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THE UNDERSEA ROBOT

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It is not often that one looks through the newspapers or magazines today without seeing an article on robots being used in the industrial environment. Whether considered a threat or blessing, these mechanical beings spark the interest of most people, and they are being readily accepted as coworkers and a compliment to the work force. Most have also heard of space robots, be they satellites or planetary explorers, such as the Viking lander on Mars, which used its manipulator to perform work operations in an environment not yet accessible by man. Thus, land and space have long come under the robotic assault, and as one would logically expect, our last frontier, the ocean, has not been excluded from the revolution. The ocean poses one of the most hostile environments that man can imagine; where extreme pressures, dynamic forces, corrosive attack, turbid water and other problems usually deal Mother Nature a winning hand. Therefore, it is no wonder that the ocean engineer would rather extend his presence into the ocean remotely, if possible, and remain topside in a warm, comfortable environment next to the coffee pot.

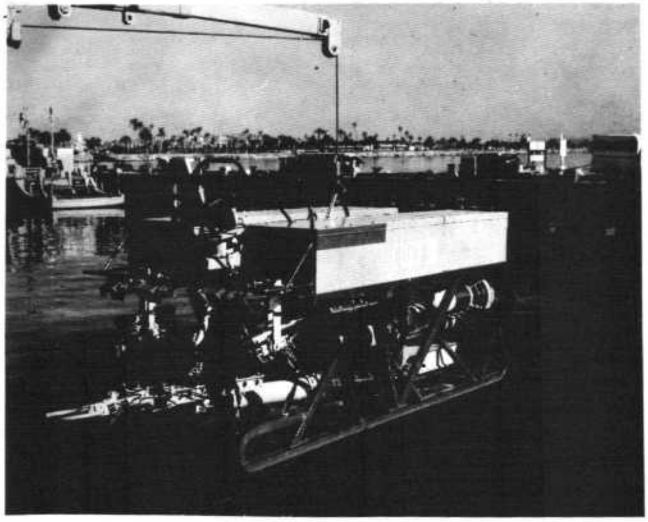

Figure 1: The Navy's CURV III with ordnance recovery claw installed.

The undersea robot, generically called a Remotely Operated Vehicle (ROV), has actually been used by the United States Navy for nearly two decades for recovery of ordnance lost during testing on its coastal ranges. These vehicles, which usually have a power and control umbilical cable to the surface, use a claw or manipulator to routinely bring up hundreds of items. Two non-routine recoveries performed by CURV III (Figure 1) have been an atomic bomb off Palomares, Spain in 1965 and the manned submersible PICES III off Cork, Ireland, in 1975 just prior to the exhaustion of the pilots air supply. One of the two men from the PICES quit piloting submersibles and opened his own ROV company, he had been quickly convinced of their invaluable aid in undersea operations.

Figure 2: AMETEK, Straza Division's SCORPI Inspection Vehicle.

The transfer of this technology moved rather slowly from the Navy into the ocean industrial community until the offshore oil boom in the mid-1970's. It became obvious that the smaller ROV's (Figure 2) could provide valuable underwater observation without placing a costly team of divers in the water. They could also be used in situations too hazardous for divers, such as high sea states or near an undersea "blow-out". Just as the workers who are replaced in industry by robots, there was an initial resentment by the divers to these mechanical intruders; however, they are becoming widely accepted by the community as they realize that they are a complement and not a total replacement. Diver assist vehicles are being developed that not only keep watch over the diver and carry his tools, but larger ones that the diver can ride on and maneuver during critical operations.

The technology is available to do much more with ROV's than industry is ready to accept. There is a lag time between development of systems and their acceptance by industry, as previously indicated by Navy vs. industrial application of ROV's. Although this period is decreasing, it will obviously remain. For example, advanced work systems have been developed by the Navy, and now in industry, but they have not been widely accepted, at least when comparing them to the exponential rise in the number of observation type vehicles in use today. It is in the development of these more advanced systems that robotics technology, such as computer augmentation, will provide great strides in the advancement of the state-of-the-art.

The Navy's Work System Package (WSP) (Figure 3) is an example of the type of work systems which will eventually be required to perform complex underwater tasks. These work systems would require, as did the WSP, multi-manipulator work suites which could exchange tools underwater and hold onto the object being worked on. With this basic capability, the role of robotics or computer augmentation really begins to come into play. It allows the engineer to begin to optimize or produce a more efficient system. Through the application of the computer, the following can be achieved:

-Preprogrammed tool exchange and manipulator movements

-Television systems programmed to follow the manipulator

-Simplified, more task oriented manipulator controllers

-Definition of planes or work surfaces

-Computer graphic overlays of the object being worked on

-Monitoring and limitation of manipulator and tool forces and manipulator movement

These previous improvements will not only make a better system, but will relieve the operator of many of the fatiguing control tasks, allowing him to take a break while acting as only a "supervisory operator". The goal of supervisory control is to develop the proper integration of man, machine, and computer. Eventually, the control console will incorporate voice interaction capabilities, allowing the operator and vehicle (or computer) to communicate using a sense previously underemphasized. The operator does not need all data at all times, and often does not need it presented visually. The computer then has the job to analyze the available data, and present the required data to the operator at the proper time in the most efficient manner. Thus, the computer carries much of the work load while the operator supervises the more critical aspects of the job.

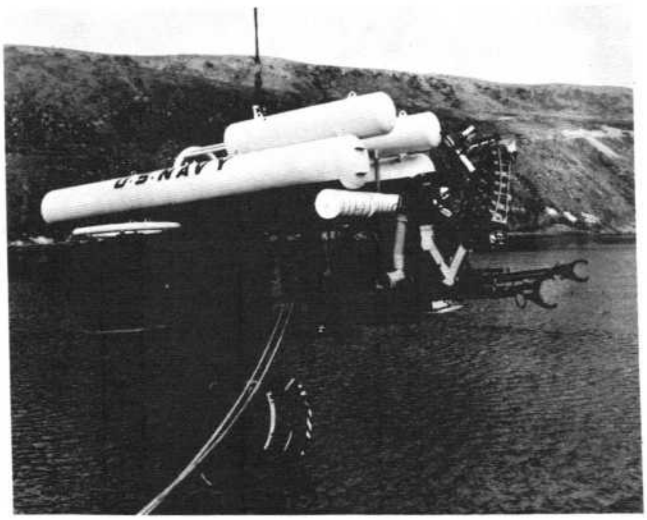

Figure 3: The Work Systems Package mounted on the Pontoon Implacement Vehicle.

The robotics applications just discussed address a "real time" communications link. The goal for the future is to sever this link through the use of autonomous vehicles. These vehicles would require the use of more advanced computer control systems which would direct it through its movements once it is launched. The computer can be programmed totally at the surface to fly the vehicle out, perform a mission, and return to the ship without further intervention from the operator. An alternative is to use acoustic communication between the ship and the vehicle to call up the desired subroutine and redirect the path of the vehicle based upon the most recent events. Although this type of ROV requires its own onboard power supply, it would use less power and also eliminate the constraint of the umbilical cable, thus extending its capability. The cable, which provides the necessary link to allow the majority of todays ROV's to perform their job, is still the weak link in the system. They are being improved and a majority of cable related problems will be eliminated, however, the "free-swimming" cableless ROV's of the future will be the next breakthrough.

The reality of these undersea robots will come about, not through the development of new advanced undersea component technology, but through the application of today's robotics technology which has been previously developed for industrial or space applications. Adapting the position sensors, materials, computers, control systems, televisions, and other sensors to the harsh ocean environment is the problem. The advancement comes in the form of component adaptation and systems integration technology, which is no trivial task. Otherwise, we would probably have placed a man on the deep ocean floor prior to his walking on the moon.

The future should be kind to the ROV industry. The more they are accepted, the more industry will design equipment for them to maintain, and thus they will be advanced even more in their capabilities. This cycle should repeat, and similar to the application of robots to the assembly line, they should become a common tool in the ocean. As the number of undersea robots increase, the problem of adapting components will hopefully decrease since there will be a market for support in this technology area at a component, rather than a system level. This trend will also increase the reliability of future systems along with reducing their cost.

Once we have provided the vehicle with a "brain", it is a logical progression that we provide it with eyes. Following the successful application of vision systems to industrial robots, this technology will also be adapted to the ROV, providing those engineers working in the field of autonomous vehicles with their dream - a programmed vehicle that can go on a mission, find and recognize an object, perform an operation and return to report the results. It is not here yet, but it is certainly on the horizon. A horizon which will show the acceptance of ROV's as complementary tools by divers and users, similar to their industrial counterparts, and not as a clone of the human body or spirit.