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SMART Cables: Integration of Environmental Sensors Into Submarine Telecommunications Cables for Improved Ocean Monitoring

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Innovative deep ocean monitoring technologies are crucial to catalyzing fundamental improvements in mitigating natural disasters, reducing human vulnerabilities, and understanding environmental threats. An attractive but untapped resource is the global submarine fiber optic cable network, which carries over 95% of international internet traffic. Key components of undersea fiber optic cable systems are repeaters, which are placed every 60-100 km along the cable to provide optical signal amplification. Integrating environmental sensors, including seismic, pressure, and temperature sensors, would enable real-time data collection for environmental and infrastructure threat reduction, natural disaster mitigation, and cable system monitoring.

A unique technology that will revolutionize the utility of these cables is the SMART (Sensor Monitoring And Reliable Telecommunications) cable concept. Although the concept has been evaluated for over 10 years by an international suite of agencies and institutions, developing a SMART repeater requires substantial investment in research and development to validate a technology that could transform an industry. To date, no commercial manufacturer has allocated the resources to produce a prototype SMART repeater. To bridge this gap, we have obtained support by the National Science Foundation's Small Business Innovation Research (SBIR) program to develop a benchtop prototype SMART repeater. As part of an international effort to help develop a SMART Cable system for the New Caledonia - Vanuatu region, we also have received support from the Gordon and Betty Moore Foundation as part of a team led by the University of Hawai`i.

Best-in-class SMART repeater sensors include a 3-axis accelerometer, absolute pressure gauge, and temperature sensor. Included with the sensors are data acquisition circuits with suitable dynamic range and precision, integration around a common communications module, an interface suitable for fiber optic cable spans up to 120 km in length, the software and firmware necessary to support the data path from the sensors to data storage servers, and precision timing for both time-stamps and frequency reference. The SMART repeater sensor system design is modular, thereby containing branch points for different sensors, as well as incorporation in different repeater

housings or as standalone units.

SMART Cables will be particularly well suited for providing essential tsunami monitoring data, particularly from the seismic and pressure sensors. More specifically, SMART repeaters provide a unique opportunity to develop significantly more extensive sensor networks of real-time ocean bottom monitoring, filling in critical near-field and azimuthal gaps frequently encountered in earthquake monitoring. Further, our SMART repeater sensor system design includes the option for either acceleration or velocity monitoring, thereby enabling better measurement of amplitudes of tsunamigenic subduction zone earthquakes while providing a lower noise sensor in ocean basins. Further, data from SMART Cables will facilitate the detection of other tsunamigenic sources, including underwater landslides. We will present the results of our sensor development efforts and upcoming opportunities for SMART Cable installations.