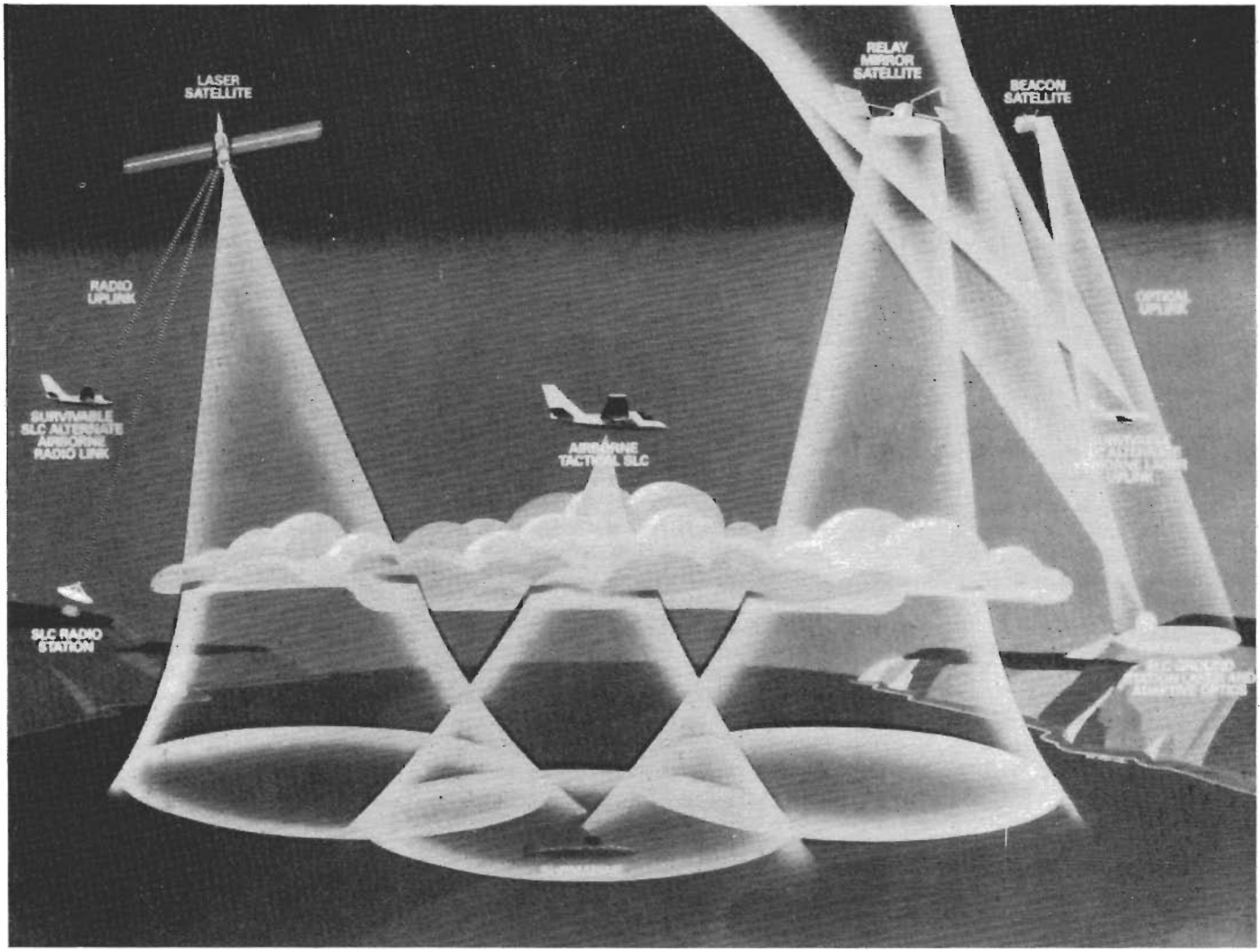
Steel Tubes and Water Droplets



If you have trouble telephoning your neighbour, imagine being under-water and 1000 miles away.

by Roger Allan

THE WORLD IS in a major political crisis.

You are three or four hundred feet underwater commanding enough fire power to take out central Canada.

You are unable to communicate with your headquarters.

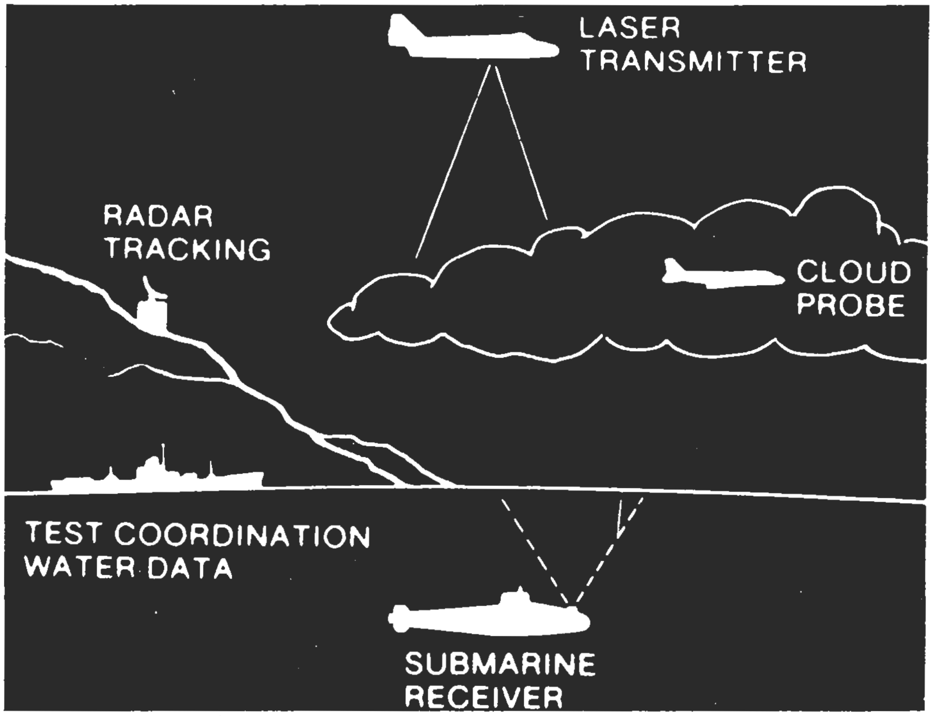
Life can be a bit tense.

You can come to the surface, thereby giving away your position, running the risk of being thumped by the other side before you get a chance to thump them, or you can sit tight and do nothing. Needless to say, the powers that walk the Pentagon's corridors don't much fancy either scenario — hence the need to beef up the U.S. Navy's command, control and communication (C^3) capability.

To communicate through water is a nuisance, for it strongly absorbs all electromagnetic waves except blue-green light and extremely low frequency (ELF) radio waves. To date, there are two ways to communicate with a submerged submarine — have it come close enough to the surface to send up a whip antenna and communicate via normal radio waves, or have a Lockheed C-130 Tacamo aircraft fly overhead trailing an eleven mile long antenna broadcasting at very low frequency (VLF). Whip antennas give away positions, and VLFs only penetrate a short distance into the ocean.

In an attempt to overcome the C^3 problem, the U.S. Navy is developing two generically alternate systems: one based on ELFs and one on lasers.

ELFs have extremely long wavelengths — some 2500 miles — and as such require extremely long transmitting antennas. A prototype has been built in Wisconsin and Michigan — with a 28 mile long overhead antenna — but despite continued funding by the U.S. Congress, the U.S. Navy is not all that happy with the system. It works fine, but can be so easily destroyed by someone with a pair of wire



The components of a submarine communications system.

cutters, much less by a bomb or missile warhead. Hence the U.S. Navy's increasing desire for a system based on the only alternate — blue-green light waves.

But to generate enough power to penetrate water requires a laser, and lasers in turn require a good deal of power to get them going with an appreciable strength with regards to sea water penetration. Thus the first difficulty: building a powerful enough generator, small enough and light enough to be carried on an aircraft or satellite (see "Particle Weapons", ETI, March '84).

But where there's a will there's a way and the Defence Advanced Research Projects Agency (DARPA) commenced working on the problem about five years ago. And they've had some success. In May of 1981, DARPA and the U.S. Navy successfully demonstrated a blue-green strategic laser communications system, known as Submarine Laser Communications (SLC), off the coast of California.

It utilized a frequency-doubled neodymium-YAG eximer laser excited by long-lived gallium-arsenide diode arrays (instead of the customary "flash lamp" system). The laser, built by GTE Sylvania, generated 1 w of pulsed power at 0.53 microns. A novel element in the system was the use of a crystal to obtain the high efficiency necessary when passing the laser beam from infrared wavelength to the blue-green required to penetrate the sea water. Customarily, a filter would have been used.

The transmission system was mounted on a Rockwell International T-39 Sabreliner, with the receiver mounted on the submarine USS Dolphin, submerged to a depth of 100 feet. Transmission times were very slow, taking several minutes to transmit a short message. While in itself too slow to be of any practicable use, it did demonstrate that the physics worked. Of a total of 16 tests conducted, 15 are reported to have been successful, though which one failed no one will say.

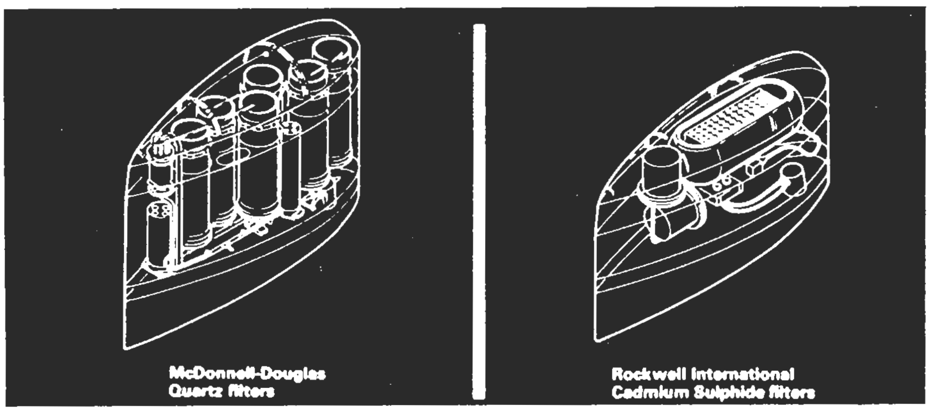
GTE Sylvania, having thereby demonstrated its ability with lasers, was then selected to develop a 10 w frequency doubled laser for a new series of tests under more challenging conditions, expected to begin early in 1984. The new laser will also be able to operate a somewhat higher pulse repetition rates than the 10 pulses/sec of the earlier model.

Acting in a competitive fashion, DARPA simultaneously contracted Avco Everett Research Laboratory to develop a xenon-flouride rare gas halogen eximer laser. The ultraviolet beam from this device will provide, it is hoped, ten times the single-pulse energy required. After propagation, the laser light will be Raman-shifted to the blue-green wavelength. In this system, electron beams are pumped into opposing sides of the laser cavity, powered by a pulse forming electrical network, rather than the customary continuous light stream.

The new series of tests will also be conducted under more difficult conditions, such as heavy cloud cover, higher altitudes, and in more turbid water.

Another problem that will have to be overcome is bioluminescence — the faint light emitted by some marine organisms that provides unwanted background noise, which in turn obscures the faint laser signals at any sort of depth. To overcome this problem, Lockheed Missiles and Space Co., working under DARPA contract, is developing filters with a bandwidth of only two angstroms and with a 15 degree wide signal acceptance angle. Such filters should be useful in excluding, or at least minimizing, bioluminescence.

Two competitive companies, McDonnell-Douglas and Rockwell International, working on the same problem, have taken Lockheed's quartz birefringent filter system and refined it — McDonnell-Douglas experimenting with pure quartz filters and Rockwell with cadmium sulphide filters. But whichever system is finally selected, they will have to be extremely accurate. At a depth of 100 feet, the pulsed power of the laser reaching the submarine will only have the directed strength of a single star on a moonless night to a person standing on the sea shore.



Experimental submarine-laser communications receivers can be installed on submarines for tests.

Should everything work out according to plan — and the U.S. Navy is confident it will, even going so far as to scale down the ELF research in favour of a $40 million a year SLC research and development program — then a practicable demonstration should be possible by the end of this decade, and a strategic system in place by the early 1990s. **ETI**