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Tom Kleindinst/WHOI

“It was completely possible to dive in the old submarine and never turn a computer on. Everything could be controlled by the pilots with analog controls and simple mechanical switches, including the driving.

Most of the work I've done at the Deep Submergence Lab at WHOI over the past 24 years has been on *Jason*, *Nereus*, and other remotely operated vehicles, or ROVs. For those, there's nobody down there to flip a switch. Commands are relayed from the surface via fiber-optic cables. When the idea of WHOI doing the new submarine came up, they came to some of us at DSL and said, 'We'd like you to offer *Alvin* pilots the same kind of automation you have provided for ROVs.'

Louis Whitcomb, a colleague at DSL and The Johns Hopkins University, had already added the capability to navigate the old submarine using a program called DVLNav and a sensor called a Doppler Velocity Log, or DVL. It measures the Doppler frequency shifts of sound transmitted and reflected off the seafloor to automatically calculate the sub's speed.

We wrote some new software that integrates DVL information with data from all the other sensors on the sub—for example, the gyroscope that tells what direction the sub's pointed in, pressure-based depth sensors, and altitude sensors that tell how far above the seafloor the sub is. The software integrates all this information and continually calculates the sub's position. It distributes the information to the pilots in real time and also makes it possible to automatically control the sub's thrusters.

That allowed us to add a variety of automatic functions similar to those we had been using on the ROVs. So a pilot, for instance, can dial in that he wants the sub to maintain its position over a certain spot to collect a sample, even in a strong current. Or head the sub in a particular direction, or go to a certain altitude above the seafloor. The pilot can say, 'I want to spin on one spot' and command the sub computers to make it happen.

All of these maneuvers require an awful lot of concentration on the part of the pilot to do without computer assistance. If you let the computer do it, it takes a lot of workload off the pilot. That's completely new on the submarine.

We also added computing systems in *Alvin* that do what we call 'housekeeping' functions. These continuously monitor the sub's electrical systems and check for ground faults or leaks, and turn things on and off.

Of course, the pilots also have a regular system of checks that they do to make sure things are functioning well. That's a key difference between an ROV and an HOV, a human-occupied vehicle. We've added automation, but without jeopardizing human safety. Even though we have software and computers, there are still mechanical switches that the pilot can flip and know unambiguously that things are either on or off. He can still drive the submarine and return to the surface with no computing whatsoever. You can turn off all the computers, and you can still get home. ▲