

UC San Diego

UC San Diego News Center

By Katherine Connor

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The UC San Diego Human Powered Submarine Team with the submarine they designed and built this year, named Vaquita.

Undergrads to Take Human Powered Submarine to International Competition

On July 2, third-year nanoengineering student Josh Gong will climb inside a 10-foot submarine built by undergraduate students at UC San Diego, hook up to an oxygen tank, and use a bicycle pedal to power the flooded sub through an underwater slalom course at the European International Submarine Races in England. He'll be racing against 11 other teams from around the world.

This feat of engineering—basically controlling the speed and direction of a torpedo underwater—is known as a human powered submarine. UC San Diego's Human Powered Submarine team is one of only a few dozen teams around the world up for the technical challenge. In fact, they elect to make it even more difficult by competing in the non-propeller category, using a tail and flipper to propel the sub forward instead of a propeller—the added engineering hurdle is part of the fun.

“Most of the science in propeller boats is figured out—everyone knows how propellers work and the math to optimize them,” said Benny Wu, a mechanical engineering student on the team. “We actually don’t know a lot about non-prop stuff. And there is a lot to learn about how fish and dolphins move, or biomimicry. It can be really fun to figure that out, partly because you feel like you’re a pioneer in the field.”

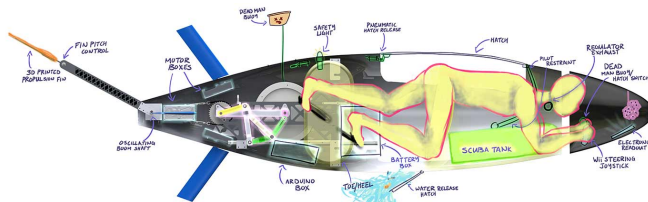
The team of 20 undergraduate students designed and built the submarine on their own time over the last year. Most of the students are engineers, though there are a few physics and applied mathematics students in the mix. Last year, the team built the third-fastest non-propeller sub in the International Submarine Races at the Carderock Naval Warfare Center in Maryland.

Building on that success, their goal for this year was to qualify for the European International Submarine Races for the first time. They got the green light in June, and in July will head to England with their sub, named Vaquita in honor of the critically endangered species of small porpoise endemic to the northern Gulf of California in Mexico.

This is the first time UC San Diego’s team is competing in Europe, but it’s not their first time in the spotlight. Subsonic, the human powered submarine the university competed with in 2000, broke the world speed record for a one-person non-propeller submarine, hitting a speed of 3.47 knots.

That record has since been broken, and this year’s team is hoping to go around 4 knots, roughly equivalent to 4.5 miles per hour.

Tobin Gutermuth, a structural engineering student and president of UC San Diego’s Human Powered Submarine Team, said the sub weighs 130 pounds out of water, and about 1,400 pounds when it’s fully flooded.



A rendering highlighting the technical components of Vaquita that the students engineered into the submarine to optimize speed and efficiency.

It’s a tuna, it’s a dolphin, it’s a.... submarine

The students made several major design and material changes to their sub this year. For starters, they’ve switched from trying to emulate the side-to-side motion of a tuna tail, and instead are mimicking the up-and-down sinusoidal movement of dolphins. The races in Maryland

only require contestants to speed in a straight line, whereas the race in England has an obstacle component that the sideways motion wouldn’t be ideal for.

“We came up with a linkage system in the submarine tail to optimize for a perfect sinusoidal force output,” Gutermuth said. “Linkage systems tend to jump, but this one was optimized using a genetic algorithm to optimize for a perfect sweeping motion.”

In another first, Vaquita's hull was made using vacuum assisted resin infusion with carbon fiber, which is a common manufacturing method for racing sailboats. They were mentored in this process by San Diego-based OceanAero, which makes unmanned maritime systems.

They're also using a different method to achieve buoyancy.

"One aspect with underwater things is you need to have your boat be neutrally buoyant," Wu explained. "There obviously will be stuff that will be negatively buoyant—we can't prevent that—so we offset that by adding in foam to the sub. We're trying a different process this year: instead of adding in foam to get it to the right spot, we're making it buoyant and then weigh it down to get it to the right spot."

It's a car, it's a fish.... It's a submarine

UC San Diego Visual Arts professors Rubén Ortiz-Torres and Pinar Yoldas, with Visual Arts facilities manager Tad Linfesty, worked with the Human Powered Submarine Team to give Vaquita a snazzy paint job. Ortiz-Torres, a photographer, printmaker and painter, first met the Human Powered Submarine team when they used the Kuka robot in the fabrication lab he runs for the Visual Arts and Structural Engineering departments to mill the composite tooling prototype for their sub.

"The students were very curious and interested in what we were making in the spray booth with custom car paint and smart materials, and, therefore, I offered to collaborate with them on the sub," Ortiz-Torres said.

His inspiration for the artistic design on the submarine came from low rider cars. Ortiz said he was buying materials at a paint store that produces custom car paint, and saw a customer buying materials to make fishing lures.

"I realized that the gaudy materials used to paint low rider cars are the same that fish are attracted to," Ortiz-Torres explained. "After seeing the shape and the design of the sub powered by a fin actioned by pedals, I figured we could make the most beautiful fish or low rider submarine, hopefully responding to both the aesthetic criteria of humans as well as sea creatures."

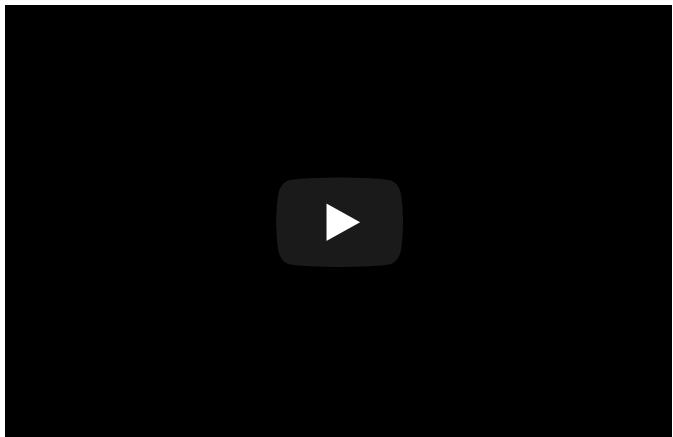
The submarine reflects an abstract, space-age version of a yellowfin tuna, with gold and blue hues representative of UC San Diego's colors.

Students, students everywhere

All of the ideas for improving the submarine, and the technical prowess to bring them to fruition, were student-generated. That's part of the fun of the Human Powered Submarine group, Gutermuth said—it's all students.

“It’s just us students, and we come up with the design on our own, we work it all out, make sketches in the beginning, make a design decision together and then we start building,” Gutermuth said. “This is our own creation, just a bunch of students who decide to do this in their free time for fun, because it’s exciting to make something of your own.”

Tamara Kawa, a mechanical engineering student who works on the human-submarine interface and also handles public relations for the team, said after two years with the Human Powered Submarine team, she’s a lot more confident manufacturing fiberglass parts, designing subsystems and working with various materials. She said she’s also gotten better at managing team logistics and the communications aspect of her role, but has most enjoyed the people she’s met.



“The most enjoyable part of the team is the friends I’ve made,” she said. “Even when things aren’t working or we’re running low on steam, we’re still holding our heads up and sharing jokes. We really do support one another, and I’m glad I work with such amazing people.”

Gutermuth said he also enjoys devoting his free time to the human powered sub because it’s a novel engineering challenge.

“I think it’s super fun to be doing something that not really anybody else is doing,” said

Gutermuth. “I don’t know if there are any other people in the world building a human powered sub that works like a dolphin.”

They can’t do it all on their own, however, and are launching a [GoFundMe campaign](#) to help fund the shipping expenses to get Vaquita and the required five team members to and from England: unfortunately, they can’t pedal it across the Atlantic. The GoFundMe page features photos and videos of the submarine during the building and testing phases.

After securing funds, their next challenge is developing autonomous steering so the submarine can control its pitch, and the pilot can focus on steering.

“There’s a concept in aerospace engineering called fly-by-wire, using electronics to help pilots control aircraft,” Wu said. “In 4th generation fighter jets, this was used so that inherently unstable airframes could be used, and planes could be maneuverable without becoming too uncontrollable to fly; computer controls assisted pilots in this. We’d like something similar, ‘swim-by-wire’, especially since dolphin flippers and tuna fins moving back and forth are inherently unstable.”

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