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Scaling a scientific Tower of Babel— Helping oceanographic instruments learn a common language

MOSS LANDING, California—Two new reports recommend far-reaching strategies for getting oceanographic instruments to work together. Communication between scientific instruments and data networks has become increasingly important in an age of ocean observatories, when data from all kinds of oceanographic instruments and sensors must be collected simultaneously, processed by a wide variety of computer systems, and presented in forms useful to different types of end users. Both reports emphasize that in order to increase interconnectivity between oceanographic sensors and data-processing systems, the designers, manufacturers, and end users of these systems must connect with one another to find areas of agreement and work toward common goals and standards.

These two reports summarize two back-to-back workshops that were held in Portland Maine in October 2006. One workshop, "Enabling Sensor Interoperability," focused on how to get individual sensors to work together efficiently in large systems such as oceanographic observing networks. This workshop was organized and hosted by the Alliance for Coastal Technologies (ACT) [<http://www.act-us.info>] and the Gulf of Maine Ocean Observing System (GoMOOS) [<http://www.gomoos.org>]. A second workshop, "Sensor Metadata Interoperability," was sponsored by the Marine Metadata Interoperability (MMI) project [<http://marinemetadata.org>], and focused on methods for describing oceanographic sensors and the data they produce. The complementary workshops were scheduled one after the other so that participants could get an overview of current challenges in connecting sensors to computers and networks, as well as some potential ways of addressing these challenges.

One of the main findings of the ACT Enabling Sensor Interoperability workshop was that sensor developers and operators of ocean observatories needed to work together to decide what types of new technologies will be needed to get diverse sensors to work together in a "plug-and-

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play” fashion. A secondary finding was that new sources of funding would be needed to develop this new technology. The workshop participants also agreed on the need for engineering guidelines to make oceanographic sensors more compatible. Such guidelines would make it easier for engineers to design sensors that can be detected and identified automatically as soon as they are plugged in to an observatory network. Industry-wide standards would also ensure that sensors from different manufacturers used consistent methods for collecting and reporting data, and might allow the sensors to be controlled (or at least reset when necessary) by end users on shore.

Over the longer term, the ACT workshop participants recommended forming a committee that would be responsible for creating and maintaining standards for 1) metadata, 2) commands, 3) protocols, 4) processes, 5) exclusivity, and 6) naming authorities. They also recommended convening an annual symposium where researchers could discuss and propose new state-of-the-art solutions to the ongoing challenges of collecting oceanographic data. Finally the workshop participants suggested that new computer models should be created to simulate ocean observatories, so that researchers could test their hardware and software for compatibility with the observatory network before the instruments were actually deployed in the field.

The Sensor Metadata Interoperability workshop was convened to help engineers and researchers agree on the best ways to create and store “sensor metadata”—information that describes a particular oceanographic sensor and the data that sensor produces. For example, the metadata for an underwater thermometer might include its model and serial number, the name of its manufacturer, the fact that it measures water temperature, and the range of temperatures it can measure accurately.

The metadata workshop participants agreed that there were already plenty of existing standards for creating and storing sensor metadata, and that creating additional standards would simply add confusion. However, many researchers felt the need for augmenting or customizing existing standards, and expected that translating, or 'crosswalking,' from one metadata standard to another was inevitable. Some suggested that a single conceptual model should be created to encompass all the detailed standards.

The metadata workshop participants also agreed that all researchers and manufacturers should be encouraged to use the same terms or variables in their products and data management

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tools. The workshop also discussed issues such as who should be responsible for creating metadata (the manufacturers, the instruments themselves, or the end users), how detailed this metadata should be, how to manage metadata changes over time, and where metadata should be stored (in the instrument, by the manufacturer, or on shore-based systems).

Participants in both workshops made many common recommendations. For example, they suggested that best practices should be identified and documented and good examples of metadata use by instruments or data-handing systems could be highlighted and made available to the research community. They also agreed that it would be useful to establish an online repository that would store metadata on commercial oceanographic instruments as well as a list of specific, well-defined terms that could be used for all sensors. Finally, they underscored the need for more communication among researchers, data managers, and manufacturers, so that different groups could agree on and use each other's terms and approaches to data management.

The reports and recommendations from the ACT and MMI workshops are available on the ACT web site (www.act-us.info/workshops_reports.php) and the Marine Metadata Interoperability project web site (<http://marinemetadata.org/smireport>), respectively. The MMI site also contains a summary of recommendations from both reports (<http://marinemetadata.org/smiaactivities>). Together, these three documents will serve as a “strategic plan” to guide future improvements in the usability and interoperability of oceanographic sensors.

Effective use of ocean science data in the 21st century will require more efficient means of communication between sensors, observing systems, and data processing systems, as well as among researchers, manufacturers, and educators. The Alliance for Coastal Technology and the Marine Metadata Interoperability project have identified many critical needs in the oceanographic community, and are working with the community to meet those needs. The October 2006 workshops set baseline goals for the future and identified communities of interested experts in the field. Over the next few years, both the ACT and the MMI projects will continue working with the oceanographic community to accelerate progress toward effective, interoperable ocean observing systems.

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