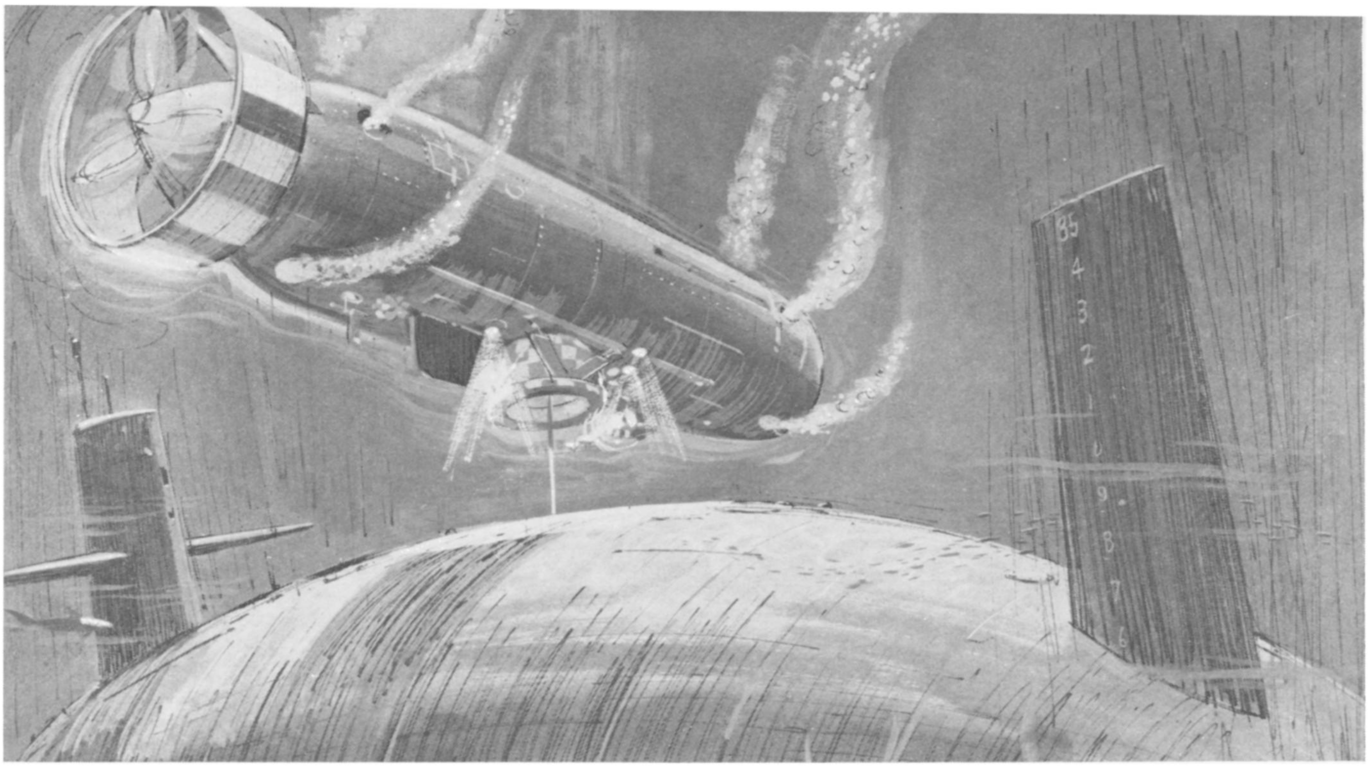


Northrop/Bob Peck

MARINE ENGINEERING

Hope for disabled undersea vessels

by Charles LaFond

Every military sea power throughout the world faces the threat of a submarine loss with each dive. This is an accepted fact in the life of the submariner.

Of the many thousands of undersea boats in operation since World War I, the majority lost at sea have been the result of military action and have suffered pressure hull ruptures from munitions or ramming. Under wartime conditions, crew rescue is far from common and losses are expected.

But since 1920 more than 1,000 men have died in 29 submarines accidentally sunk at depths above their hull-collapse limits. Yet U.S. Navy officials estimate that all of these disasters offered at least the possibility of crew rescue: Nearly half of the vessels subsequently were salvaged.

Growing numbers of military submarines, added to a proliferation of nonmilitary, unregulated submersibles for oceanographic, commercial or amusement applications, have made the lack of a deep-water rescue capability more acute. The situation prompted the Navy in 1964 to start an advanced vehicle development program to provide a solution.

If its present schedule is maintained, the Navy will have two prototype Deep Submergence Rescue Vehicles (DSRV-1 and -2) ready for operation by 1972 or 1973. These will be the forerunners of a force of six craft the Navy ultimately would like to have for deployment in pairs around the world, at roughly equidistant bases.

DSRV-1 was launched at San Diego, Calif., on Jan. 24 and is now undergoing shallow-water builder's trials. Its sister craft is in final construction by the prime contractor, Lockheed Missiles and Space Co., at its Sunnyvale, Calif., facility.

Measuring nearly 50 feet in length overall, the DSRV is designed to carry a three-man crew and have a capacity for retrieving 24 survivors at a time from a stricken submarine. Its maximum operating depth is 5,000 feet, well below the collapse depth of even the best military submarines, according to Navy sources. Thus, the craft will have a secondary mission capability for deep search and recovery or salvage.

In a typical rescue operation, a Naval Operations Command, upon receiving word of a sunken or uncontrollable submarine on the ocean bottom, would assign the nearest available DSRV pair to the mission. Surface support ships would be dispatched to the accident site and nuclear mother submarines, required to transport the DSRV's piggyback, would be sent to rendezvous with the rescue vehicles. Two DSRV's are deemed necessary by the Navy to assure reliability—and when operable, the rescue time required could be nearly halved by sequencing their operation.

Each 65,000-pound DSRV, with its specially built flat-bed trailer, would be loaded aboard a Military Air Command C-141 cargo plane and flown to a designated port. There it would be trucked to the dock, off-loaded by crane onto a cradle of pylons atop the mother submarine, and latched.

Travel to the disaster area would be submerged at speeds up to 15 knots. At the accident site, the DSRV would detach itself from the transport submarine and, using its sensors, approach the stricken vessel. The submarine would hover nearby to receive survivors. Nearing the disabled craft, the DSRV would maneuver over either the forward or aft escape hatch, settle down on it, and latch securely.

The mating section, an airlock, would be blown free of water and the hatches opened to receive the first 24 crewmen. Oxygen tanks would be passed through to assure a safe atmosphere in the submarine during the rescue operation. With the hatches closed and the pressure again equalized, the DSRV would disengage for its return to the mother vehicle, remating and transferring of survivors to safety.

American submarines carry crews of from 100 to 160. The expected rescue cycle time is about two hours—that is, from mother sub to disabled sub and return. Because of a battery power supply limitation, the DSRV would have to be recharged by the mother submarine after eight hours of operation. Therefore, if more than four trips were necessary for crew evacuation, total rescue time would be from 10 to 14 hours. Two DSRV's operating from the same hatch sequentially could reduce total time to about eight hours and avoid the recharge time delay.

Weather and sea state permitting, survivors could be transferred to a surface ship, or they could remain aboard the rescue submarine for return to port.

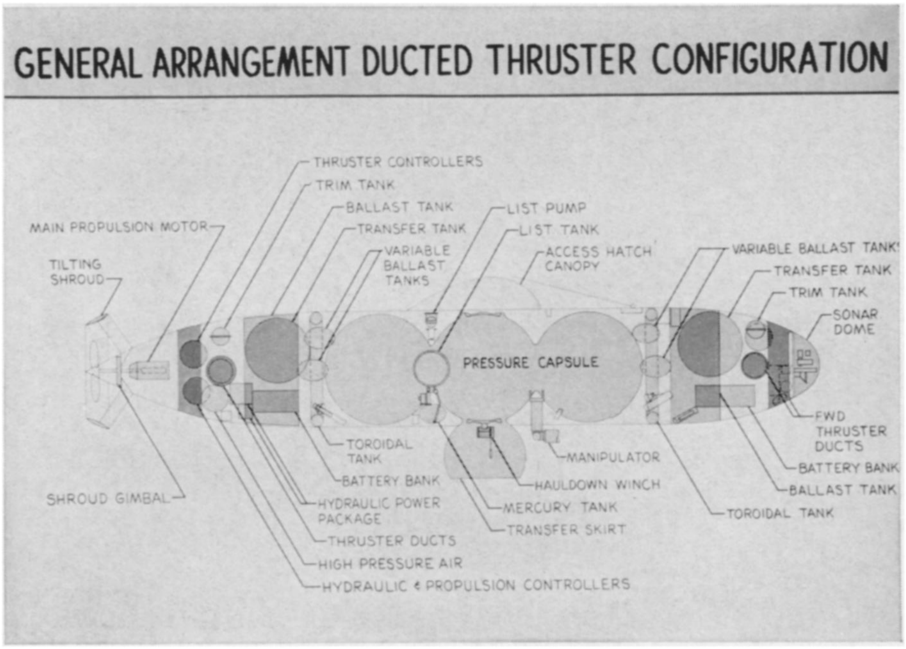
Building the prototype vehicles has not been easy. Early in the program military planners expected that most subsystems required would be commercially available by the late 1960's, but the contrary proved to be true: Every major subsystem—propulsion, navigation and control, external sensors, life support, external manipulators—had to be designed to meet the mission and environmental needs, assuring high reliability. Some ready-made equipment actually was procured; without exception each was later found unacceptable, according to the Navy.

Even welding proved to be a problem. The pressure hull of the DSRV is formed by joining three 8-foot-diameter spheres in line. The steel employed, HY-140, was relatively new and little was then known about its handling characteristics. Much time was lost just in learning how to weld the material to assure a collapse limit of 7,500 feet.

Another troublesome problem was encountered with the craft's outer shell, which gives it a streamlined shape and encloses the subsystems that are outside the pressure hull. The shell was finally fabricated from a glass fiber-reinforced plastic sheet of heroic proportions.

The result of these and other developmental difficulties was predictable: An enormous cost increase, estimated at 250 to 300 percent, is forecast, due to contractor overruns and design changes sought by the Navy. In 1964 the Navy planned a program to build six vehicles, each with a 12-man rescue capacity, at a total cost of $119 million. At present the two prototypes plus all associated testing, training and support-ship modifications are projected to $220 million through 1975. A six-boat force would require $480 million, Dr. Robert A. Frosch, the Navy's Assistant Secretary for Research and Development estimates. Even with inflation, the cost is staggering, he admits.

Because of the cost increases, the DSRV has come in for its share of Congressional criticism. Dr. Frosch had to defend the higher-than-planned expenditures before Sen. William Proxmire's (D-Wis.) subcommittee on economy in Government late last year. But the need for the vehicle was so great and so obvious that the program continues.



Navy

Three-sphere pressure capsule houses crew, control system and survivors.

Vehicle design is such that the forward chamber of the three-sphere hull accommodates two operators and the sophisticated Integrated Control and Display system, designed and developed by the Instrumentation Laboratory of Massachusetts Institute of Techology. The third crewman remains aft in the survivors' dual chamber.

Propulsion power and auxiliary electrical power are provided by silver-zinc batteries which can be recharged—they have a maximum charge life of 13 hours. The life support system for oxygen supply and removal of carbon dioxide and excess humidity is good for 36 hours.

Electric motors at the stern drive a propeller for primary thrust. Around the blades is a tiltable circular shroud that provides directional control; neither the rudder nor diving planes employed by conventional submarines is needed. Maximum speed is 4.5 knots.

In addition there are ducted thrusters at the bow and stern, two horizontal and two vertical, for attitude control and fine maneuverability. For trim and list control, the craft employs both liquid mercury ballast and a variable water ballast system. The ascent/descent rate is 100 feet a minute.

A hydraulically powered external manipulator is controlled by the crew forward and is directed visually from the bow viewports or by means of closed-circuit television enhanced by floodlights. Primarily intended for moving or cutting away debris that might interfere with the mating operation, it also is designed to grasp and lift objects weighing up to 250 pounds. Greater loads are possible using vehicle lift.

The MIT control system pumps an array of internal and external measurements into a computer, which then controls the vehicle automatically in all three spacial axes, and displays the data immediately to the operators. The major attitude and navigational sensors are an autopilot and a miniaturized inertial guidance system that provide velocity and directional inputs to the computer. External sensors include the TV cameras, a beacon system and Doppler, narrow-beam and short-range sonars.

Final maneuvering to mate the vehicle with another, despite all the onboard gadgetry, can only be accomplished manually. For this intricate operation, closed-circuit TV and the precision short-range sonar, directed downward from the mating skirt, are used. A grappling hook and powered winch can be used for the last few inches if the current is troublesome or if the disabled craft is listing heavily. Docking can be accomplished at angles up to 45 degrees from the horizontal.

Deepsea testing of DSRV-1 probably will get under way in October or November, according to Samuel Feldman, head of the Navy's Vehicle Branch, Deep Submergence Systems Project. Builder's tests, which began early in the spring, are directed by Lockheed, but the crews are Naval personnel. In this way test and evaluation also serves to train the 14-man full complement assigned to each vehicle.

"No serious problems have been encountered so far," Feldman says, "but

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Vehicle and trailer fly together.

the usual rash of small difficulties have shown up as expected." For the DSRV, however, multiple failures do create a time loss because each must be corrected sequentially due to space limitations and the total integration of subsystems.

The first deep dives this fall will be attempted off San Clemente Island near San Diego. A test fixture for mating purposes, to be anchored on the Pacific floor, can be oriented to angles up to 45 degrees off horizontal.

Initially, the DSRV-1 will be restricted to a maximum depth of 3,500 feet, Feldman says, because of a depth-simulation limit imposed by the only test tank available when the pressure hull was completed. DSRV-2, to be delivered late this year, will be able to go to full depth. Its hull was fully checked out in the new tank facility at the Annapolis [Md.] Naval Ship Research Laboratory.

Depth tests at sea will be accomplished in increments of 500 feet to minimize danger to both crew and vehicle. The technical evaluation program, developed by Northrop Corp., involves a full year of test operation for each craft and is intended to prove the acceptability of all subsystems and operating capabilities.

Testing with a mother submarine will start late next spring with the USS Salmon, a diesel-powered vessel. Meanwhile, 24 nuclear attack submarines are being outfitted to carry the DSRV and several of these will be used in final evaluations, Northrop officials say. Support will be provided by the new rescue ship USS Pigeon and the Lockheed-owned Transquest, an oceanographic ship. □