Ocean Data Telemetry Microsat Link (ODTML)

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LONG-TERM GOALS

The long term goal of this program is to have a reliable, inexpensive, satellite-based, world-wide real-time ocean monitoring system. This system will allow cost effective monitoring of all ocean data platforms, including ocean buoys, ocean gliders, and other newly developed ocean monitoring systems. The ODTML (Ocean Data Telemetry Microsat Link) system consists of three components, being developed in unison under two different ONR contracts. The components are: 1) the Spacecraft Communications Payload (SCP) that will fly on satellites, 2) the Ground to Space Communications Terminal (GSCT) that will be placed on the various ocean platforms, and 3) the Network Control Center (NCC) which will provide the communications link between the users and the ocean platforms. The contracts that are developing this system are: TacSat-3 and -4 Spacecraft Communications Payload, N00014-06-C-0349, and Ground to Space Communication Terminal, N00014-07-C-0525.

OBJECTIVES

The short-term goal of the ODTML program is to provide a real-time demonstration of a complete ocean monitoring system. This is being accomplished by designing, building, and deploying a flight qualified SCP on the TacSat-3 spacecraft, which will launch in December 2008, and deploying several newly designed GSCTs onto ocean platforms. Using the TacSat-3 SCP and the NCC being installed at Praxis HQ in Alexandria, VA, we will be able to send data to and receive data from widely dispersed ocean platforms to validate the ODTML concept. The culmination of this work will result in a robust, cost-effective two-way (space-to-ground and ground-to-space) satellite system with significant increases in the amount of data that can be collected from autonomous platforms. Of primary importance is a two-way delay-tolerant messaging capability providing Internet-like services on a global basis. The ODTML architecture allows evolution and expansion for future sensors, and it decouples platform (buoy) upgrades from future space segment system upgrades. Thus, new technology can be introduced seamlessly into either the sensor grid or the satellite system. This work is developing a cost-effective constellation of space payloads (SCPs) and ocean platforms (GSCTs) to meet the DoD (and civil sector) needs for a real-time Integrated Ocean Observing System, and general

Report Documentation Page

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1. REPORT DATE **30 SEP 2008**	2. REPORT TYPE **Annual**	3. DATES COVERED **00-00-2008 to 00-00-2008**

4. TITLE AND SUBTITLE **Ocean Data Telemetry Microsat Link (ODTML)**	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Praxis, Inc.,5845 Richmond Highway, Suite 700,Alexandria,VA,22303**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
code 1 only

14. ABSTRACT

The long term goal of this program is to have a reliable, inexpensive, satellite-based, world-wide realtime ocean monitoring system. This system will allow cost effective monitoring of all ocean data platforms, including ocean buoys, ocean gliders, and other newly developed ocean monitoring systems. The ODTML (Ocean Data Telemetry Microsat Link) system consists of three components, being developed in unison under two different ONR contracts. The components are: 1) the Spacecraft Communications Payload (SCP) that will fly on satellites, 2) the Ground to Space Communications Terminal (GSCT) that will be placed on the various ocean platforms, and 3) the Network Control Center (NCC) which will provide the communications link between the users and the ocean platforms.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**6**	

purpose data exfiltration/infiltration system. The U.S. Navy is the direct beneficiary of the system, as it enhances the Navy's ability to gather sensor information on a global and near real-time basis by interrogating and tasking ocean observing platforms. Such capability has applications in the area of anti-submarine warfare, surveillance, oceanography, and other ocean-monitoring activities.

APPROACH

Our approach is to design, develop, demonstrate, and test engineering development units (EDU) of the entire ODTML system consisting of the following elements: a microsatellite SCP (serving as a "router in the sky"), ocean observing platforms (e.g., free-floating buoys) equipped with GSCTs for the RF link to the SCPs, and ground stations acting as gateways to the Internet with the NCC as the system manager. Using TacSat-3 as our initial test bed for the SCP, we will demonstrate the capabilities of the ODTML concept over the coming year of TacSat-3 operations. The NCC will apply the concept of IP addressing of sensor nodes and Internet-based "instant messaging" to create a network out of the traditionally inefficient ocean monitoring platforms and the associated communications relay system. The users will be able to interrogate and task a number of ocean monitoring platforms, gather geographically distinct measurements nearly simultaneously for an extended period of time, and thereby acquire an improved awareness of the target environment. Sensor network technology allows near real-time exchange, which includes node-to-node type (when nodes are within line-of-sight of each other) and node-to-relay (when nodes are beyond line of sight from each other). The stand-off distances can be in tens to hundreds of kilometers. Data transmission rates can range from 1200 to 9600 bps.

Praxis has designed, built, and delivered a low cost, low power, space qualified, two-way Spacecraft Communications Payload (SCP, Figure 1) for flight on the TacSat-3 spacecraft (FY09 Q1 launch). This payload is the first generation version of the SCP, a concept originally envisioned in ONR SBIR, N02-062, Ocean Data Telemetry MicroSat Link, and uses a commercial off-the-shelf (COTS) RF transceiver, furnished by SpaceQuest, Inc., and a custom built quadrifilar antenna. This payload, built by Praxis in conjunction with Silver Engineering, Inc., will provide data exfiltration/infiltration capabilities via the Internet for ocean buoys and other low data rate sensors once it is launched on TacSat-3.

Figure 1. The TacSat-3 Flight SCP (Spacecraft Communications Payload)

Praxis has also developed a miniaturized ocean buoy RF terminal, known as the GSCT (Figure 2). This terminal is small (2" x 3"), low power, smart (onboard processor), and low cost. Praxis is planning on building several dozen of these GSCTs and placing them on ocean buoys and other platforms of

opportunity. The terminal's small size and low cost allow proliferation of these sensors around the world, providing a great opportunity to demonstrate the utility of the ODTML architecture.
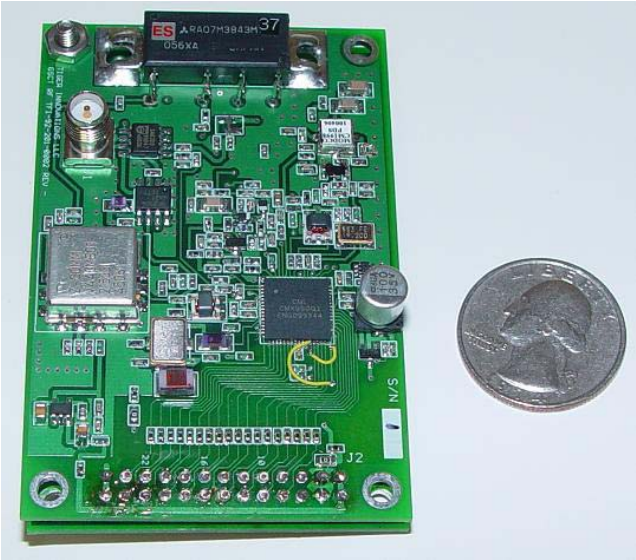

Figure 2. Ground to Space Communication Terminal (GSCT)

In addition, Praxis is developing the NCC to provide software management of the ODTML system. For the TacSat-3 demonstration, the NCC software is hosted by the Portable Gateway Station (PGS, Figure 3). The NCC furnishes a world wide web interface for ODTML system users. The NCC paradigm of operation will be a TPPU (task, post, process, utilize) methodology as opposed to the old TPED (task, process, exploit, disseminate) methodology. In the TPPU paradigm, the producer of the data posts the raw data as well as every interim solution so that everyone who needs it can pull it into their own evaluation process.

Figure 3. Portable Gateway Station (PGS), Host for NCC Software

The ODTML architecture allows evolution and expansion for future sensors, while maintaining backward compatibility with all existing data systems. It decouples platform (buoy) payload upgrades from future space segment system upgrades. Thus, new technology can be introduced seamlessly into either the sensor grid or the satellite system. Because of the modularity, small size, low power, and ease of installation, the SCP can be integrated on many different space platforms. (It has already been manifested on two additional spacecraft, TacSat-4 and STPSat-2, which are scheduled to launch in FY 10.) Similarly, because of its small size and low cost, the GSCT can be installed on a plethora of sensor platforms. Finally, the NCC will allow seamless dissemination (TPPU) of the data. Thus, ODTML will move the U.S. Navy closer to the goals of persistent monitoring and having an integrated global ocean observing system.

WORK COMPLETED

(1) Delivered the first SCP to the Air Force Research Laboratory, and completed integration and testing on the TacSat-3 spacecraft.

(2) Completed the design and build of an upgraded SCP for flight on the TacSat-4 spacecraft.

(3) Delivered the second SCP to the Naval Research Laboratory (NRL) and completed integration and testing on the TacSat-4 spacecraft.

(4) Designed and built an SCP for flight on the STPSat-2 spacecraft.

(5) Performed end-to-end testing of the Army Tactical Downlink (ATDL) software to be used to send TacSat-3 hyperspectral imaging data messages to a PRC-117, carried by an Army soldier in the field.

(7) Designed, built, and tested the prototype GSCT.

(8) Developed initial software for the NCC and tested a preliminary version of this program.

RESULTS

Praxis has completed and delivered the first two SCPs for flight on the TacSat-3 and -4 spacecraft, and has built the prototype GSCT. In addition, Praxis has defined the requirements for the NCC and developed a preliminary version of the software. We are preparing for the first live demonstration of the ODTML system as soon as the TacSat-3 spacecraft launches.

Praxis has completed the three option efforts under the SBIR Phase II. Under the SBIR Phase II effort, Praxis was required to design, develop, demonstrate, and test an EDU of the ODTML system. All of the tasks were completed as described in the ODTML Phase II Base Final Report. Based on the successful completion of all Base period tasks, we were asked to proceed with all three tasks of the Phase II Option effort, which completed the design and build of an SCP flight unit, and prepared it for a field demonstration on the TacSat-3 spacecraft.

IMPACT/APPLICATIONS

This work is a giant step toward the deployment of an ODTML system capable of persistent surveillance of ocean sensors through the use of a constellation of cost effective, space qualified SCPs and GSCTs. ODTML will meet the DoD (and civil sector) needs for a real-time Integrated Ocean Observing System. The U.S. Navy will be the direct beneficiary of the system, as it will enhance the Navy's ability to gather sensor information on a global and near real-time basis by interrogating and tasking ocean observing platforms. Such capability has applications in the area of ASW, surveillance, and other ocean-monitoring activities. An ancillary benefit would be the ability to also monitor other data sensors, such as unattended ground sensors and low probability of intercept (LPI) communication devices. In fact, once a system is in place, it could be used for data exfiltration from a host of different data terminals.

The ability to provide near real-time situational awareness is essential for the next generation ocean observing system because the response time to an occurring event, military or scientific, is increasingly tied to operational effectiveness. The ability to query or interrogate a sensor that has detected an event is important because users often desire confirmation or more frequent observation of the event. Current systems do not meet these needs because they are based on dated technologies.

A major achievement of this program will be the increased intelligence value realized by being able to network a group of individual sensors into a grid of smart, cooperative nodes. With onboard processing, smart sensor nodes will evaluate gathered data and make knowledge-based decisions on whether to notify other sensors or query them on their information. In other words, they will become a team, sharing data and helping each other to know either what has happened or what to expect. Data fusion, data sharing, and data queuing are all new capabilities that will be introduced by this concept of networking smart sensors. This will greatly enhance the intelligence value of the sensor grid over having individual sensors unable to communicate.

RELATED PROJECTS

The TacSat Program. The Office of Force Transformation (OFT) started the TacSat program in 2003, and has passed its program management on to AFRL. This program is looking for fast turnaround, low cost payloads to fly to demonstrate that space doesn't have to "cost too much and take too long." NRL built TacSat-1 and -4, while AFRL built TacSat-2 and -3. The SCP is being flown on TacSat-3 and -4.

Operationally Responsive Space (ORS.) ORS is a new DoD program office tasked with providing responsive, militarily useful space payloads. Because of its small size and low cost, the SCP is under serious consideration to be a future standard ORS payload that will be manifested on many ORS spacecraft.

DoD Space Test Program. This DoD program funds I&T costs for payloads to fly in space. Each year a Space Experiments Review Board (SERB) evaluates and ranks payloads, and an attempt is made to match payloads with available space rides. ODTML was ranked in the 2004, 2005, 2006, and 2007 SERB, and STP furnished the funds to integrate it onto the TacSat-3 and -4 spacecraft.

Smart Sensor Node (SSN) In House (Praxis) R&D Effort. To evolve to the GSCT "smart" sensor goal, Praxis undertook an in-house effort to design a small, low cost RF terminal with a CPU and a DSP to increase the processing capability of terminals to allow on-board data fusion.