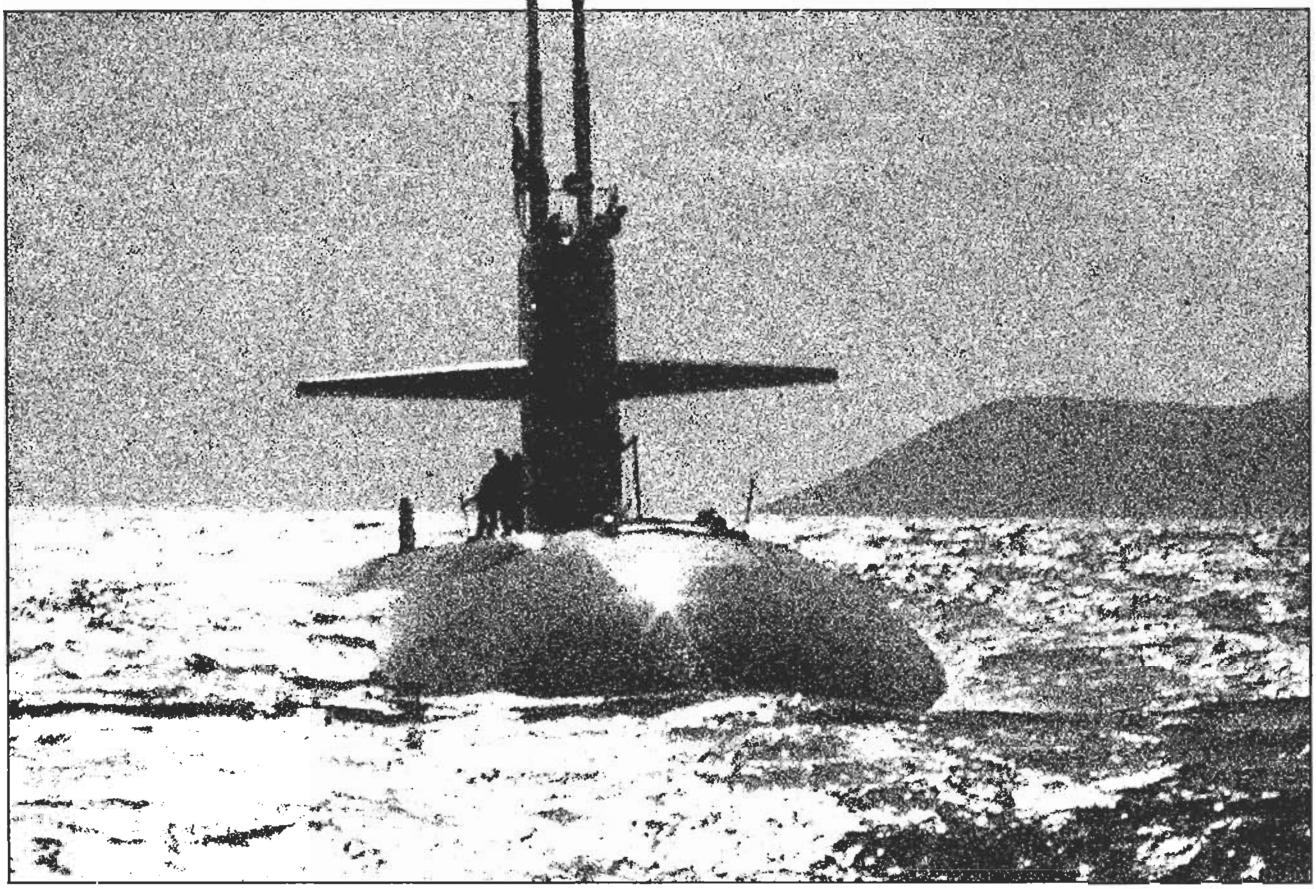


Understeer, Oversteer, Undersea

We join the hunt for *Red October.*

BY CSABA CSERE

• Our home for the next three days, the nuclear submarine USS *Dallas*, looked barely afloat. Lying low at pierside, she showed no bow, stern, or beam—just an ominous rounded shape that curved into the wavelets lapping at her exposed surfaces. The phrase "a fish out of water" came to mind—and not surprisingly, for the USS *Dallas* is designed to operate submerged, not afloat. Lying on the surface, she is as out of her element as a fighter plane in ten feet of water.

Designated SSN 700, the *Dallas* is destined to become the most famous nuclear sub since the *Nautilus*. Now a legitimate movie star, the *Dallas* is the American submarine portrayed in *The Hunt for Red October*, the film version of Tom Clancy's novel of undersea warfare. (A sister ship was used for the actual filming.)

The *Dallas* is one of the United States Navy's 45-vessel fleet of *Los Angeles*–class nuclear attack submarines, the most sophisticated and deadly attack submarines in the navy—and, by most reckoning, the world. Packed with torpedoes, she represents the most potential destructive power it's been our privilege to test-drive.

Her capabilities are extraordinary. So self-sufficient that she can sail completely around the world underwater without stopping for fuel, air, water, or food, the *Dallas*'s entire 360-foot length is as densely packed with sophisticated machinery as a Porsche 959.

Little of this machinery is visible on deck. A vertical structure once called "the conning tower" rises from the hull. Today, submariners call it "the sail." A clutter of mooring lines attached to retractable blocks complete the few exterior attractions.

PHOTOGRAPHY BY LARRY GRIFFIN

Going below, we begin to appreciate the ship's mechanical density. The ceilings ("overheads," in naval parlance) are covered with a thick mat of cables, wires, hoses, ducts, valves, switches, and brackets. Headroom compares to that of a doorway in your home. Lateral space is also tight. As we deposited our gear on one of the tables in the roughly fifteen-by-twenty-foot dining hall (crew's mess), a sailor told us that we were in one of the largest rooms (spaces) on the submarine.

A long corridor (passageway), barely two feet wide, leads to the forward crew quarters, where we will sleep. When meeting someone in the passageway, you must pancake against the wall (bulkhead) to allow passage.

The sleeping quarters redefine the words "limited space." Bunks (racks) are stacked three high and end-to-end, with less than two feet between rows. Entering one taxes your flexibility and rewards you with the spaciousness of a coffin. Eighteen inches separates your thin mattress from the bottom of the rack above, and you lie on about 26 inches of rollover room. Only the legroom feels generous.

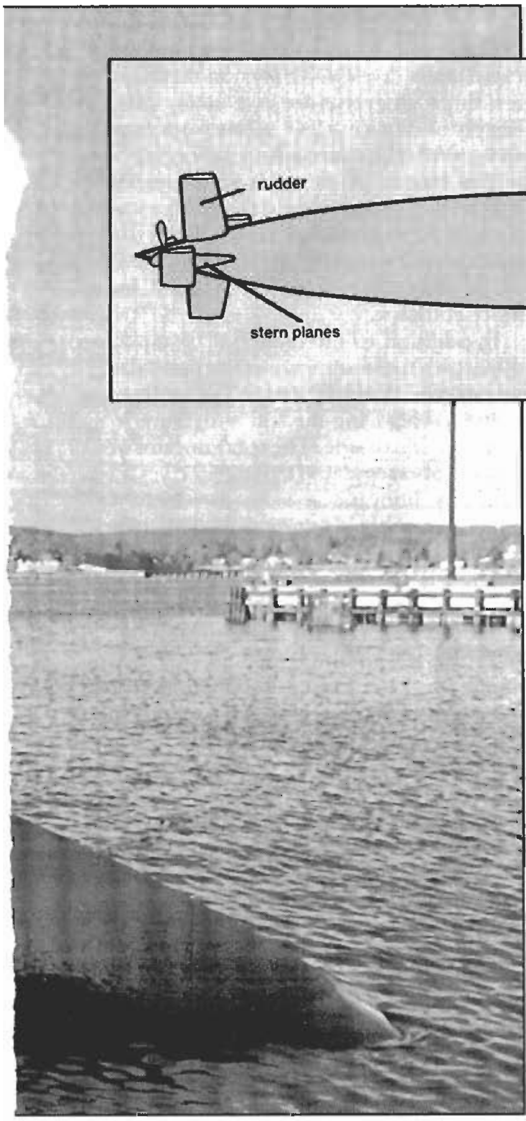
Pulling the rack's curtain provides a bit of privacy; each rack has its own reading light. A small storage box hangs above your feet and stores emergency breathing apparatus—for use should acrid or poisonous fumes unexpectedly fill the space. The light is well placed for reading, but you must wedge your book between your chest and the rack above.

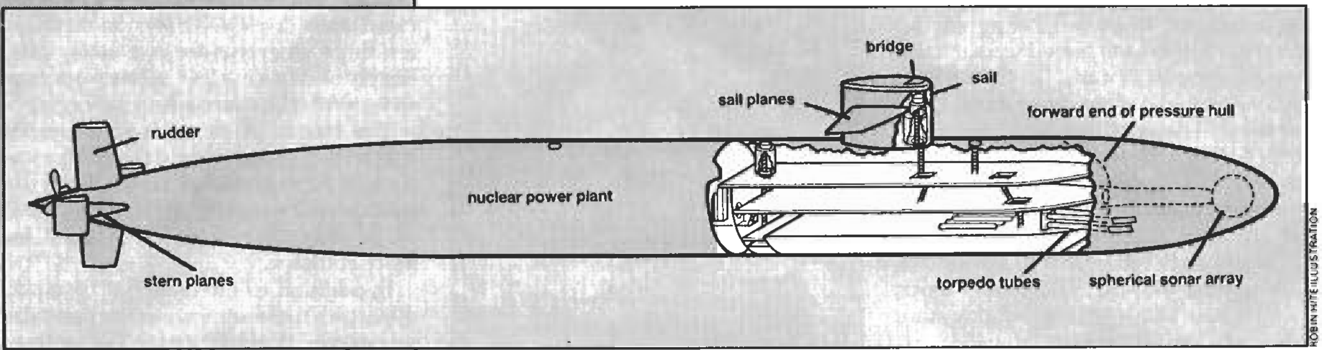
Lift the rack's mattress and you'll find a hinged panel. Lifting the panel reveals a storage area some two feet wide, seven feet long, and maybe five inches deep. This can hold either an ironing board or your worldly possessions.

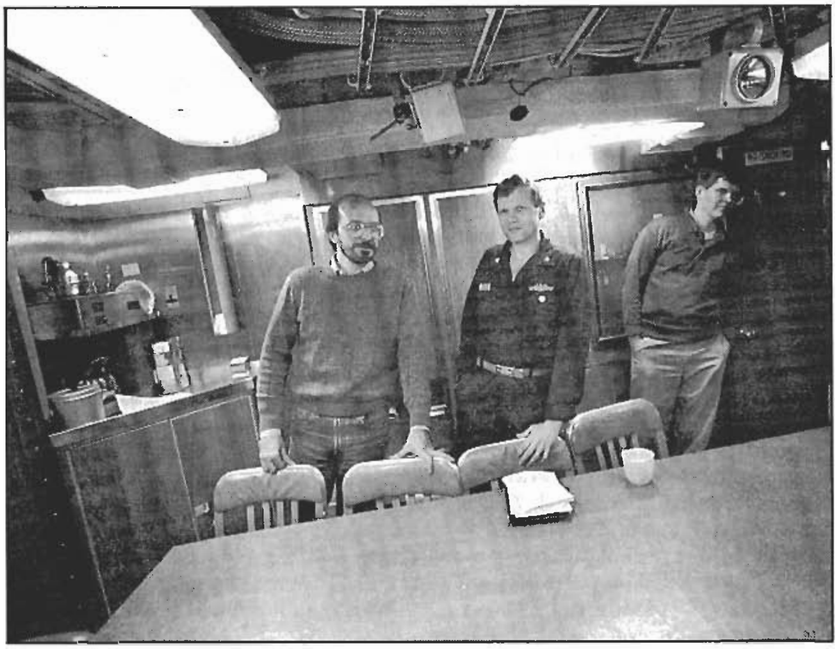
That's if you're lucky. The *Dallas,* we learn, doesn't have enough racks for all of her 115 enlisted men. Eighteen of them must either coordinate rack time with the schedules of other sailors or sleep on mattresses stuffed in random passageways or in unused torpedo slots.

Other facilities are similarly cramped. The crew's shower is so tight that one must exit in order to retrieve a dropped bar of soap. The three crew's toilet areas (heads) are similarly constricted. In a space ten feet by six feet, shipbuilders have shoehorned two showers, two toilet stalls, one urinal, a counter with three sinks, and two doorways (hatches).

One might ask why a vessel as long as a football field, with a width (beam) of 33 feet, displacing 6900 tons submerged, and containing three decks doesn't have more space for its 127-man complement. One reason is that the cylindrical pressure hull, which protects the crew and







The Dallas, left, prepares to leave its home base in New London, Connecticut. Even modest ten-degree dives, above, are obvious to everyone aboard.

most of the machinery from the ravages of the sea, doesn't run the full length of the ship (see diagram). Between the bow and the populated area lie a series of ballast tanks and a large spherical detection device that looks like a water tower lying on its side. Another series of ballast tanks lie between the vessel's rear (stern) and the pressure hull, along with the propeller shaft and the hydraulics used for moving the stern control surfaces.

Of the internal space remaining, more than half is devoted to the nuclear power plant. We weren't allowed into that area, but anyone who recalls photos of Chernobyl can see that cramming an atomic power system into a 33-foot-diameter tube is no easy matter.

The power plant uses its atomic pile to generate heat. Highly pressurized water transfers this heat to a steam generator that powers a series of turbines. The turbines spin the submarine's large single propeller and also power generators that produce the electricity needed to run the submarine's operating systems.

The payoff is an estimated 30,000 horsepower, enough to push the *Dallas* through the water—submerged—at more than 30 knots, according to the latest edition of *Jane's Fighting Ships*. The reactor provides energy for about ten years, meaning that the sub's cruising range is limited largely by its food supply. Beyond owning large numbers of cutting torches, the navy is said to make no provision for refueling the reactor.

Which brings us to the critical issue of hull integrity. Fabricated from HY80 high-strength steel 1.75 inches thick and reinforced by heavy internal rings located every few feet of its length, the hull must withstand the immense pressure created by the weight of the sea. How much pressure? That depends on depth.

"Why don't we say that these subs can dive deeper than 400 feet and just leave it at that," an officer told us. *Jane's* puts the *Dallas*'s limit at 1475 feet. At 1475 feet, the ocean would exert a pressure of 650 pounds on each square inch of the hull. Pressure actually compresses the hull, and the *Dallas* loses 50 cubic feet of volume for every 100 feet it descends.

Space is scarce everywhere, including the control room—the vessel's nerve center. About twenty feet square, with electronic consoles and control panels impinging two feet from each bulkhead, its center is dominated by periscopes and a pair of map (chart) tables. It's a densely packed office for the fifteen persons who normally control the ship.

As we pull out of the navy's sub base at New London, Connecticut, noise rises in the control room. We hear constant ranges and bearings being taken through the periscope, reports of other vessels' positions, and the pulsing beeps of radio direction finders, all aimed at maintaining an accurate plot on the chart of the *Dallas*'s position as we move down Connecticut's Thames River. The level of activity during what we thought would be a routine task approaches the intensity found in a Formula 1 pit on the last day of qualifying.

"If you don't run your ship aground or hit anything with her, your career tends to advance. That's why everybody stays keyed up," an officer later explained.

Once free of the river, the *Dallas* will run on the surface for several hours until it's beyond the continental shelf and in waters deep enough for safe diving. We use this time to tour the sail bridge. One look at this open-air station reveals the extent to which a modern submarine is optimized for undersea rather than surface operations. Ahead of us, the sub's rounded bow is totally submerged, with water flowing smoothly back toward the sail—beyond which it turns into a frothy, turbulent wake. The deck is awash, and even with lifelines it would be impossible not to be washed overboard.

The bridge, at the forward end of the sail's top, is marginally more comfortable than the deck. There's an open well three feet wide and two feet long that two persons fill entirely, especially if they're bulked up with winter foul-weather gear. Behind the bridge, a lookout can stand on the slightly convex top of the sail—albeit aided only by a railing and fully exposed to the cold sea wind. All of the periscopes and the masts for communications gear and electronic countermeasures lie within the sail and beneath flush housings or covers, leaving a smooth surface to face the ocean.

Driving the Dallas is like flying on instruments—with no seat-of-the-pants feel.

Even with relatively mild seas, waves frequently smash against the sail, salting everyone with spray. The sub rolls gently, although its perfectly round hull causes it to hang longer at the extremes of its roll angles than surface ships do.

Prior to submerging, crewmen remove the bridge windshield and cover the bridge well. All this would hamper the rapid crash dives we've seen in the movies. But such events are rare in any case, largely because nuclear submarines usually spend entire missions submerged.

The theory of diving is conceptually simple. Valves are opened that let sea water into the main ballast tanks. When the submarine's weight exceeds its buoyancy, it sinks. The actual mechanics are more complex.

In addition to the main ballast tanks, other trim tanks are scattered around the submarine. Water is pumped in and out of them, balancing the sub both front to rear and side to side. The total amount of water is also regulated to make the vessel neutrally buoyant, a state in which it tends to neither rise nor sink. This balancing act must be repeated every time a weapon is fired, sewage is dumped, or the density of the ocean changes.

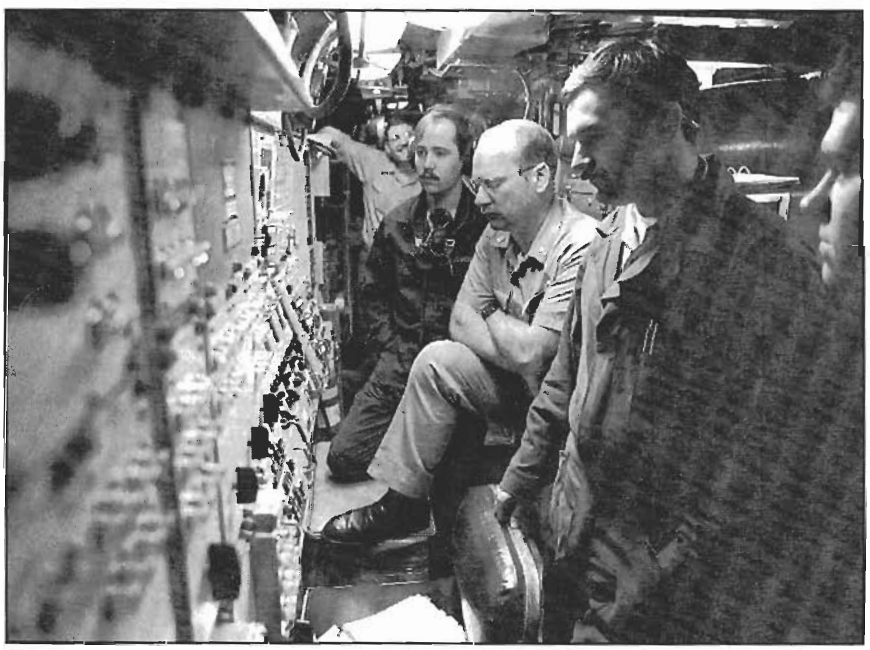
We feel no pressure change that indicates the submarine is diving. A feeble imitation of the klaxon horn familiar to moviegoers sounds over the intercom, the submarine adopts a slightly nose-down attitude, and we eventually level out. Because wave action is a surface phenomenon, the submarine soon becomes very smooth and steady. Other than that, we have no sense of being submerged. Just as on the surface, all lighting is artificial and the loudest sound is the muted whir of the ventilation system.

Once underwater and properly trimmed, the submarine's depth and attitude are governed by its four control surfaces, a pair of diving planes mounted on the sail, and another pair at the stern. The stern planes form a cross with the sub's top and bottom vertical rudders, which provide directional control.

The control surfaces suggest that the sub could perform underwater maneuvers much like an aerobatic aircraft, but that's an exaggeration. A half hour spent at the *Dallas*'s helm teaches us that.

The submarine is steered by two wheel-and-yoke stations located side by side, as in an airliner cockpit. The wheel on the right (starboard) controls the rudder, while its fore-and aft yoke position controls the diving planes on the sail. The left-hand (port) yoke controls the stern diving planes; the left-hand wheel is a disconnected, redundant rudder control. The helmsman sits to starboard and the stern planesman sits to port.

The two crewmen face a panel perhaps five feet wide and covered with instruments, including compasses, rudder and diving-plane position indicators, knotmeters, course-error displays, an en-



The eyes and ears of the Dallas are found in the electronic displays of the sonar room.

gine telegraph, and no fewer than seven depth gauges, depth being to a submarine what altitude is to an airplane.

We take the helm and are ordered to just keep the *Dallas* on its course of 200 degrees at a depth of 150 feet. The stern planesman leaves his controls centered, leaving us in full control of course and depth. Maintaining them is a totally instrumented process, because 198 degrees feels just like 200 and 152 feet feels no different than 150. Unfortunately, the compass with the highest resolution is located so far up the instrument panel that one is obliged to adopt a slouched seating position reminiscent of sitting in the front row at the movies. The most readable digital depth gauge is also unfortunately located several feet away from this compass. Ford could teach the navy a thing or two about ergonomics.

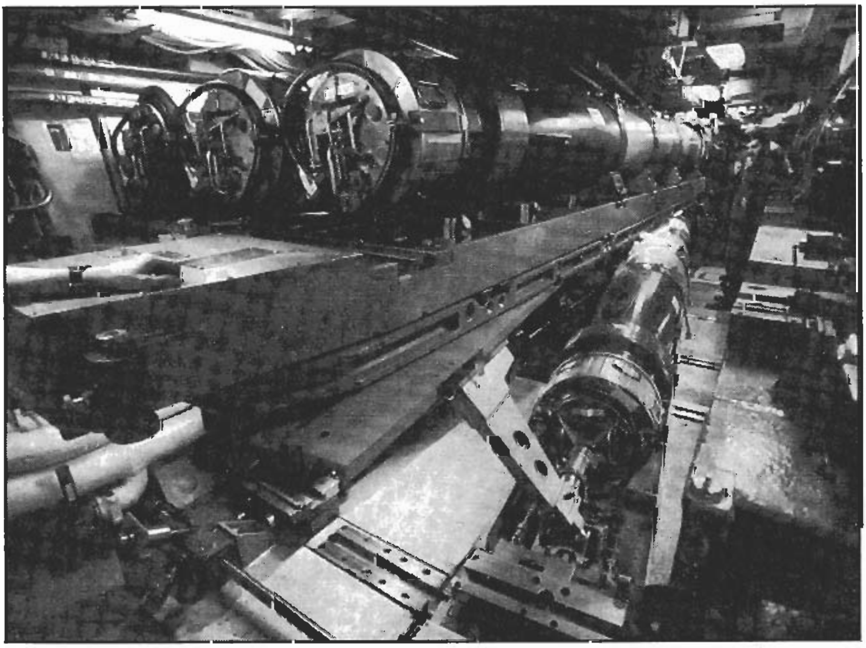
Control feel and response are not up to automotive standards, either. The sub is trimmed heavy and tends to sink while we're at the helm, requiring a stout backward pull on the yoke to maintain depth. Turning the wheel to operate the rudder requires far less effort than pulling back on the yoke, which makes for an awkward mixture of sensations. The resistance feels artificial in both cases.

Once the ship is properly trimmed, we concentrate on the ship's on-center steering and discover that the *Dallas* is a high-polar-moment-of-inertia conveyance that doesn't turn with the verve of a Formula Ford. Propeller rotation causes a drift to port, so to stay on course we wait until the sub is half a degree or so off

A total of 24 crewmen sleep and store their belongings in the tiny racks in this aisle.

course, then turn the wheel to starboard slightly for perhaps a second. Nothing happens right away, but after several seconds the sub starts drifting to starboard. Make the correction properly and the drift runs out of steam about a half degree starboard of the true course, and the drift to port begins again. We then repeat the entire cycle.

Should you turn the wheel and hold it until the compass starts moving—or, worse, turn it far enough and long enough that you can actually feel the sub-



Hydraulic machinery transfers the torpedoes from their racks into the tubes for firing.

marine turning—you're in for a major overshoot. When turning through a significant arc you do use significant steering input, but opposite lock is needed about fifteen degrees before reaching the desired course—or you will swing well beyond.

"The less fishtailing, the better the helmsman," we are told.

The planes on either side of the sail move together, as do the two stern planes, so there's facility for making the *Dallas* bank or roll like an airplane. A loop is theoretically possible, but it would make something of a mess.

"Nothing is designed to stay in place upside down," a crewman tells us. "Besides, the relationship between the center of buoyancy and center of gravity would make inverted running unstable."

When turning hard, the sub does lean into the turn somewhat. But that is caused by the sail twisting the hull as it drifts sideways through the water. When opposite rudder is applied at the end of a hard turn, the sub can snap a roll in the opposite direction abruptly enough to roll crewmen out of their racks.

Good control requires careful coordination between the two yoke operators. At high speeds, the helmsman only steers the ship while the stern planesman controls the depth on his own. The operators must be particularly coordinated when running at periscope depth so that the periscope isn't excessively exposed, a task made more difficult by a sort of reverse ground effect: the water rushing between the surface and the top of the submarine's hull creates a suction that tries to pull the vessel to the surface.

The officers and men on board the *Dallas* follow a rigorous schedule. The crew is divided into three watches. Each watch lasts six hours and is followed by twelve hours off. The alert reader will notice that this means an eighteen-hour cycle, just one of the impediments in the way of getting sufficient sleep.

When officers and enlisted men are on watch, they are at the helm, at a radar scope, monitoring the power plant, and generally running the submarine. Performing maintenance or repair work when on watch is prohibited, because divided attention can lead to a concentration lapse culminating in a collision or grounding.

If any repair, adjustment, or inspection needs to be done, it's done by those not on watch. Between watches, three or four hours of such work is the norm.

Even when your machinery is gleaming and shipshape, you can't relax. Should the captain order battle stations (general quarters)—genuine or drill—every man on board must report to a specific place and remain there until the captain ends the condition. Once a week, on "field day," all hands get down and scrub the ship. No one is excused, never mind that a crewman might have just finished six hours of greasy repair work that came on the heels of a six-hour watch.

Such a regimen means twelve or thirteen hours of work every day, ensuring that the navy and the taxpayers more than get their money's worth from every man aboard. Moreover, most sailors and officers spend their off hours studying the ship's manuals—in the modern navy, knowledge is the path to promotion.

Even the trash collector must be an expert. All solid garbage on the submarine is processed through a compactor that produces a slug twenty inches long and ten inches in diameter. The slug is next wrapped in a sheet of perforated sheet metal, weighted with a cast-iron slug, capped at both ends, and ejected from what is essentially a miniature torpedo tube. It then sinks to the bottom without a trace. A mistake in this operation might create a ten-inch-diameter leak, meaning that poor garbage disposal execution could theoretically sink the ship.

Such heavy demands on the energies of everyone aboard, combined with such close confinement, leave little room on a submarine for superficial spit-and-polish discipline. The dress code is relaxed for officers and crew alike. Most everyone wears dungarees or blue jump suits with sneakers. Khaki work uniforms seem formal. Insignia of rank and grade are worn, and orders are promptly followed—but we didn't see a single formal salute in three days.

Commander C.B. Dunn, captain of the *Dallas,* doesn't fit the Hollywood image of the steely-eyed warrior of the deep. A big bear of a man, Dunn is clearly an expert in systems engineering, training, and management. He must keep his crew combat-ready and fully trained to operate every system, and he must also make sure that all systems—including the human ones—operate at peak efficiency. Nowhere does the buck stop with more finality than with a ship's master, and C.B. Dunn seems equal to his tasks.

Simplifying Dunn's job somewhat, high technology is not applied to every aspect of the *Dallas.* The network of valves that control the various flows of air, water, steam, and hydraulic fluid are not all automated and computerized. Manual operation is employed surprisingly often to both simplify the technology and preserve redundancy. Should one plumbing system fail, almost infinite rerouting is possible—and not on computer consoles; it's performed manually by the crew.

Conversely, the *Dallas*'s various sonar (sound navigation and ranging) systems, used for navigation and detection, are state-of-the-art. A submarine senses and locates other vessels primarily by listening, using one of its many networks of sensitive microphones—called "hydrophones." In addition to the spherical sonar array in the nose, several other arrays are housed along the hull, and a special one is trailed on a mile-long cable—far from propeller noise—to provide rearward "visibility."

Some of these arrays are active sonars that send out pulses of sound and locate other vessels by tracking their reflections. Though accurate, this approach also reveals the searching submarine's position, much like a radar gun reveals the location of a police car to a driver equipped with a radar detector. Therefore, most of the sub's sonars are passive devices that only listen for sounds. They are remarkably sensitive and can pick up other vessels, even quiet prowling submarines, miles away.

Though sonarmen still use headphones to hear their signals, they rely increasingly on visual displays that employ computers to remove noise from the signal and accurately position its source. This makes possible a data bank of sound signatures of enemy vessels, permitting easier identification.

It is imperative in this game that the *Dallas* make as little noise as possible, not only to not mask its hydrophones, but to make its own detection difficult. To that end, the propulsion machine is rumored to be mounted on rubber-isolated subframes similar to a car's powertrain cradle. The sides of the hull are covered with sound-absorbing rubber tile, and the decks are all flexibly mounted to the hull to minimize creaks and groans as the hull compresses under water pressure. Even the overhead pipes are mounted in rubber grommets to isolate their vibration against the hull.

Should the battle of acoustic cat and mouse turn real, the *Dallas* is equipped with a formidable arsenal concentrated in the torpedo room, which runs the full width of the forward part of the lower deck. Two torpedo tubes, one above the other, are found on either side, angling outward seven degrees to clear the bow-mounted sonar array.

Two horizontal layers of weapons lie behind the tubes on hydraulically movable racks. The main weapon is the Mark 48 torpedo, a 21-inch-diameter, 19.5-foot-long cylinder with a maximum speed of about 55 knots (63 mph), a range of about 25 miles, and a 600-pound high-explosive warhead, according to *Jane's.* Interestingly enough, the torpedo is powered by a six-cylinder swashplate internal-combustion engine, burning Ottofuel II—a liquid that contains both the fuel and oxygen necessary for underwater combustion. The torpedo uses wire guidance, as well as active and passive sonar, to locate its target.

The *Dallas* can also launch a variety of rocket-powered weapons from its torpedo tubes. Sub-Harpoon is an anti-ship missile similar to an Exocet, except that it's fired underwater. The Tomahawk is a cruise missile cluster launched from torpedo tubes in a canister. When the canister breaks the surface, individual missiles separate and begin what can be a several-hundred-mile journey toward a land or sea target. (Until last year, the *Dallas* also used Subroc—a rocket-assisted anti-submarine torpedo.)

For the crew, going through routine long days of watches, maintenance, and study, it makes little difference whether the *Dallas* is submerged or on the surface, whether it's day or night, whether it's summer or winter, whether it's rainy or sunny. There are no portholes. Lighting in the control room is kept extremely dim to enhance night vision during periscope use when the sun is down, but the vessel is otherwise well lighted. Activity and ambiance are unaffected by the hour.

Four meals are served every 24 hours, giving everyone a fighting chance to have three meals every day without regard to the watch schedule.

This may sound like a tough environment, but it's surprisingly comfortable. The climate-control system is amazingly effective—heating, cooling, dehumidifying, filtering, and oxygenating the air as needed. Despite no prohibition against smoking in certain areas, the air stays pure. According to one crewman, after a lengthy patrol in the submarine's wholesome atmosphere, the fresh air in some of the world's dingier ports can make you sick to your stomach.

We can't say that we had that sensation when we left the *Dallas* near the navy's torpedo-test-firing range in the Bahamas. But we're twenty years too old and far too fond of fast cars and the open road to develop a taste for undersea life.

What we are not too old to do is appreciate the dedication and the expertise of the officers and men we met, and to stand in awe of the prowess of the USS *Dallas,* SSN-700. •