TECHNOLOGY TRANSFER FROM THE
HAWAII DEEP WATER CABLE PROGRAM

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I. INTRODUCTION

The Hawaii Deep Water Cable Program (HDWCP) is a research and development effort to determine the feasibility of installing and operating a submarine power transmission system between the Islands of Hawaii and Oahu in the Hawaiian Archipelago. The benefits of such a system have been identified and discussed in past documents. The purpose of this briefing is to summarize the present status of technology transfer opportunities from this R&D effort.

Technology transfer from the HDWCP can be divided into two groups. The first involves the transfer of cable design, installation, and repair techniques to other locations or different types of installation, such as oil and gas pipelines. The second involves ideas and concepts, equipment and instrumentation, and methodologies conceived and developed for the HDWCP, but with potential application well beyond the confines of submarine power transmission system design and installation.

As an overview, these are shown, together with potential users, on this slide and in your handout material. I will illustrate, with specific examples, the uses of technology developed under the HDWCP.

II. TECHNOLOGY TRANSFER

Cable Design And Installation Technology

The design requirements imposed by the depth of the Alenuihaha Channel and the severity of its wind and wave climate demand an advancement in the state-of-the-art for both the design and installation of submarine power cables. This has been a proprietary area, where information is closely guarded by a few large multi-national organizations. This condition is created by the competitive nature of the market, but leads to a multiplication of effort, a lack of technical advancement in the absence of information exchange, and a consequent inefficiency in design. The HDWCP and has placed the methodology for design of a submarine power cable under technical scrutiny in a public forum. With a fundamental parametric approach to cable design, a generic methodology has been developed with laboratory validation for a specific set of conditions. The same is true for installation techniques, with mathematical models for vessel and cable handling equipment control validated under actual and rather extreme environmental conditions at sea. Since the HDWCP is a government-sponsored program, results of these evaluations are in the public domain and available for the first time to U.S. industry.

The HDWCP is tasked not only with showing technical feasibility, but that this feasibility is a logical and realistic extension of the present state-of-the-art. Only in this manner can the concepts be accepted with credibility by the conservative financial community and profit-based industry. Quantum leaps of technology are not desired nor considered; the uncertainty of impelemntation associated with such an approach is unacceptable.

For example, computer analytical techniques have been used to evaluate the dynamic response of the coupled cable and vessel system to winds, waves and currents. Results indicate that the resonant frequencies of the dynamically coupled system are in the high-frequency region of wind/wave spectra. Technical literature has tended to disregard this region, both in theoretical analysis and in direct field measurements, since it has not been of concern in the design and construction of common ocean structures. Nevertheless, analysis shows that these resonant forces can be of major importance for the deployment of large cables and pipelines from surface vessels. To quantify this issue, a high frequency wave measurement and analysis program was conducted. The results are applicable to other deployment configurations, such as oil and gas pipelines and instrument packages in similar ocean environments.

Another example is the cable vessel control system, which is the heart of the at-sea test experiment. This system is an amalgam of state-of-the-art, commercially available instrumentation, equipment and techniques, melded into a predictive and corrective array through a unique computer program. The model uses vessel position, speed and heading, cable payout rate, bottom topography data and vertical ocean current profiles to calculate the bottom touchdown position of the cable. Measured reaction of the cable to actual currents allows fine tuning to achieve required touchdown location and tension. The control program, while complex, represents for the first time a serious effort to predict the position of a cable on the ocean bottom, in a relatively automatic mode using only sensor information.

While the HDWCP will advance the state-of-the-art for power cable installation in very deep water, its technology could be applied to other situations of similar complexity. For example, the problems of cable or pipe deployment in shallower waters, but with high current velocities are likely candidates. The technology is similarly applicable to the installation of acoustic arrays for military purposes. Bell Laboratories has requested technical information in regard to the use of power cable for active sonar systems for anti-submarine warfare.

Southern California Edison's long-range transmission planning involves an intertie to the Pacific Northwest and possibly Canada. An offshore transmission option to avoid the social and environmental impacts of overland transmission could be provided through HDWCP technology transfer. The depth of installation available through HDWCP techniques would minimize risk of mechanical damage from anchors or trawlers. Both technical and cost information has been supplied to Southern California Edison at their request.

Development Of A Unique Laboratory Cable Test Program

Present standards for testing submarine power cables are limited to individual tests which verify only that the cable will withstand a specific mechanical or electrical stress. Under actual conditions of installation and operation, a submarine cable must endure a sequential series of stresses, which include mechanical, electrical and thermal loads varying in level and duration. For the first time, a laboratory testing program has been developed which simulates the life of a cable. Following verification that the cable can withstand the unprecedented mechanical loads associated with the depth of installation in the HDWCP, the cable's response to electrical stresses will be demonstrated.

Laboratory testing will also include an accelerated simulation of the effect of diurnal currents on the cable over its minimum 30-year life, confirming that fatigue failure has been properly considered in design. Finally, the testing program introduces the issue of combined corrosion and abrasion as a fundamental design parameter for the armor layers of the cable. Corrosion and abrasion have been considered previously but dealt with independently. Considering the renewal of unoxidized metal through abrasion, with the potential for more rapid corrosion, is a unique aspect of the HDWCP testing program.

The approach to cable testing in the HDWCP should be of great interest to institutions such as CIGRE, responsible for the development of international testing standards. With or without the acceptance of HDWC testing as a standard, the opportunity through HDWC experience to create a test specification which models installation and operation should be beneficial to both cable manufacturers and purchasers, increasing confidence that the cable specified and fabricated can meet the actual sequential requirements of its environment over the design life.

III. BY-PRODUCT INFORMATION AND TECHNOLOGIES

Development Of A High Resolution, Deep Ocean, Bottom Roughness Measuring System

To verify the feasibility of a minimum 30-year service life of the power cable on the ocean bottom, detailed knowledge of the ocean bottom roughness was required to a very high degree of accuracy. Any submarine cable will have limits in how much it can be bent and how great a distance it can span without support. But unless detailed bottom survey data is made available, project engineers cannot determine the best route for the cable; indeed, they cannot determine whether a feasible route exists.

One of the most difficult aspects of this task involved a requirement for resolutions of less than 6 inches at ocean depths of 6,300 feet. This meant that data acquisition equipment could not be located on the ocean surface; an instrument package had to be "flown" near the bottom. There was no commercially available system that could acquire the data to the accuracy required; it had to be created.

A new instrument system was developed using commercially available state-of-the-art sensors and an internal recording capability. A special vertically stabilized platform was designed to house the instruments. This system was successfully used during the first Bottom Roughness Survey in October-November 1985. Resolution was even better than predicted.

The application of this high resolution bottom mapping system is now being explored for other purposes. For example, the exploration and development of cobalt-rich manganese crusts in the exclusive economic zones (EEZs) of the Hawaiian Archipelago and Johnston Island are keyed to an accurate evaluation of the crust resource thickness. Economic analysis shows that the primary factor determining economic feasibility of this development is the volume of substrate versus crust material mined. Average thickness of crust material is 1 inch. Thus, in order to design and efficiently operate a bottom moving miner, very accurate and high-resolution bathymetric information is necessary, of a level heretofore unavailable. In addition, interest has been expressed by the Naval Undersea Warfare Engineering Center in using the bottom roughness system in the installation of sonar tracking arrays. The University of Hawaii is now developing proposals to the National Science Foundation/Office of Naval Research for the use of the bottom roughness system for undersea plate techtonics studies.

Initial Testing And Operation Of The SeaMARC/S System (Funded with State of Hawaii Funds)

The newest and most sophisticated member of the SeaMARC class of high-resolution side scan sonars is the SeaMARC/S system, owned and operated by Seafloor Surveys International, Inc. The SeaMARC/S is the first side scan sonar system which simultaneously obtains both very high-resolution side scan imagery and down-looking echo sounder (fathometer) bathymetry data from a single towed vehicle. The SeaMARC/S can obtain both sets of information simultaneously in large swaths with one pass of the vehicle. Its first operation following testing involves a survey of the entire route from the Alenuihaha Channel to the island of Oahu for the HDWCP. This verification of the accuracy and quality of SeaMARC/S imagery will serve as a credibility benchmark for future applications of this remarkable instrument. Many proposed users, including the U.S. Navy, are anxiously awaiting final results from this survey.

Scientific Knowledge Of The Alenuihaha Channel

The HDWCP has sponsored significant oceanographic, meteorological, geological and bathymetric data acquisition programs in the Alenuihaha Channel, to acquire basic environmental data for cable design and installation. These field measurement programs at this depth are unrivaled in the Hawaiian Archipelago. Results indicate that the dynamics of flow through the constricting passage between islands is a highly complex response to tides, oceanic currents and surface wind stresses. HDWCP data can help define the relationship among these variables.

The value of this scientific data, independent of its value to the HDWCP and to further commercial cable applications, is very significant. For example, there is a concerted effort by the University of Hawaii, Department of Oceanography and Harvard University's Department of Oceanography to develop a computer/numerical model of oceanic flows around island systems. Their proposal to the National Science Foundation has focused on the Island of

Hawaii and the Alenuihaha Channel in particular, due to the complexity of its flows and the availability of extensive oceanographic measurements. Much of this oceanographic data has been obtained by the HDWCP.

In addition, the availability of high resolution bathymetric data in both the Alenuihaha Channel and along the proposed commercial cable route is a valuable data base. This is confirmed by the recent request from the Defense Mapping Agency for copies of all available data for defense purposes.