis-

san option and requested a new build.

The company signed a contract with the Detroit office of Ricardo Plc, a global strategic engineering and environmental consultancy specializing in transport, energy, and scarce resources, to build a motor within six months that met the military criteria. But the motor, according to Woodruff

Sr., was delivered late and did not pass the military’s test. The seven-figure sum spent with nothing to show in return forced him to take out a second mortgage.

George, by now joined by his son Chris, focused on the Tohatsu 50-hp two-stroke low-pressure direct-injection outboard as a base for the multi-fuel outboard the military wanted. “We purchased four Tohatsu 50-hp TLDI outboards and began modification,” George noted. “After six months we demonstrated and tested the motors at Nellis AFB [near Las Vegas, Nevada].” On the upside, the motors ran on JP-5 and JP-8, they were submersible, they had an electric starter, and Raider had an excellent catalog of spare parts. However, at more than 200 lbs (91 kg), they were too heavy to be carried and too complicated and difficult to maintain in the field with electronics and periodical software updates. Now the Woodruffs had a compliant product, which they got paid for, but one that the customer did not like. Also, Orbital Corporation Ltd of Australia, which made the TLDI fuel injection, demanded a hefty licensing fee.

The Woodruffs took another look at the old IMARS motor, which was refreshingly simple and still well liked by the troops. It was compact and lightweight, had practical features like the shifter on the front, was submersible without a bag, and was easy to repair. “Let’s make something for the soldier to do his mission...get home, and forget high technology,” George Woodruff recalled. The next phase was dedicated to resurrecting the IMARS idea but with some modern touches. To get around the EPA’s emission rules that effectively outlawed the sale of new carbureted two-stroke motors, “Raider received a security exemption from the government that permits the EPA to approve our outboards for military applications,” George Woodruff said. “All Raider engines are new and are only sold to the U.S. Government, not to the public.”

The Tohatsu 40C was well regarded in the consumer market for reliability



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and performance. Besides, it is, in some respects, similar to the IMARS motor. Raider had learned from past mistakes and mishaps and developed a product that hit all the right notes, and included the Navy's patented dewatering system, which they had permission to use. All looked good—until the two demo motors blew up within minutes of each other during testing with the U.S. Air Force. “I wanted to crawl under a rock,” Chris Woodruff said. “We took the motors back to Titusville and found the problems: a faulty oil injection and an errant metal shard.” A week later they got another chance, and both motors “ran flawlessly and passed the test with flying colors,” according to Woodruff. The Air Force did not respond to *Professional BoatBuilder's* requests for comment but must have been sufficiently impressed to place orders for 132 motors for Special Ops and 150 for the Guardian Angels.

The Navy also got in on the act but wanted the 50-hp version, which Raider continued to develop along the same guidelines for simplicity, but also customized for specific applications: The Air Force wanted a battery

disconnect and transparent fuel lines, while the Navy asked for an 18” (45.7cm) fuel attachment extender that makes it easier for SEALs to plug in the fuel line when wearing gloves. “We are now on the second generation of motors that feature better carburation, a new battery case, new mounting brackets, a new head design, an

improved fuel system, and better overall performance, which is a result of honest, sometimes withering feedback from the boathouse technicians,” Chris Woodruff said. “During testing [with inflatables] we found it was important to place the motors on center [of the transom]. Also, if the jack-screws got loose when going into a

Long-range rescue

On July 7 and 8, 2017, the U.S. Air Force's 920th Rescue Wing set out from Patrick Air Force Base near Cape Canaveral, Florida, to pull off a risky and logistically challenging rescue that went beyond the operative range of the U.S. Coast Guard. Its task? Picking up two injured and exhausted German sailors drifting in their life raft on the open ocean, about 500 miles off Florida's east coast. Their ancient Bénéteau sailing yacht had caught fire and sank. There were 80 airmen involved, 30 hours of combined flight time between two HC-130P/N King fixed-wing aircraft, and two HH-60 Pave Hawk helicopters, and eight aerial refuelings. Six

Guardian Angels and their gear were deployed by parachute over the accident site, along with one inflatable and one of Raider's motors. The pararescuemen saved the two shipwrecked sailors, one with severe burns on his legs, and transferred them onto a diverted tanker nearby, where they were airlifted to an Orlando hospital. The bravery of the rescuers earned accolades including the 2017 Jolly Green Association Rescue Mission of the Year and the German Search and Rescue Service's Medal of Honor.

—Dieter Loibner

sharp turn, you might lose your motor. As a result, Raider and the Air Force came up with a new transom plate [that] centers the motor and provides a lip that [secures] the motor when

entering a sharp turn.”

And sometimes necessity is the mother of invention. “Selling outboards to the Marine Corps proved to be an issue,” said George Woodruff,

who told the story of the Safety Jet. “The U.S. Marines use a pump jet on their motors to provide safety to the soldiers. They do not run open propellers. We went to the maker of these



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pump jets to have them build one for the Tohatsu. They declined, [so we] decided to develop our own. We did not like the existing design, which required modifications to the lower

unit. And if damaged, it had to be sent back to the manufacturer.”

The more than two years it took the company to ready the Safety Jet for prime time were well spent, as the

product filled an important niche. The military acquired 100 Safety Jets for the Raider 40-hp motor, while the one for the 50-hp model, with an improved impeller design, is expected in 2019. Eventually, these drives will fit a wide range of different outboards, and Raider has plans to make them commercially available in 2020.

New products in the pipeline

While basic technology is the heart of its motors, Raider is investing in modern development tools. In addition to a 3D printer for rapid prototyping, during my visit Chris Woodruff was in the final stages of researching 3D scanners for product design, customization, and reverse engineering. “This could have saved me months during the development of our motors,” he said after a demonstration by TriMech—a firm specializing in 3D design and



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Resources

prototyping tools—of an Artec Leo 3D Scanner. “I like to [use it to] scan the lower units, which will help with development of the Safety Jet drives.”

Raider recently received a \$250,000 contract to develop a submersible electric outboard, a sturdy unit that will have to match the fossil-fuel models in performance and reliability and that someday might become available for the commercial market; and a \$100,000 contract for a patented hard-deck roll-up inflatable, to be built in Massachusetts by Inflatable Boat Racing, and will have space to safely stow the batteries without having to carry large waterproof Pelican boxes.

Woodruff Sr. seems happy with the underdog status of Raider Outboards Inc., which must compete with much larger outfits when selling motors and accessories either to the military or in the commercial market. “We have a good record, because we don’t

squander money,” he noted. He’s a bit more philosophical about his own involvement—including applying for government grants and contracts that have funded much of Raider’s business to date—which has kept him busy and vital. “I am 75. I still get excited. I had a knee replaced. I don’t fish anymore. I don’t hunt anymore, and I’m a lazy golfer. What else am I going to do? If you don’t do a job that you like, you probably won’t like what you’re doing.”

Next time the HSBO Forum rolls around in Gothenburg, the Woodruffs might not just crash the high-speed party with a tiller-steered two-stroke outboard that’s submersible and thrives on a 50:50-mix of diesel and gasoline if it has to, they might bring their own boat, too.



About the Author: Dieter Loibner is an editor-at-large of Professional Boat-Builder.

Artec Leo 3D Scanner: artec3d.com/portable-3d-scanners/artec-leo

Bombardier Inc.: us.bombardier.com/us/home.htm

Donzi Marine: donzimarine.com

Evinrude: evinrude.com

High Speed Boat Operators Forum: hsbo.org

Orbital Corporation: orbitaluav.com/about-us/our-business

Pulstar spark plugs: pulstar.com/

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Raise3D N2 printers: raise3d.com

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TriMech 3D design and prototyping: trimech.com/about

ZipperMast: zippermast.com