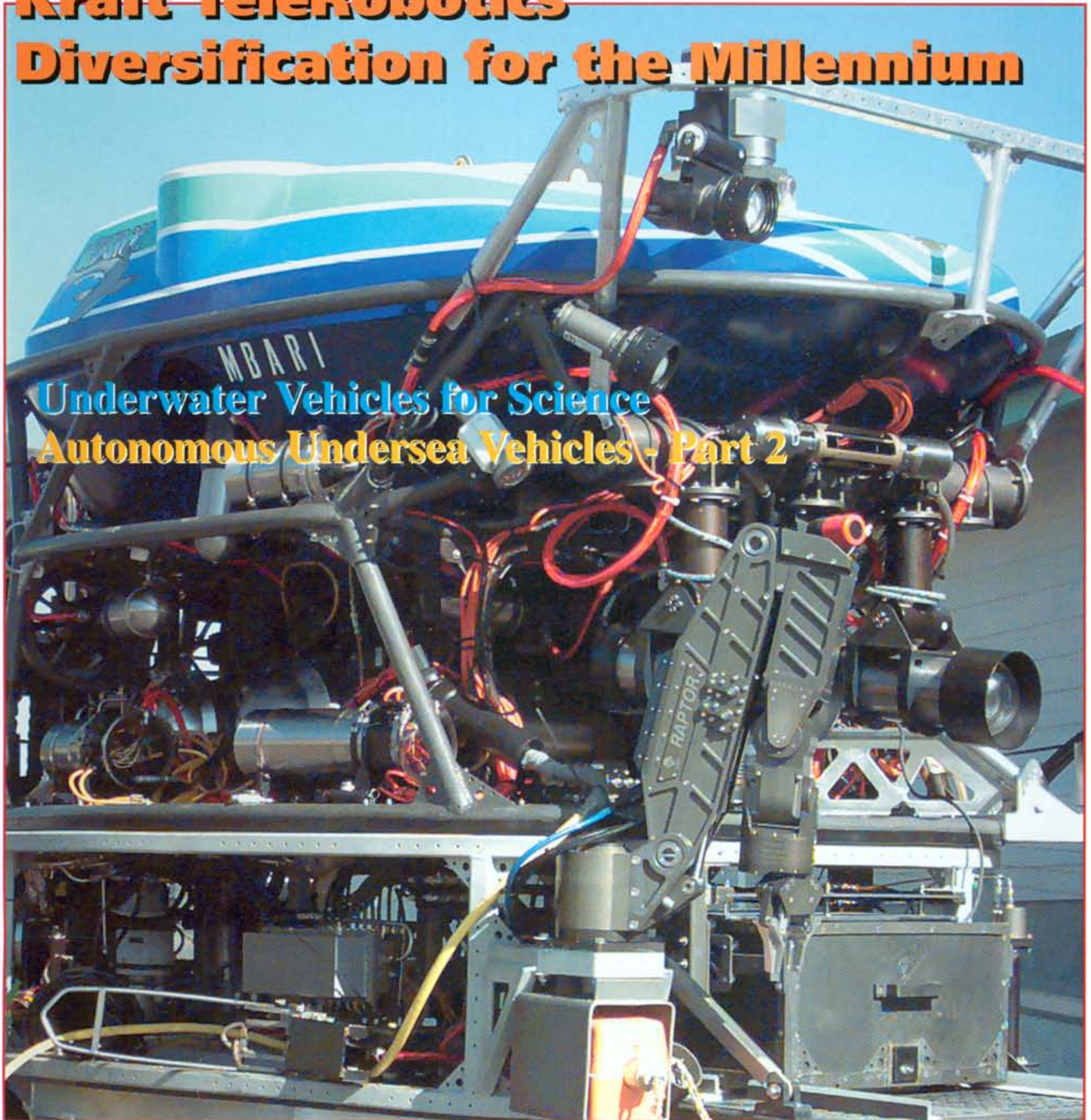


Kraft TeleRobotics Diversification for the Millennium



Underwater Vehicles for Science
Autonomous Undersea Vehicles - Part 2

Argos for Global Ocean Monitoring

Acoustic Sensor

Monitoring System

Hydrotometers

Diversification & Opportunity

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In the early 1980s, Kraft focussed entirely on developing and manufacturing undersea manipulator systems for use offshore, and between 1983 & 1988 Kraft produced a variety of very successful systems. These included the Grips 7-function master/slave manipulator, which was widely used on the famous Ametek Straza SCORPIO vehicles. A 7-function joystick controlled manipulator arm, which incorporated a forearm rotate function, and a 9-function platform cleaning & inspection manipulator with the characteristics of an elephant's trunk, and the ability to reach around platform members. The early eighties were good to everybody working offshore, and it was during this period that Kraft became devoted to the idea of building a force feedback manipulator system for underwater use. Thanks to the nuclear industry the value of force feedback had already been proven, and like many others, Kraft recognized the importance of bringing this technology offshore.

The idea of force feedback manipulator arms for use underwater was not new; however, the implementation of this technology offshore had been severely limited by the fact that all the previous arms had been too heavy and too costly. It was clear that to be successful, Kraft would need to produce a lightweight high performance force feedback manipulator system that didn't include sticker shock. At the end of 1989, following a long expensive development effort, Kraft introduced its first production force feedback manipulator system. Using the solid field proven GRIPS manipulator as the starting point, Kraft developed a revolutionary new force feedback system for undersea use. The new system employed custom state of the art electronics, advanced computer technology, and a new force reflecting hand controller, to provide a level of force feedback and intuitive control never before realized. The new Kraft system delivered exactly what the doctor ordered, a reliable, light weight arm, that didn't cost too much.

Within a few months, the force feedback manipulator system was being enthusiastically embraced by a wide variety of potential customers, including people from within the military, NASA, the nuclear industry, and the electric utility industry. Ironically, however, the offshore oil & gas industry for which the technology had been originally developed, was in terrible shape, and a new force feedback manipulator system, no matter how good, was of little interest to anyone.

Beyond offshore

While working on a force feedback manipulator system for use offshore, Kraft had in fact made a number of technological breakthroughs that would position Kraft as a world leader in its field, and the sole source for cost effective force feedback systems. To help deal with the cyclic activity level

within the offshore arena, Kraft decided to aggressively pursue other market opportunities and find new uses for its unique control technology. To achieve this goal, Kraft adopted a marketing philosophy based upon the premise that many successful products, like the electric light, were never

developed in response to anyone's request, but rather in response to a need. By offering new technology and innovative solutions to real problems, Kraft was able to eliminate competition, and cultivate lucrative new market opportunities. Today, Kraft TeleRobotics, Inc. manufactures remotely operated manipulator arms and mobile robots for use in a wide variety of industrial, scientific, and military applications.

Undersea Offshore

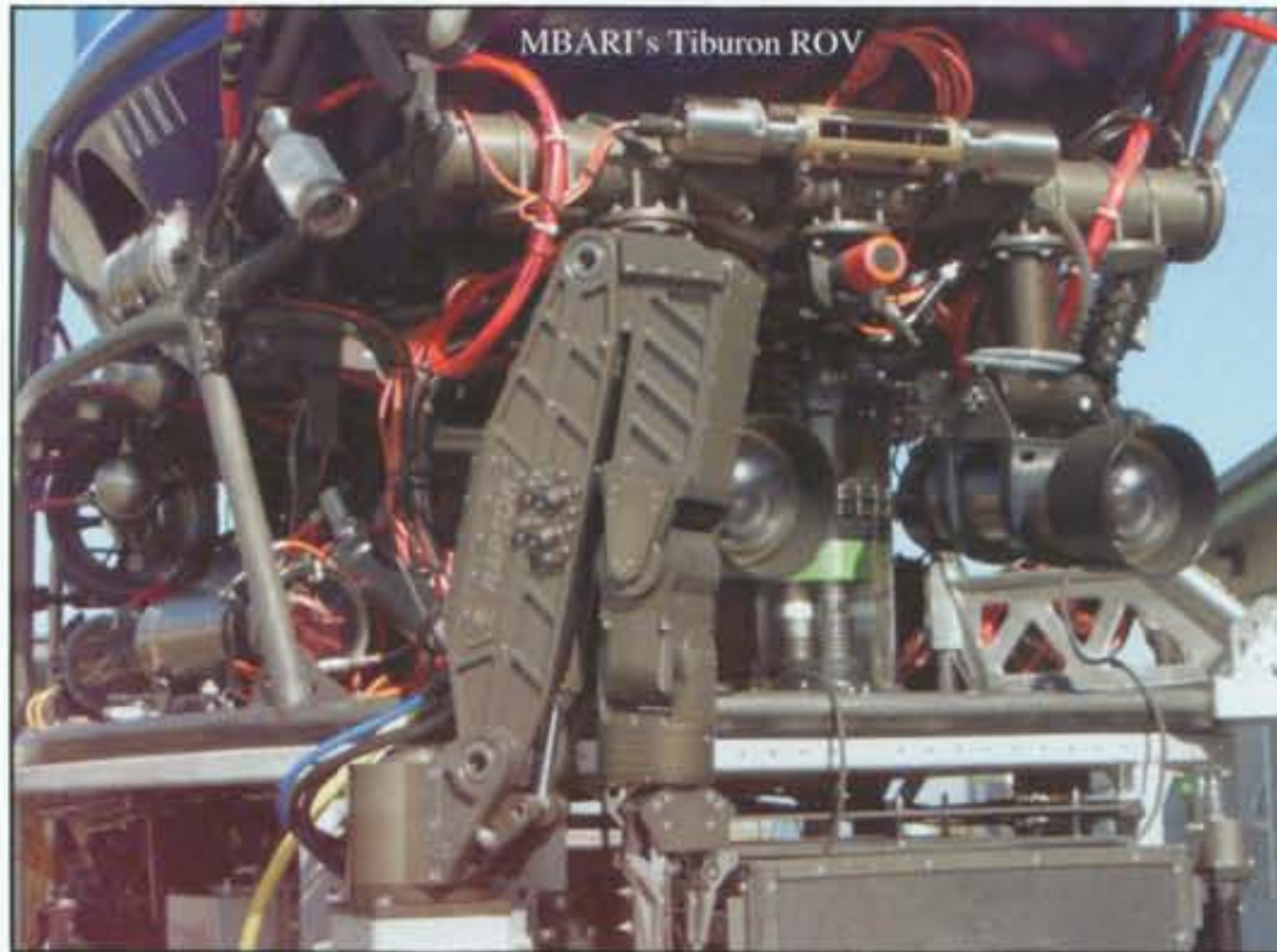
Underwater contractors including Stolt Comex Seaway, Sonsub, Canyon Offshore, and Caldive are all using Kraft manipulator arms to perform subsea tasks in support of deepwater drilling and offshore construction activities. Undersea research organizations such as the Columbus America Discovery Group, the Monterey Bay Research Institute, and others, fully appreciate the value of force feedback manipulator technology. In the performance of their work these organizations must often complete difficult tasks that require a highly intuitive manipulator control capability.

Electric Utilities

Within the electric utility industry, Kraft force feedback manipulator systems are used to perform complex installation and maintenance tasks on energized power distribution lines. For example, while seated inside an air conditioned cab at the end of an insulated boom, a lineman operator using two insulated hydraulic arms, is ready to perform a variety of complex tasks on energized power distribution lines. The insulated manipulator arms, which have gripper hands to hold tools, may be extended or retracted from the base of the operator's cab. The manipulator arms can be assisted in their work by an articulated boom and winch, which can be used to raise objects from the ground. The entire system is insulated to withstand voltages several times greater than the energized line voltage, allowing the lineman operator to work live line, and do whatever work is necessary in any kind of weather. Older, more experienced linemen lost to the work force because of physical demands, can now be actively utilized in the field. Whatever the tasks, the lineman operator will do the whole job by himself, without ever having to get up from his comfortable seat in the insulated cab.

Nuclear

The nuclear industry is the largest user of manipulator arms in the world, and Kraft is proud to be a supplier to this industry. During the early days of Three Mile Island, Kraft





manipulator arms were selected by Carnegie Mellon University for the remote work vehicle (RWV) program, also known as "Workhorse". "Workhorse" is a mobile work system for remote reconnaissance, recovery, and decontamination operations in radiological environments. The Kraft manipulator arm on "Workhorse" demonstrated impressive capabilities while supporting clean up efforts in the basement areas of the Three Mile Island, Unit-2 nuclear facility. With the decommissioning of government and commercial nuclear facilities on the increase, the wide spread use of Kraft force feedback manipulator technology will continue to grow.

Hazardous Waste

The excavation and handling of chemical and radiological waste can put an equipment operator at great risk, and controlling large construction equipment from a remote location can also be risky. To reduce such risks, Kraft introduced HAZ-TRAK, a force feedback excavator and material handling robot that combines the power and mobility of a commercial excavator with the dexterity and controllability of a force feedback manipulator arm. Like the operator of a force feedback manipulator, the HAZ-TRAK operator is intuitively linked to the excavator arm through a single force feedback hand controller. As the operator moves his own shoulder, elbow, wrist, etc., corresponding joints on the slave excavator arm move as if they were physically attached to his body. Add to this the sensation of feeling created by force feedback, and you have a highly intuitive control system that dramatically improves operator awareness and performance. Special tools and attachments mounted on the end of the excavator arm allow the operator to perform a variety of complex tasks, including tasks that require great sensitivity.

U.S. Military (EOD)

Explosive Ordnance Disposal (EOD) is a major area of concern within all three branches of the military. The clearing of unexploded bombs, artillery shells and other ordnance is extremely dangerous, and now, removing the control electronics from unexploded smart bombs has been added to the list. When a smart bomb does not explode, the only way to diagnose the problem is to dissect the bomb and remove the electronics (brain) for examination. This is a delicate job, and in order to successfully perform this task by remote control, the US Air Force acquired two Kraft radio controlled force feedback manipulator arms. These two arms which are mounted on a radio controlled tracked vehicle, have recently completed various levels of field testing and successfully demonstrated their ability to perform the tasks at hand.

Confined Space

The increasing demand for greater safety while working in confined spaces prompted the development of a system that would provide an alternative to sending electric utility workers underground for inspection purposes. Working in cooperation with major utility companies, Kraft developed the M5-A SCOUT remotely operated inspection vehicle. SCOUT is a battery powered radio controlled vehicle that can be easily operated by one man. A typical operating scenario would include a compact truck or van with a bumper mounted lifting device. SCOUT is lowered into the vault using a unique launcher that protects the vehicle as it passes through the manhole, and eliminates the need to attach any lift lines to the vehicle. When deployed in its launcher, SCOUT will pass through a 29 inch dia. opening; however, if necessary, SCOUT can be deployed through a 24 inch dia. opening if the launcher is not used. Once deployed, SCOUT can easily maneuver within the confined spaces and narrow



passages of a crowded vault. A unique patented wheel system allows the SCOUT vehicle to rotate smoothly about its own axis, and drive over obstacles such as cable runs, etc. During a typical vault inspection, SCOUT can be called upon to perform a variety of tasks including, detailed color video inspections from floor to ceiling, pinpoint laser aimed infrared temperature measurements, and atmospheric testing for flammable gasses, toxic gasses, and oxygen levels. SCOUT is completely sealed, water tight, and may be operated for 10 hours or more on a single charge. A two way audio system allows the remote operator to communicate with personnel in the area, or listen for sounds that may indicate a problem, such as the sound of boiling transformer oil. During the inspection process, all video, audio, temperature, and gas analyzing data is displayed continuously on the operators monitor where a permanent record of the entire inspection can be recorded on video tape.

In Summary

You know the old saying, "Never Put All Your Eggs In One Basket", well, Kraft TeleRobotics, Inc. is a real believer, with highly diversified market opportunities both undersea offshore and on land. Kraft's careful attention to the inland market, as well as the opportunities found offshore, has paid big dividends with strong hardware and technology sales to a wide variety of international customers.

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