DIETER LOIBNER

The High-Speed **Boat Operations** Forum Turns 20

An editor's report from the invite-only event in Gothenburg, Sweden.

by Dieter Loibner

***Above**—At the High-Speed Boat Operations (HSBO) Forum 2023, demo boats are docked in front of the Eriksbergshallen and the hotel, which are part of the venue in Gothenburg, Sweden.*

Last summer the High-Speed Boat Operations Forum (HSBO) in Gothenburg, Sweden, quietly marked the 20th anniversary since the inaugural event on Känsö Island in a 17th-century quarantine station, in the Gothenburg Archipelago. That 2003 event, which had yet to find a name, drew 15 attendees, who slept in bunk beds and adhered to a dress code that was "completely informal—just warm enough." It was initiated by the Swedish Coast Guard and hosted by the navy to report a joint R&D project evaluating the efficiency of the Ullman Cockpit system. The focus was on the physical limits of operators and on reducing their exposure to impacts while operating fast boats in adverse conditions.

While the mission has not changed much, its setting and attendance have. Today it's an invitation-only gathering that drew 405 delegates from 27 nations,

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Speakers held their presentations before a packed conference auditorium at the hotel. HSBO offered 36 individual talks from industry professionals.

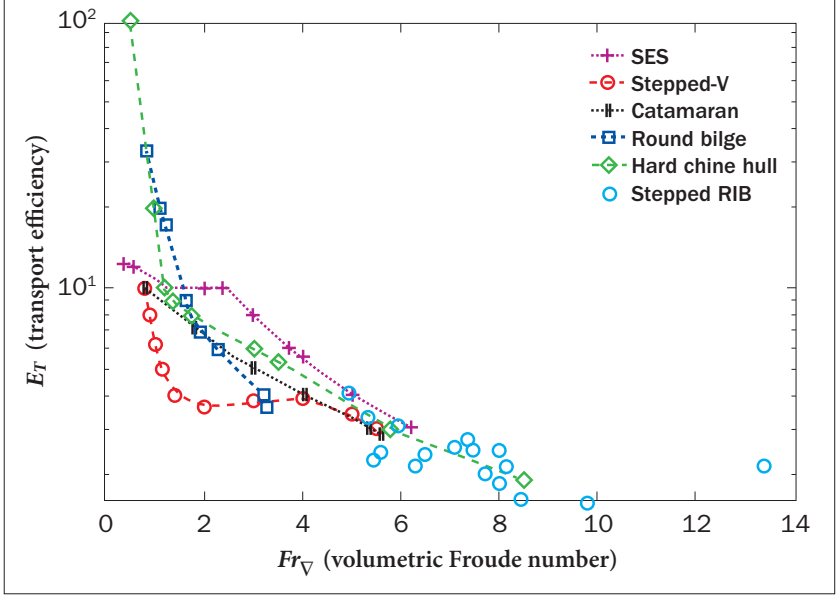
including representatives of military, police, pilots, Coast Guard, academic researchers, and medical professionals, as well as equipment, boat, and propulsion-system manufacturers, who met for three days at Eriksberg, a historic shipbuilding area on the banks of the Göta River. The main sponsor and organizer is Ullman Dynamics, known for shock-absorbing suspension seats. The guiding spirit of HSBO is company founder Johan Ullman, who is also a specialist in anesthesiology, intensive care, and occupational medicine; a flight surgeon; a Fellow of the Royal Institution of Naval Architects; and a reserve officer in the Swedish Navy (see **interview** on page 41).

HSBO 2023 offered 36 talks in 13 sessions that included human factors, impact exposure, injury prevention, operations, technology, and design, along with product exhibits and on-the-water testing of 27 high-speed boats. This year, geopolitical events—Russia's war on Ukraine, which hit Scandinavian countries close to home—figured prominently in conversations and shifted procurement strategies. Agencies urgently needing high-speed craft with advanced capabilities are increasingly looking for off-the-shelf solutions rather than going through traditional procurement cycles, which can take years.

Efficient Hullforms

Armed conflict notwithstanding, this event also featured vendors and researchers whose products and presentations are relevant to the leisure boating market. One such seminar was delivered by Abbas Dashtimanesh, an assistant professor of naval architecture at Sweden's largest technical university, the KTH Royal Institute of Technology in Stockholm. He addressed the impact of the 3.5 million small recreational craft in use in the Baltic region today, especially in coastal habitats for sensitive species. His concern was reducing emissions with better energy efficiency, optimized hullforms, and new propulsion systems. "We primarily focused on the development of efficient hullforms," Dashtimanesh told me. "Our literature review showed that stepped hulls are the best option, considering their transport efficiency at high and moderate speeds" (see **Figure 1**). He and his

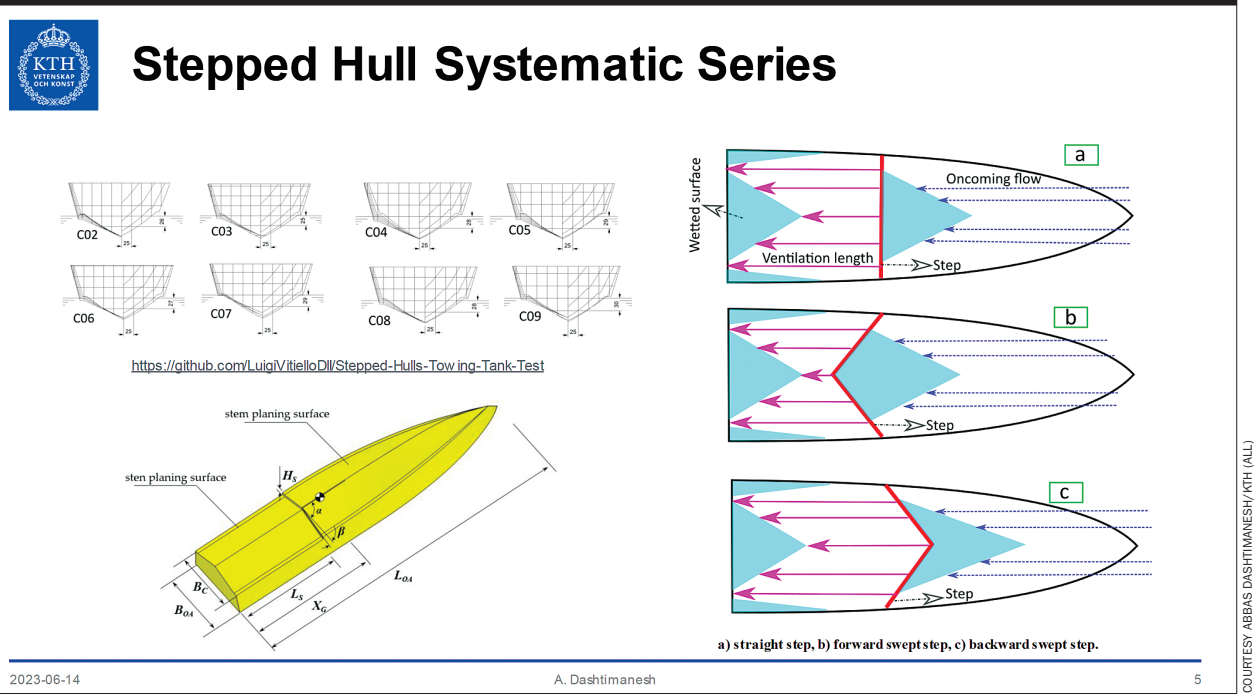
Figure 1. Gabrielli–von Karman Transport Efficiency Index



COURTESY ABBAS DASHTIMANESH/KTH

The Gabrielli–von Karman transportation efficiency index shows advantages of stepped hulls at high speeds.

Figure 2. Transversal Body Planes of Stepped Hulls & Hull Step Shapes



COURTESY ABBAS DASHTIMANESH/KTH (ALL)

Abbas Dashtimanesh's stepped-hull research included different step orientations and eight variations of hullforms tested at various speeds in calm conditions.

colleagues developed a series of stepped hulls using the towing tank at the University of Naples in Italy to assess the effects of step location, height, position of the center of gravity, and the number of steps. The program also investigated the running attitude of eight different stepped hulls (**Figure 2**). "We also have developed mathematical and CFD models that can be used for further developments," Dashtimanesh added. "The 2D+T model is capable of predicting stepped-hull motions in calm water and waves with a high accuracy (**Figure 3**). The developed CFD models have also been validated against experimental data and can be used in the detailed design stage" (**Figure 4**).

After analyzing and comparing the resistance test results in calm water at very high speed (Fr_∇ between 5 and 6.7), hull C04 trimmed aft came out ahead; while at high speed (Fr_∇ between 3.4 and 5), hull C05 trimmed aft showed the most promise. In the medium-speed range (Fr_∇ between 2.6 and 3.4), hull C05 at even keel delivered the best numbers; and at slow speed (Fr_∇ between 1.1 and 2.6), hull C06 trimmed forward topped all others, but further analysis is needed to validate performance in waves.

About the surge in foil-borne or foil-assisted craft marketed with the promise of increased efficiency, he thought that after several false starts because of technical and operational challenges in the past, hydrofoil boats might gain a

***Left**—The 2D+T method is compared with computational fluid dynamics (CFD) simulation and experimental data. **Right**—Comparison of a CFD simulation and experimental tests.*

Figure 3. Data Comparison

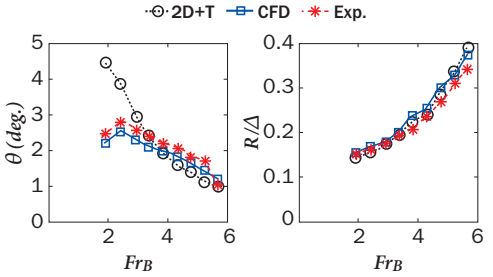
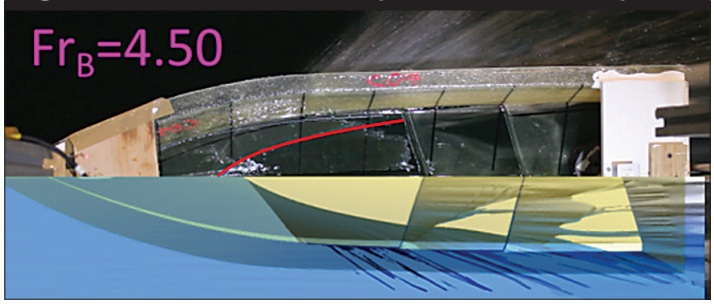
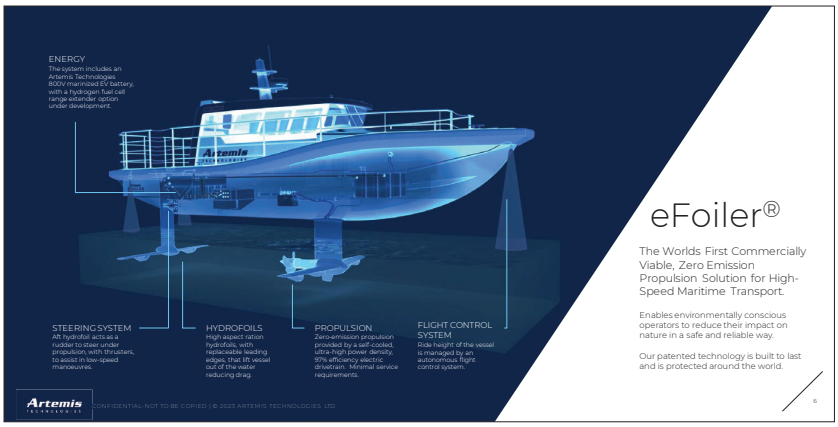


Figure 4. CFD Simulation and Experimental Tests Comparison





COURTESY ARTEMIS TECHNOLOGIES (ALL)

Top left—*The eFoiler from Artemis (Northern Ireland) is based on 800V automotive batteries; it includes a set of two fully submerged foil assemblies on centerline and the propulsion pod on the forward foil, while the aft foil doubles as the rudder.* ***Below left—****The firm is developing foiling multihulls to serve as passenger ferries or crew transfer vessels for wind farms.*

better foothold this time around due to advances in ride-control systems and increasing environmental concerns. To him, a combination of stepped hulls and hydrofoils in catamarans present an attractive subject for future design/research.

"From my perspective as a researcher, boat design plays a fundamental role in achieving environmental sustainability in recreational craft," he said. "By considering factors like hull design, propulsion systems, materials, waste management, and user experience, boat designers can contribute to the reduction of the ecological footprint associated with recreational boating and help protect the natural environment for future generations."

Artemis Foiling Technology

Foiling technology for military craft and workboats was the subject covered by John Cumming, the business development manager for defense, ports, and pilot boats at Artemis Technologies (Belfast, Northern Ireland). The outfit is run by Iain Percy, a multiple world champion and Olympic medalist in the Finn and Star classes. Artemis Technology is a spinoff from the Artemis Racing *America*'s Cup Challenge of Swedish billionaire Torbjörn Törnquist, the co-founder and majority owner of Gunvor Group, "one of the largest commodities conglomerates in the world," according to Forbes.

Cumming spoke about £250 million in R&D investments before introducing the Artemis eFoiler concept, a technology package with tandem T-shaped hydrofoils (the aft foil doubling as a rudder) and forward-facing electric pod drives for propulsion. Given that design briefs of naval craft do not prioritize zero-emission operation, Cumming emphasized the stealth nature of electric propulsion, its low noise and heat signatures, negligible wake when fully foiling, and less crew exposure to slamming in a seaway at high speed, with as much as six times less pitch acceleration at 40 knots, according to his slide deck.

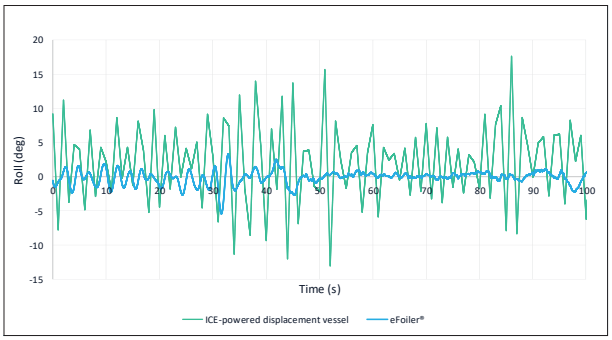
A key piece of technology is an advanced marine simulator Artemis engineers use to develop and optimize autonomous ride control during mission simulations in a range of sea and weather conditions. While Artemis does not license the eFoiler package to outside builders, it cooperates with select manufacturers to build boats to Artemis's design. "There is a significant amount of engineering required, and therefore cost, to design an eFoiler system for a bespoke ship design," Cumming said. "Therefore, a one-off project wouldn't make commercial sense. We

To obtain comparative data, Artemis trialed this foiling prototype alongside a sistership in a conventional non-foiling configuration.

have developed a range of Artemis eFoiler boats for a variety of applications including crew transfer, passenger transport, and pilotage."

This includes the EF-12 Workboat for six passengers and two crew, with a top speed of 34 kts and an advertised range of 60 nm at 25 kts. Power comes from modular marinized 800V automotive batteries, with an optional hydrogen-fuel-cell range extender under development. Cumming also spoke about 45-kt average speeds and ranges around 400 nm with a hybrid setup, and the ability to carry payload of up to 18 tons for military versions of larger craft Artemis intends to build.

Some attendees were skeptical about using craft with nonretractable foils around rocky shores, where it would be difficult to land personnel due to draft issues. Others were concerned about unintentional groundings or collisions with floating objects at speed and wondered about maintenance, repairs, and cost of ownership. "The idea of making something that is virtually maintenance free appeals to the military," Ullman said of that market. "When agencies ask for quotes, they also ask how many spare parts of each kind they need."



	Gasoline Sister Ship Seahorse	Artemis eFoiler Pioneer
Energy consumption at 17 knots, 0.1m Hs	38.0 kWh/Nm	6.53 kWh/Nm
Energy consumption at 17 knots, 0.6m Hs	52.1 kWh/Nm	6.92 kWh/Nm

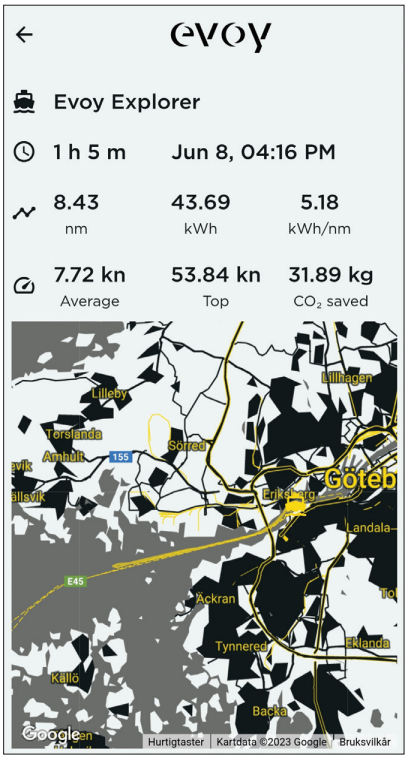
COURTESY ARTEMIS TECHNOLOGIES

Illustrating the efficiency of foiling craft, Artemis revealed data comparing roll characteristics as well as energy draw of foiling and nonfoiling craft at different sea states.

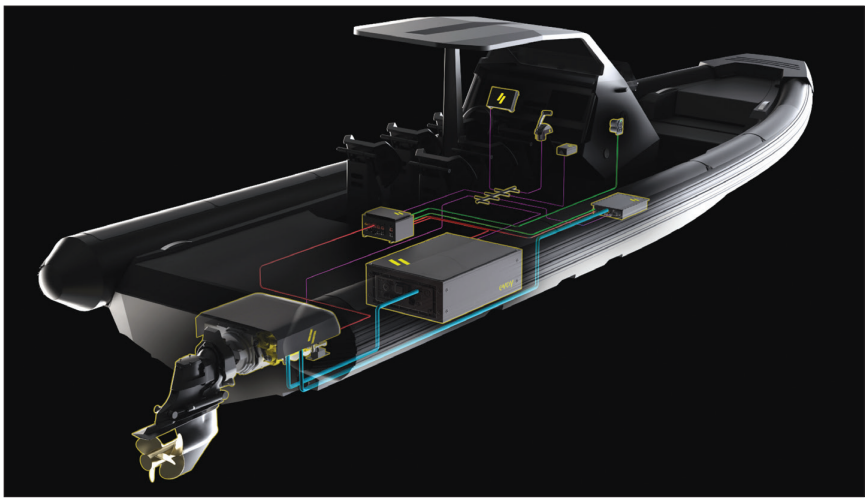
Cumming also mentioned fuel efficiency. Comparing the energy consumption of the EF-12 eFoiler with that of an identical nonfoiling sistership powered by internal combustion, his data showed that the electric foiling boat drew 6.53 kWh per nautical mile at 17 kts in flat water, while its nonfoiling sistership burned 38 kWh/nm. At 0.6m (2′) wave height and 17 kts, the eFoiler's energy draw increases slightly to 6.92 kWh/nm, while the conventional boat burned 52.1 kWh/nm, or 7.5 times as much.

With fuel supply critical for commercial and military operators, battery charging times were of special interest. Cumming said Artemis cooperates with customers "to deliver an optimal charging solution depending on their operational profile." Charging time varies according to vessel, he said, but a 320-kW ultrafast DC charging system can charge the EF-12 Workboat in an hour.

***Below**—Norwegian propulsion systems manufacturer Evoy demonstrated the Goldfish X9, a carbon RIB with two 400V Kreisel batteries and a 300-kW inboard system.*
***Right**—Trimmed for speed outside the harbor in flat water, the boat exceeded 50 knots with ease, as shown in this screenshot of the Evoy app.*



COURTESY EVOY (BOTH)



COURTESY EVOY (ALL)

The schematic shows the arrangement of the Evoy propulsion system in the tested RIB. Claiming simplicity and ease of installation, the company uses off-the-shelf components for motor and batteries but developed the operating software to integrate them.

Plugging In

Battery charging was also on the mind of Leif Stavostrand, the CEO of the Norwegian electric-propulsion-system integrator Evoy, who demonstrated a 9.7m (31.8′) Goldfish Explorer X9 RIB that topped out at 55 knots outside Gothenburg Harbor. At the end of a demo day, Stavostrand brought the boat to a public pier and connected a mobile charger pulling power from a 32-amp/400VAC outlet, which was inverted to 20 kW DC. At this rate it took approximately six hours to charge the 126-kWh Kreisel liquid-cooled lithium batteries (400V in series) that powered the boat's 300-kW Evoy Hurricane inboard, which is built around a permanent-magnet AC motor. The company currently offers outboards of 90 kW and 225 kW (120 hp and 300 hp equivalent) and inboard systems of 90 kW and 300 kW (400 hp equivalent), with 150-kW and 225-kW models coming in 2024.

Sitting on the bulkhead wall outside Eriksbergshallen, one of the HSBO venues, Stavostrand shared Evoy's strategy for a rapidly changing market with big players (e.g., Mercury) that had watched from the sidelines before making their move.

"Our focus is on electric propulsion to cut emissions and to create a nice customer experience by building an ecosystem around the boat," he said. This includes a touch-screen-based information system and an app to connect users with their boats (and Evoy) around the clock to offer real-time information and diagnostics, charging management, sensor readings, trip logs, shared boat access, and, in the future, CO_2 impact and geofencing.

On the builder's side, simplicity will win the day, the CEO believes. "We test each system at the factory before sending it to the builders. [The systems] have to be easy to install, because complexity is a source of mistakes." Evoy shares about 80% of components across the different propulsion systems and claims to reduce installation time by 50%.

It's been a fast trip from the humble beginnings in 2018 to putting a prototype in the water in 2019 and delivering the first Evoy-powered boats in 2022. Now the firm has 45 employees and boasts revenues of €20 m ($22 m), operating in a country where tax breaks and other incentives drive the switch to electric mobility. Reportedly 80% of new passenger cars sold in Norway in 2022 were battery-electric vehicles.

"Better to deliver systems to 5,000 boatbuilders than being boatbuilder 5,001," Stavostrand noted on one of his

Technicians work on various drivetrain components at the Evoy factory in Florø, on an island 145 miles (233 km) north of Bergen in a remote part of the Norwegian coast.

COURTESY EVOY (BOTH)

Left—*Working with boatbuilders that include Axopar from Finland, Evoy strives to develop a portfolio for commercial and leisure applications that also use electric outboards.* ***Right***—*Although its significant sovereign wealth stems largely from oil and gas production, Norway, under Prime Minister Erna Solberg, shown here on an electric boat with Evoy CEO Leif Stavostrand, continues its rapid adoption of electric mobility.*

slides, which listed an eclectic mix of boats that have Evoy's propulsion systems. He follows the strategy of Torqeedo, the German company that introduced small electric outboards with lithium batteries 20 years ago before adding larger systems. It took Torqeedo 18 years to sell 200,000 units, half of them in the last three years. Evoy is not yet in this league, but with some estimates projecting the global electric boat market to reach $15 billion by 2033, its timing looks fortunate. Stavostrand expects that growth curve to mirror electric cars with some delay

and reckons that electric propulsion systems above 38 kW (50 hp equivalent) will bring in most of the revenue and reach 18% of new boat sales by 2030. Helping along the way are decreasing battery cost and larger capacities (trending toward 200 kWh) and infrastructure that enables charging rates of 1C (one hour to charge from zero to 100%). European markets are leading the charge in those projections, but the U.S. is catching up. "Most of the inquiries [on] our website come from the U.S.," he said. "The plan is to start showcasing our systems in Q1 of 2024, and hopefully deliver the first system to customers before summer."

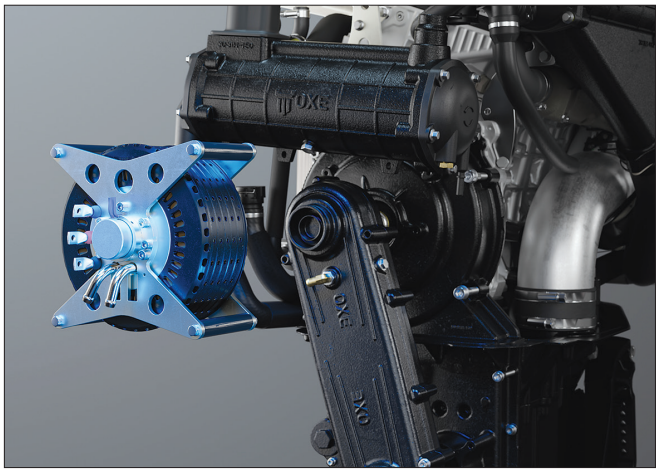
Apropos the U.S.: Unlike Seattle-based Pure Watercraft, which announced plans to build electric-powered, foil-assisted pontoon boats (see "Purely Electric, Foil Assisted," *Professional BoatBuilder* No. 204, page 8), Evoy is looking for partnerships with boatbuilders. Axopar from Finland, one of the largest leisure boat builders in Scandinavia, recently bought a 10% stake in Evoy during a strategic bridge funding round that raised €6.4 million and included €1-m equity investment from the European Innovation Council (EIC) Fund. But Stavostrand also knows how to get government attention. A candid photo shows him with Norway Prime Minister Erna Solberg taking a joyride on an Evoy-powered boat.

COURTESY OXE MARINE

Swedish manufacturer OXE has expanded its product line to include 6-cylinder diesel outboards based on a BMW 6-cylinder diesel engine, shown here mounted on a Nimbus cabin cruiser.

Diesel Outboards

My personal joyrides at HSBO included a trick at the helm of a Tideman HDPE workboat (see "Black



COURTESY OXE MARINE

The firm's marketing pitches traditional diesel's qualities but is also preparing for the rollout of the new OXE 450 Hybrid in early 2024. It combines a diesel engine with an electric motor and a lithium-ion battery.

Plastic Boats," PBB No. 179, page 46) that was powered by a massive-looking 300-hp diesel outboard by OXE Marine, headquartered at Ängelholm, 200 km (125 mi) south of Gothenburg. At first, the throttle work felt a bit like driving a BMW diesel, cultivated and pleasant with loads of torque, only louder. But that similarity was not just imagination—the powerhead is a marinized version of a 3-l, 6-cylinder turbocharged motor also found in the BMW 5 Series diesel cars (see "Diesel Outboards," PBB No. 179, page 8).

"It's mostly about design," said Paul Frick, OXE's new chief executive, who came from the automotive sector and previously was the firm's chief financial officer. "Having the crankshaft and the bevel gears in the lower unit is the same sort of challenge everyone needs to overcome," he said. OXE mounts the motor horizontally, which makes for a bulky appearance but has the advantage of the gear box being moved up and beefed up to better deal with torque.

Proving that it is possible to combine the convenience of outboards with the reliability and durability of diesel technology was the initial idea when OXE started as a company in 2012. It sold its first motors in 2016 and now does business worldwide, offering models of 150 hp, 175 hp, 200 hp, and 300 hp. OXE's sizeable presence in the U.S. spans a subsidiary (OXE Marine Inc.), and an assembly plant in Albany, Georgia. Customers include the U.S. Navy and commercial outfits like Penn Cove Shellfish in Coupeville, Washington. The parent company, OXE Marine AB, listed on the Swedish NASDAQ stock exchange, has a current market capitalization of approximately SEK 284 million ($25.5 m). At SEK 79.1 m ($6.8 m), sales for the first two quarters of 2023 were up about 3% above the same period in 2022.

With most military and commercial applications continuing to operate on diesel fuel, OXE promotes the benefits of traditional diesel: high torque, fuel efficiency (compared to gasoline), reliability and robustness, lower cost of ownership, and its ubiquity (a part of NATO's Single Fuel Concept) in developing economies with spotty logistics. At the same time, OXE also claims that diesel outboards can reduce CO_2 emissions "by over 35.5% to a comparable gasoline alternative, and when fueling with HVO100 [100% hydrotreated vegetable oil] or biodiesel, net CO_2 emissions are reduced by 94%."

High hopes for lower emissions are also riding on the Hybrid 450 outboard, a new product still being field-tested at the time of this writing. It combines the 300-hp diesel with a 400V 124-kW (150-hp equivalent) Axial Flux electric motor that has a 42-kW lithium-ion battery serving as a booster for the diesel and a battery charger as a zero-emission propulsion option. Discussions continue with battery suppliers about adding more capacities for different applications and usage. OXE calls it "the world's first diesel-electric-hybrid outboard," and it was presented at the 2023 Miami boat show, with a market release projected for the second quarter of 2024.

While the hybrid is new to OXE's lineup, the concept was introduced to the marine market some 15 years ago by Steyr Motors, the Austrian manufacturer of a parallel diesel-electric-hybrid inboard combining a marinized automotive monoblock diesel engine and a 5-kW electric motor that engages with the flywheel. The system offered diesel power, electric propulsion, and battery charging. It also used the e-motor as a starter motor and as a high-torque booster for the diesel. It was an option for the Frauscher 757 St. Tropez runabout and the Island Pilot DSe Hybrid power cruising catamaran, among others.

But why go hybrid, I asked Frick, when the migration toward battery electric propulsion is gaining momentum? "We started studying the full-electric option, looked at a typical application, and wanted the same sort of performance on this boat," he replied. "How big would the battery have to be? The calculations came out at 12 tons worth of batteries. It became clear that if our core market is commercial users who need functionality, they need a hybrid."

Pragmatic analysis of purpose and functionality is important to those who go to sea in small high-speed craft and risk life and limb to carry out dangerous missions. By nature these operators rely on thorough research that includes hands-on testing and listening to the opinions of peers before making decisions. That's why they attend HSBO.

This year attendees also had the opportunity to learn about foiling technology in a workboat context, try out a fast electric RIB, test diesel- and gasoline-powered high-speed craft, and see if production builders might be able to fill urgent procurement needs.

www.hsbo.org.

About the Author: *Dieter Loibner is editor-at-large of* Professional BoatBuilder, *a media partner of HSBO.*

In the Beginning

As a physician, scientist, and inventor, Johan Ullman brings to bear his multidimensional skillset at Ullman Dynamics, the firm he founded, to develop, manufacture, and sell ergonomic seats for high-speed craft; the goal is to reduce human exposure to the impacts from the hull's violent slamming, which can exceed the gravitational force equivalent of 20 g and cause musculoskeletal and brain injuries. (By comparison, a loop on a roller coaster creates 3 g to 4 g, and fighter jet pilots experience around 9 g flying radical maneuvers.)

These seats can be found on most boats at HSBO, and are used by boat manufacturers and government agencies around the world, including the United States Special Operations Command (SOCOM) and the Naval Sea Systems Command (NAVSEA).

"There is no positive training effect of overexposing people to impact. You don't get stronger; you wear out the cartilages or tear ligaments," Ullman told the crowd, making the case for looking at impact magnitudes and force vectors, not at mean values of vibration. "We must measure impact on the humans; measuring on a seat or a seat pad is not relevant. We have to strap sensors on the humans." Pain, he concluded, is the only physiological parameter predicting the risk of injury without having to stick needles into people. "When we have this information, we can advise people on how hard they can drive each type of boat." It's a quest that gave rise to the HSBO Forum, which has stayed true to its initial mission.

LEFT: DIETER LOIBNER; RIGHT: COURTESY ULLMAN DYNAMICS

***Left**—Johan Ullman poses with a member of the Royal Canadian Mounted Police, one of 400+ attendees from 27 countries. **Right**—Most demo boats are equipped with Ullman seats, which according to the company protect crew and passengers on high-speed craft from injury by body posture optimization and a shock-mitigation system.*

PBB: What sets HSBO apart from other symposiums that deal with high-speed craft?

This is the only place where you actually can try a number of boats and talk to a number of people to compare notes. Assessing a car or a boat, you want to get other people's input, and these are the most demanding users in the world that come here to learn from each other.

How and where did you launch the conference?

The first event, which was not yet called HSBO, occurred in 2003 on an island out here [Känsö,] in a 300-year-old quarantine station, a restricted area. There were two Norwegians, two guys from the U.K. Ministry of Defense (MoD), and there was a doctor

Demonstrations of robust HDPE workboats inside the harbor or on small submersibles with peers help delegates evaluate the exhibited vessels.

DIETER LOIBNER (BOTH)

DIETER LOIBNER (ALL)

Above—*From enjoying a buffet on the pier facing Gothenburg's city center, to trying virtual reality goggles* ***(bottom)*** *in the exhibit hall* ***(right)****, HSBO is in essence a networking event by invitation.*

from the surgeon general's staff in Germany, and a few Swedes, a total of 15 [attendees].

What kind of boats and equipment did they try out?

We put a steering bar system and a saddle-shaped seat on a boat with a single water jet. Well, the first one actually was an outboard, then we did it on one of the amphibious forces' 8m (26.2′) boats. The Brits tried to teach the German doctor to handle a waterjet and how to dock the boat. There was no way he could do that, but when they put him in exactly the same boat with a steering bar, he parked it like a little Volkswagen.

Did you have a product?

The Brits said they were building new boats, a small combat vessel with an open aluminum hull, and wanted these seats, but we didn't have any production at that time. And then the technical director of the Swedish Coast Guard asked if we could supply four seats.

So you had orders but no finished product?

The actual seat was a fiberglass structure. The [prototype for] the first saddle seat I made was an old police saddle on a wooden plinth. And the steering bar we cut off a lady's bicycle.

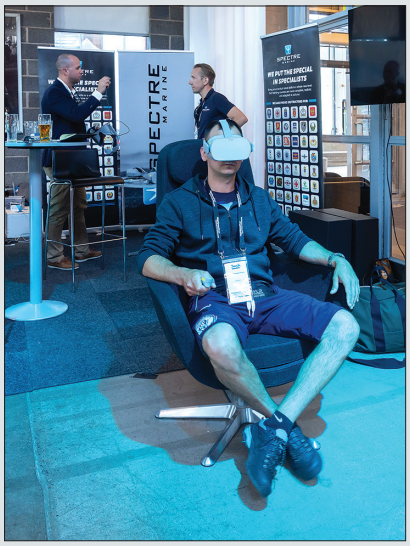
What's next?

Because we had had that little conference and the Brits came and standardized on our seats for the new series of boats, I told the boys, "Let's do a conference again. Let's book 25, 30 rooms in this area." Sixty people wanted to come in 2006, so we had to move it to another island. We had to be by the sea so we could have boats. It lasted from Tuesday lunch until Wednesday lunch, there were three, four guys in some rooms. Some were sleeping in a church, and people said, "This was the best conference we've ever been to. If you do this next year, we want to come."

So why not every year?

We were quite exhausted, even though it was a small event, and we did not think there would be enough new science or technical development to report, but maybe in two years. In 2008 we had 120 and were in the newly opened office for the Swedish Sea Rescue Institution, which is next door to Ullman Dynamics. We did it from Tuesday lunch until Thursday lunch, and it was fantastic. Next time we'd have 300 people, so we moved [to Eriksberg], because there is nowhere else in the world where you can do this. The critical mass is what makes this vibrate. Everyone is in the same place; you meet them for breakfast, for lunch, beer, and dinner [to network]. If you had to bus people to a dock and travel back and forth, it just wouldn't work.

(Ullman said he was invited to hold HSBO in other cities in Europe, Asia, and the U.S., and held it abroad in 2015 in Lisbon, Portugal. That event was well attended too, but logistics were difficult, so HSBO returned to Eriksberg, where hotel, restaurant, auditorium, conference rooms, exhibit hall, and marina are within a 100m/300′ radius.)



Would you change anything in the current format?

We could charge builders to show their boats, but we don't because we are depending on people who work in this environment with only a theoretical background to meet those who do the job in the darkness of the night so the rest of us can sleep safely. They need to see the boats and talk to the operators who know the business.

—Dieter Loibner

PBB