THE INNERSPACE RACE - WHERE IS IT?

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Abstract

This paper discusses the critical hurdles which must be overcome to explore the world's oceans to their deepest limits in a meaningful way. Surprisingly, the critical path is not necessarily technology, but that of education, a dedicated set of goals and the international funding to support them.

Introduction

The primary intent of this Special Session is to discuss the international status of ocean technology from a Pacific Rim point of view. Each of the participants, representing those countries bordering the Pacific, will present a collective assessment of the state-of-the-art of their country's technology in this area. However, I would like to vary this theme slightly. Although a discussion of the leading edge technologies will be presented, there is more missing than technology. The missing ingredient is the binder, which is necessary to hold all this advanced technology together and to direct it's application. Of primary concern here is the technology used under the sea, not that surface and space-based technology are any less important. Why? Because that "final frontier" is not in outer space, it's off our own coasts. And, to properly conquer it, maybe a little old fashioned competition is needed - an "Innerspace Race." Also, the race is not to reach the deepest depths of the ocean, that has been accomplished. The race is to reach them in a meaningful way, one in which a real presence and capability is established.

Technology Today

The advances made in undersea vehicle technology during the past 15 years have been tremendous. With the investment of the offshore oil companies in this technology, beginning in the late 1970's, it has progressed to a very reliable point, at least as far as relatively shallow water (3,000 to 6,000 ft) observation and work systems are concerned. The miniaturization of the electronics for command and control, communication and navigation has led this advance and helped spearhead the development of the now prolific Low Cost Remotely Operated Vehicles (LCROVs). And, the 20,000 foot barrier for ROVs was not only broken, but exceeded twice within one week by the CURV vehicle (Eastport International) and the Advanced Tethered Vehicle (Naval Ocean Systems Center). But dangling a "plumb bob" at the end of a 20,000 foot tether, no matter how sophisticated, still does not represent a "meaningful" presence. The observation by manned submersibles on limited dives, with usually no more that 6 hours bottom time at 20,000 feet, also does not provide a meaningful presence even though four countries (France, United States, Soviet Union, Japan) have that capability. Therefore, if we have the technology today to reach such depths by manned and unmanned submersibles, what is preventing the establishment of a meaningful capability in the ocean?

The technology which has the greatest impact on the establishment of this undersea capability is energy. ROVs have become successful because of their unlimited supply of energy, however, their capability is still limited. The newer autonomous systems are severely limited by their energy storage capability at this time, as are manned systems. We can make things stronger, albeit bulkier. We can navigate to a given location, although we may hit a few "dead ends" along the way. Using "brute force and ignorance" we can even accomplish some meaningful undersea work without using sophisticated force-feedback manipulators and many of the other new tools available. However, without adequate energy for propulsion, hotel load, and environmental conditioning we can only reach blindly into the vastness of the ocean.

Power Sources

Existing power sources can be classified into chemical, fuel cells, combustion and nuclear [1]. Chemical sources such as Lead-Acid, Silver-Zinc and Silver-Iron secondary batteries provide us with a limited capability, however, their application to undersea use gives our systems no more capability that the X-15 did in space exploration, just a limited

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journey. The most promising electrochemical source is the lithium thionyl chloride primary battery which has been developed to a size of 10,000 amp-hours by GTE for the US Air Force. Lithium secondaries now under development may also have a significant impact, however, even they would need to be renewed during long-term underwater operations. Fuel cells and high efficiency engines are advancing rapidly, however, they suffer the same fate as the others in that their capacity is limited unless additional fuel or recharging is supplied.

Solar energy provides us with the long term power necessary for space exploration, so maybe the place to begin for innerspace exploration is to use the fuels of the sea - seawater batteries may fill a certain nitch and research into membranes which can extract the chemicals to power some of the previous systems may be more important than originally believed. The one neglected area which would solve most of the problems would obviously be nuclear power. This technology is not new, and now may be the time to begin a proper program to exploit it and apply it to undersea use. Political concerns should be solvable, there are nuclear submarines operational throughout the world today. For our application, their depth is just "a little limited." Therefore, we aren't technology limited in this area either, what is limited is the desire to reach a significant goal. Where a desire exists, funding often follows.

Electric Subsystems

Up to this point, the most efficient way of transferring power to actuators, thrusters, etc. was through the use of hydraulics. However, a minor problem which could be easily overlooked is the effect of the temperature and depth on the hydraulic fluids at 38,000 feet [2]. This opens the requirement for efficient electric actuators and drive systems with unique methods of coupling, possibly magnetic, which counter these adverse effects. The deep ocean is not the only application forcing this requirement. The future of totally autonomous undersea systems, which will require highly accurate, energy efficient subsystems that are computer friendly, will also benefit from this technology.

Test Facilities

One of the many aspects of developing systems for the deep ocean is that of certifying the components, subsystems and the overall systems themselves. In the case of 20,000 foot applications, there exists a substantial capability at the David Taylor Research Center (DTRC) with their Ocean Environment Simulation Facility which can test objects in a 10 foot diameter by 27 foot long pressure chamber capable of 12,000 PSI (27,300 foot depth equivalent). Smaller chambers can provide component testing to extreme depths such as 38,000 feet, however, their size will be extremely limited. Also, we cannot ignore the certification of manned systems which usually test to 1.5 times the operating pressure? This requirement further underscores our present limitations. Therefore, even if we have all the technology to reach a full ocean depth, we don't have the facilities to properly test our equipment. These can also be built, but, as in the development of the required power sources, it will take considerable funding.

Education

The development of key technologies is not the only critical path in this scenario. The development of the future's "key technologists" is also of major concern. Those engineers and scientists who will be involved with deep ocean programs during the next decade are today's high school students. Now is the time to educate them, interest them in the ocean and open their eyes to the wonders of the ocean.

Jacques-Yves Cousteau gave us a good educational start with his expeditions which have been highlighted on many television programs. And, Bob Ballard has increased the momentum through his discoveries of the Titanic, the Bismarck and his other expeditions. The JASON Program which he has started is one of the most advanced in the world in educating our youth, taking them directly to the operational site via satellite with the deep sea explorers themselves. The world is also getting a taste of this exciting technology through movies such as "The Hunt for Red October" and "The Abyss," even though they may take a little "poetic license" with the technology. International disasters requiring the recovery of instruments and equipment from the deep ocean, treasure galleons being discovered, and more recently, insurance fraud all provide the seeds of knowledge to educate those who know little of this fascinating technology.

But, there is a long way to go in educating the public. For example, just prior to the recent Remotely Operated Vehicle conference in Florida (ROV '91) the aircraft of the famous "Lost Patrol" was presumably discovered in the infamous Bermuda Triangle. After listening to a presentation on this discovery, seeing the exposition of high tech equipment and talking to others who have found undersea treasure, a reporter from one of the local newspapers asked me if there was still anything left to find in the ocean. The only logical answer was another question - "Have we found everything on land yet?" His question shows the naivete' of most people who don't realize the vastness of the ocean, it boundless resources and energy, and it's effect on the rest of the world. Today's youth are not as ignorant when it comes to outer space. There are programs like the "Young Astronauts" which give them the opportunity of be a part of the quest, and several "space camps" exist which give hands on training. Maybe it's time to begin an analogous "Young Aquanauts" program which can do the same thing for innerspace. Now is the time to begin this education.

The Innerspace Race

It seems that the world revolves around competition. Give them a game or a race and they will attend. You can be sure that there was more that a little competition to be the one to discover the Titanic. Consider the number of entries in the "Human Powered Submarine Races" being held in Florida for only the second time, a little competition has brought the corporations and technologists our in mass. In the movie "Field of Dreams," the phrase "build it and they will come" was a key theme. The same theme certainly applies in this case. The amount of energy, ingenuity and funding put forward for the space race has been tremendous to date, and it still isn't over. On a comparative basis, the amount of funding to properly challenge the depths of the oceans would be minuscule.

Therefore, why not a new challenge to help educate and involve the people - The Innerspace Race? The biggest challenge in this scenario would be the development of a consortium of companies in the financially competitive, free enterprise society of the United States. Not that it can't be done, the moon wasn't reached in July 1969, only 8 years after President John F. Kennedy's challenge, without a concerted effort by a team of leading corporations. And it is certainly being done in other countries. Canada has their SPIRIT program, to develop an advanced undersea work vehicle, which is supported through government funding. Japan put more that $100M into their Advanced Robot Technology Research Association (ARTRA) which assaulted three high risk technologies: nuclear, fire fighting, and undersea. And two new consortiums are now in existence in Europe to develop advanced autonomous vehicle systems. The EUREKA program is looking at $50M to develop two vehicles, a Work and Inspection Robot (WIR) and an Autonomous Robot for Underwater Survey (ARUS). This 5 year program, which began in 1989, incorporates 17 companies from Britain, Italy and Denmark. The British National Environmental Research Council's (NERC) program will also develop two vehicles called the Deep Ocean Long Path Hydrographic INstrument (DOLPHIN) and the Deep Ocean Geological and Geophysical Instrumented Explorer (DOGGIE). It is in the first of four phases planned at about $1M per year.

Such international consortiums are a beginning, and with some focus, could combine to open the vastness of the oceans to meaningful research. A favorite fortune cookie proverb which I've saved for nearly 20 years stated "Look afar and see the end from the beginning." That is what we need to do today. Determine what is needed in the ocean to really accomplish our long term goals and establish a plan to reach them. The expenses need not be borne by only one nation. Through a cooperative program of technology transfer and sharing, all could benefit. Not every country would have to build the extremely high pressure test facilities to certify their systems, any more that every country built their own towing tanks to refine their America's Cup sailing boat designs. What is needed now is a long term commitment by the countries, both in cooperation and funding, to allow the competition to begin. Perhaps a good starting point is the "Deepest Ocean Presence" forums which have recently been held in association with conferences of the Marine Technology Society [3].

Conclusion

The limitations which exist in reaching the ocean depths exist primarily in the areas of establishing meaningful international goals and the political and financial support of them. We're not technology limited, but we are limited in commitment. Key areas of technology such as energy sources are on the critical path, however, most other technological areas which would be involved would be along for the ride if a major ocean exploration program was initiated. And, the key to such an endeavor would be the involvement and education of our youth, for they are the future.

References

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