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Stealth and Speed: Welcome to Supercavitation

Underwater Express Moves Ahead

By Nick Adde

When a mission demands rapid movement of personnel or assets, the U.S. Navy must rely upon conventional aircraft or rapid surface transports. When stealth is critical, aircraft or submarines do the job. But in all instances, key tactical elements are sacrificed: speed for stealth with noisy aircraft and surface vessels, for example, or stealth for speed with submarines.

Enter the Super-Fast Submerged Transport program, known familiarly as Underwater Express. Sometime in the not-too-distant future, scions of Underwater Express could enable the Navy to stealthily transport SEALS or equipment underwater at speeds that can't be matched by present watercraft.

Now under development by a partnership that includes the Naval Undersea Warfare Center at Newport, R.I., the Naval Surface Warfare Center at Carderock, Md., the Defense Advanced Research Projects Agency (DARPA), General Dynamics, and several other contractors, with input from a couple of engineering schools at major U.S. universities, the first scale-model prototypes of Underwater Express should be ready for testing sometime next year.

Before Underwater Express can work as advertised, researchers, engineers and designers must first resolve issues involving the supercavitation technology that is essential to achieving and sustaining its speed.

Essentially, a supercavitation vehicle like Underwater Express can move quickly by generating a more or less parabola-shaped vapor barrier, or "supercavity," which emanates from the nose cone and envelops the entire vehicle.

At lower speeds, gas injection would likely create the water vapor "cocoon" necessary for supercavitation. At higher speeds, gas, exhaust from the vehicle's power plant, or both, would generate it, depending upon how the vehicle is designed.

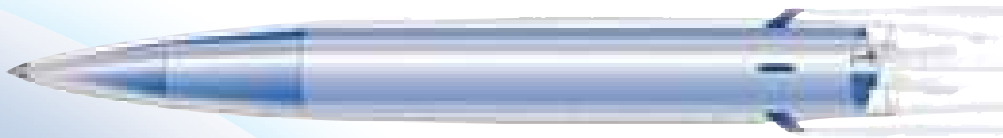
Because the vehicle meets resistance from air rather than water, it is in theory subject to significantly less drag. In turn, that translates into more speed and better fuel efficiency, all while operating in the same quiet and invisible environment as submarines. Radar would not be able to find it. Rough seas would not hinder its deployment or mission-execution schedule.

The technology is by no means new. At least two U.S. engineering professors, recently retired Marshall Tulin of the University of California-Santa Barbara and fluid dynamicist Roger E. Arndt of the University of Minnesota, began contemplating the practicality of supercavitation in the 1950s. In academic and commercial venues, Tulin played a key role in the development of supercavitating propellers for maritime uses, to move vessels through water more efficiently. Arndt is still actively working on the development of a prototype supercavitation vehicle.

"People have been doing it for awhile, but [the vehicles have been] pretty much straight runners," says Franz R. Edson, the director of submarine payloads, sensors and strategic weapons systems at General Dynamics. "They don't change speed and don't go for very long."

Better than Shkval?

The Soviet Union went so far as manufacturing and deploying the Shkval (translated "squall") torpedo in the 1990s. It is said to move as quickly as 500 kilometers an hour, once it reaches a speed



A notional idea of what Underwater Express might look like. General Dynamics has not released images of its vehicle.

sufficient to generate the supercavitation space. Shkval is now a mainstay of the Russian navy's weapons inventory, not to mention a popular item on the international arms market. China and Iran both have Shkvals in their fleets.

But while Shkval is easily the fastest and most dangerous torpedo in the world right now, it lacks maneuverability.

"The Russian [torpedo] works with spring-loaded pads that touch the cavity," says Gary Balas, the head of the Aerospace Engineering and Mechanics Department at the University of Minnesota. "They're always centering the vehicle by dynamically moving it as it rides through the water."

Planners have loftier goals for Underwater Express, as well as what they say is both the steady funding and realistic timetable necessary to meet their initial milestones.

With $20 million from previous U.S. Defense Department budgets to work with, the Underwater Express team at General Dynamics and its government, academic and industry partners are building a quarter-scale model of an eventual prototype. With it, they will evaluate controllability, speed and endurance challenges.

"We're designing and building a free-running vehicle, about two feet in diameter and 24 feet long, to run out on a range to show that we can actually control [it] while supercavitating," says Jennifer B. Panosky, who has oversight over Underwater Express as the program manager for advanced programs and future payloads with General Dynamics.

Next year's tests will take place in Narragansett Bay, just off the coast of the Navy's undersea warfare facility at Newport, and should conclude by the end of May.

"This is not a demo of any kind of specific autonomous behavior," Panosky says. "No sonar. We're just going to send it out there to run and show supercavitation."

The goal, Panosky says, is to show that Underwater Express can be controlled at a depth change of 10 feet, plus or minus one foot, as per DARPA's requirements.

Once complete, the project will move into "Phase III" (the initial test being a combination of the first two original phases) almost immediately. This time, the goal will be to make the prototype model travel at a speed of 100 knots for 10 minutes.

A deployable vehicle, capable of moving personnel and gear, is still years away. The DARPA program's goal is to prove supercavitation works, not to develop an autonomous vehicle.

Some observers are not sure that supercavitators will ever emerge from the concept stage into vehicles the Navy can actually use. To

operate more efficiently than conventional "fully wetted" vehicles, they say, a supercavitator must prevent drag by generating a cavity in front that would keep the rest of the hull out of contact with the water. But that cavity will generate considerable drag of its own.

Another potential problem, some experts say, surrounds power generation. For a supercavitating vehicle to move through the water rapidly as intended—fully navigable, and able to operate at varying depths—it will need a very-high-density power plant. Adapting supercavitation-capable engines to smaller vessels, as envisioned by the Navy, poses a stiff challenge, some observers say.

Such challenges do not daunt the people working on Underwater Express. Both Panosky and Edson say that the government selected the General Dynamics vehicle in September 2008 instead of one submitted by a competitor because it contains a proprietary system that will soon be classified. Other than that, they are not saying much else.

"If the technology would really work, it would be revolutionary," says Edson. But, he added, "Jen and the team proved that this revolutionary technology does work and that we can increase the endurance given a fixed volume [of space] for fuel."

For government support to continue beyond Phase III, Edson says, the development team must prove that the capabilities they will have demonstrated on a small scale will work on full-size prototypes and vessels.

With larger size vessels, factors such as equations of motion, controllability, actuation of control surfaces and dampening of oscillations caused by surface ocean movement in shallow environments will happen more rapidly than with the scale models.

"We're confident we will work through it," Edson says. "Other than that, it's nuts-and-bolts on how to incorporate the technologies of the unmanned vehicle."

Freelance writer Nick Adde has covered technology and personnel matters, primarily relating to the U.S. armed forces, since 1983.

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