NOAA Technical Report NOS CO-OPS 34

Ocean Systems Test and Evaluation Program (OSTEP) Development Plan

Silver Spring, Maryland
April 2001

noaa National Oceanic and Atmospheric Administration

U.S. DEPARTMENT OF COMMERCE
National Ocean Service
Center for Operational Oceanographic Products and Services

Center for Operational Oceanographic Products and Services
National Ocean Service
National Oceanic and Atmospheric Administration
U.S. Department of Commerce

The National Ocean Service (NOS) Center for Operational Oceanographic Products and Services (CO-OPS) collects and distributes observations and predictions of water levels and currents to ensure safe, efficient and environmentally sound maritime commerce. The Center provides the set of water level and coastal current products required to support NOS' Strategic Plan mission requirements, and to assist in providing operational oceanographic data/products required by NOAA's other Strategic Plan themes. The Center manages the National Water Level Observation Network (NWLON), and a national network of Physical Oceanographic Real-Time Systems (PORTS™) in major U.S. harbors. The Center: establishes standards for the collection and processing of water level and current data; collects and documents user requirements which serve as the foundation for all resulting program activities; designs new and/or improved oceanographic observing systems; designs software to improve CO-OPS' data processing capabilities; maintains and operates oceanographic observing systems; performs operational data analysis/quality control; and produces/disseminates oceanographic products.

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Ocean Systems Test and Evaluation Program (OSTEP) Development Plan

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U.S. DEPARTMENT OF COMMERCE
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NOTICE

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EXECUTIVE SUMMARY

The burden on the Nation's coastal ocean and waterways continues to grow at an accelerating rate, while insufficient resources are available to adequately monitor even the most basic parameters. Advances in technology and communications systems offer a wide variety of potential solutions, also at an accelerating rate. The challenge is to introduce these new capabilities into existing monitoring networks in a cost effective and responsible manner.

A variety of coastal programs are presently in the early stages of development. Through them there here is a growing awareness of the value of existing infrastructure and the difficulty of operating permanent monitoring systems. NOS should be prepared to accept the logical demand for additional sensors.

The OSTEP seeks to facilitate the transition of new technology to an operational status, selecting newly developed sensors or systems from the research and development community and bringing them to a monitoring setting. OSTEP will also provide quantifiable and defensible justifications for the use of existing sensors and methods for selecting new systems. The program will establish and maintain field reference facilities where, in cooperation with other agencies facing similar challenges, devices will be examined in a non-operational field setting. Through OSTEP, sensors will be evaluated, quality control procedures developed, and maintenance routines generated. The quality of the reference systems used in the field will be assured by both rigorous traceable calibrations and redundant sensors.

1.0 INTRODUCTION

1.1 Purpose of Document

This document is a plan for the development of an OSTEP and the establishment of an Ocean Systems Test & Evaluation Facility (OSTEF) in Chesapeake, VA, in cooperation with the Old Dominion University, the National Institute of Standards and Technology (NIST), and the Naval Surface Warfare Center/Carderock Division.

1.2 CO-OPS Mission Statement

The National Ocean Service (NOS) Center for Operational Oceanographic Products and Services (CO-OPS) collects and distributes observations and predictions of water levels and currents to ensure safe, efficient and environmentally sound maritime commerce. The Center provides the set of water level and coastal current products required to support NOS' Strategic Plan mission requirements, and to assist in providing operational oceanographic data/products required by NOAA's other Strategic Plan themes. For example, CO-OPS provides data and products required by the National Weather Service to meet its flood and tsunami warning responsibilities. The Center manages the National Water Level Observation Network (NWLON), and a national network of Physical Oceanographic Real-Time Systems (PORTS™) in major U.S. harbors. The Center; establishes standards for the collection and processing of water level and current data, collects and documents user requirements which serve as the foundation for all resulting program activities, designs new and/or improved oceanographic observing systems, designs software to improve CO-OPS' data processing capabilities, maintains and operates oceanographic observing systems, performs operational data analysis/quality control, and produces/disseminates oceanographic products.

The Center is divided into four Divisions to address various functionally important areas. The divisions are Requirements & Development, Field Operations, Products and Services, and Information Systems.

1.3 Background

1.3.1 National Water Level Observation Network

CO-OPS is responsible for the management of the U.S. National Water Level Program (NWLP). The foundation of this program is the National Water Level Observation Network (NWLON), a network of water level measurement stations in the U.S. coastal ocean, including the Great Lakes and connecting waterways, and in U.S. Trust Territories and Possessions.

The data and information from the NWLON represent one of the most unique and valuable geophysical data sets available. In addition to about 140 continuously operating NWLON stations in U.S. tidal regions and 49 continuously operating stations in the Great Lakes, the Center operates about 50 temporary water level measurement stations each year in support of National Ocean Service mapping and charting, hydrography, and Great Lakes water resources management. Several stations have continuous data series starting in the mid and late 1800's. Data and information are available from several thousand additional locations in the U.S. coastal ocean where shorter series of observations have been collected. Networks of local bench marks maintained at each location are used to maintain and update vertical reference systems.

Using the foundation provided by the NWLON, the NWLP provides for the determination of and maintenance of vertical reference datums used for surveying and mapping, dredging, and coastal construction, water level regulation, marine boundary determination, tide prediction, and for analysis of long-term water level variations and trends.

1.3.2 National Physical Oceanographic Real-Time System

The National PORTS™ provides observations and predictions of oceanographic and marine meteorological conditions for decision support in which life and property are at risk. A legal liability for the observations and predictions demands that PORTS™ provide information which is of the best quality available. The measurement quality must support not only direct application of the data to decisions, but also derived products and services such as computer model simulations based on real-time data assimilated into the model. Derived products and services place an additional level of accuracy on the measurements obtained by PORTS™. PORTS™ measurements must be of sufficient accuracy so that the derived products and services maintain the level of accuracy required for decision support. For example, water levels generated by a nowcast model for real-time underkeel clearance applications must have a similar level of accuracy as the direct observations.

1.4 Goals & Objectives of an Ocean System Test & Evaluation Program

The goal of the Ocean Systems Test & Evaluation Program (OSTEP) is to provide a non-operational setting in which to test and evaluate oceanographic and marine meteorological sensors and systems. OSTEP will facilitate the introduction of new sensors into an operational setting by providing test data quality assurance to a level required for NOS to accept legal liability for observations and derived navigation safety products and services.

There are five objectives of OSTEP:

1) Evaluation of new technology for use in measurement systems;
2) Integration and testing of field measurement systems;
3) Development, test and evaluation to determine measurement system readiness for operational deployment,
4) Life cycle evaluation of system performance, operations, and maintenance, and;
5) To provide and oversee the establishment of quality control parameters that will be used by the Continuous Operational Real Time Monitoring System (CORMS).

OSTEP will provide three basic data quality assurance capabilities;

1) Measurement standards traceable to the NIST of sufficient accuracy in the field to determine an uncertainty budget for measurements used directly as observations and for hydrodynamic model predictions,

2) Legally identifiable independent organization and management with the authority and resources needed to meet the goal; and

3) A quality process appropriate to the type, range and volume of calibration and testing activities to meet the most demanding CO-OPS product and service quality assurance requirements.

CO-OPS will provide the capability through partnerships, including: 1) existing and continuing contracts with the Naval Surface Warfare Center/Carderock Division, 2) the Cooperative Institute for Coastal Physical Oceanography recently formed with the Old Dominion University, and 3) planned participation in the National Voluntary Laboratory Accreditation Program (NVLAP) operated by the NIST. OSTEP will be accredited against ISO 25 standards under the NIST NVLAP to ensure that the three capabilities are continuously improved to meet evolving program requirements.

1.4.1 Evaluation of New Technology for Use in Programs

The NOS acquires new technology for integration into oceanographic and marine meteorological measurement systems. NOS must evaluate the advantages in a life cycle sense of the incorporation of the new technology into NWLON and PORTS™. The OSTEP must provide the opportunity for NOS and instrument makers to evaluate, under realistic field conditions, the performance and reliability of new sensors, data communications, and data collection/acquisition software and hardware. OSTEP must develop and maintain detailed test and evaluation standards as well as a credible field facility, in order to certify the performance of systems to support NOS programs and to attract instrument makers to utilize OSTEP to evaluate their equipment.

1.4.2 Integration & Test of Systems Under Development

OSTEP must provide the capability to Integrate and Test (I&T) systems under development at field sites around the country. Systems which can be tested early in their development under realistic field conditions are more likely to perform well over their life cycle than those which undergo their first realistic environmental conditions upon operational deployment.

During I&T the system is incrementally built and interfaces tested across the adjoining subsystems. Not all subsystems may be available during I&T. OSTEP must provide the ability to simulate subsystem components not yet available. This is often done by computer simulation of the characteristics of missing subsystems.

1.4.3 Development Test & Evaluation

End-to-end systems test will be conducted under OSTEP to determine the readiness for operational deployment at customer/user sites. Fully integrated systems will encounter realistic environmental conditions at OSTEF. All components of the system to be deployed will be tested system wide. The actual power and communications links may not be the same as actual deployed conditions but should be as realistic as possible.

The results of the development test & evaluation will be formally reviewed to receive approval to deploy for operations at the remote customer/user's site.

1.4.4 Life cycle Evaluation of Systems

The OSTEP will utilize at least one PORTS™ site which will test life cycle performance including measurement accuracy, reliability, availability, and maintainability. This system will be used as the PORTS™ demonstration system for marketing as well as in day-to-day ship operations in the Norfolk, VA, area.

1.5 Partners

1.5.1 Old Dominion University, CCPO

The Center for Coastal Physical Oceanography (CCPO) at Old Dominion University has a long working affiliation with the FOD. The CCPO was established by the Commonwealth in 1992 to facilitate innovative research in the coastal ocean. The center has built an international reputation for such research.

The CCPO has characterized the oceanographic and marine meteorological conditions of the OSTEF. Their knowledge of marine hydrodynamics will help to establish the cause and effect for physical processes which will provide variability in the test environment. Their expertise in field oceanographic data collection, analysis, and modeling will assist in the interpretation of test results. NOAA personnel work at the CCPO on a real-time model of the circulation of Chesapeake Bay called the Chesapeake Bay Operational Forecast System (CBOFS). The use of CBOFS with data from OSTEP will greatly enhance the understanding of the assimilation of real-time observations into computer hydrodynamic models.

1.5.2 National Institute of Standards & Technology

The calibration services of the National Institute of Standards and Technology (NIST) are designed to help the makers and users of precision instruments achieve the highest possible levels of measurement quality and productivity. Their services constitute the highest order of calibration services available in the United States. They directly link a customer's precision equipment or transfer standards to national and international measurement standards. These services are offered to public and private organizations and individuals alike.

The NIST maintains the absolute standards for temperature, electrical conductivity, pressure, and fluid flow which are essential to the establishment of measurement error budgets. NIST also administers the National Voluntary Laboratory Accreditation Program to accredit facilities to ISO 25 measurement standards and procedures. The NIST has two roles in the establishment of OSTEP; 1) transfer of standards to OSTEP, and 2) accreditation of OSTEP.

1.5.3 Naval Surface Warfare Center, Carderock Division

The Naval Surface Warfare Center/Carderock Division (NSWC/CD) provides unique water tank facilities and measurement test equipment to calibrate current meters for use in PORTS™. Staff hydrodynamicists are available to transfer primary fluid flow measurement standards from NIST to the OSTEP field site.

1.5.4 Other Potentially Interested Entities

It is anticipated that other organizations close to the selected OSTEF site will have an interest in the program. These groups include:

Cooperative Institute for Coastal Physical Oceanography
The Cooperative Institute for Coastal Physical Oceanography was jointly created in 1998 by ODU and NOS to facilitate the development and operational utilization of scientific and technological advances in oceanography.

NOAA Atlantic Marine Center in Norfolk, VA
The NOAA Atlantic Marine Center manages the Atlantic Hydrographic Field Branch which surveys the bathymetry in the Bay.

US Army Corps of Engineers, Field Research Facility in Duck, NC
Open since 1977, the FRF is internationally recognized for its coastal studies. Central to the facility is a 560 meter long pier and unique specialized equipment.

US Army Corps of Engineers, Norfolk District
The U.S. Army Corps of Engineers Norfolk District maintains the channels of the ports in the area and provides permits and other in-kind services.

Greater Hampton Roads Maritime Industry
The Greater Hampton Roads Maritime Industry ranges from pilots to freight forwarders who are keenly interested in research and operations that will increase their competitiveness. The National Association of Maritime Organizations (NAMO) is located in Hampton Roads and works with all U.S. Maritime organizations to promote safe and efficient maritime commerce.

US Coast Guard Facility Design Division, Norfolk, VA
The FOD has long standing relations with the U.S. Coast Guard Facility Design Division, through the local aids to navigation and search and rescue functions.

1.6 Relationship to Other Test Facilities

1.6.1 Field Research Center - US Army Corps of Engineers

The Army Corps of Engineers maintains a Field Research Facility (USACE/FRF) in Duck, NC. The coastal location, together with the extensive specialized instruments located there, provides a unique setting for the evaluation of marine sensors, especially wave sensors and radar derived surface currents. In the past, wave observations at the FRF have been used to develop an understanding of their impact on the beach profile. Radar derived surface currents have been evaluated with emphasis on maximizing range. The OSTEP will evaluate such sensors as appropriate for specific application to PORTS™. The OSTEP will seek a formal alliance with the USACE/FRF similar to the FRF agreement with the National Data Buoy Center (NDBC).

1.6.2 NWS/NDBC

The primary observations of NDBC, coastal meteorology to support the National Weather Service (NWS), are the ancillary observations of CO-OPS. Likewise, the CO-OPS focus on water levels has been a collateral task at NDBC. It is well recognized that the two centers have a synergistic relationship, but their primary functions are unique. A variety of cooperative investigations are envisioned. A good example would be the evaluation of a microwave bridge clearance sensor, highly desired at several PORTS™. Since the device is also capable of observing wave height and period, NDBC has expressed interest for use at CMAN stations.

2.0 REQUIREMENTS

2.1 CO-OPS Data Quality Assurance Requirements

For every scientific or technical investigation, a means must be provided to assure that the data used, are sufficiently accurate to support the objectives of the investigation.

A mechanism to attain such accuracy is the Data Quality Assurance (DQA) plan. Such a plan provides for the selection and certification of measurement devices, the specification of procedures to be used in both field and laboratory operations, and processing and evaluation of the data collected. Evaluation of the data includes the specification of acceptable limits of accuracy and the definition of the causes of errors. The DQA plan also provides for continuous monitoring of the data collection process to see that specified procedures are followed, that error analyses are being used to control data quality, that data meet program objectives, and that data quality is known at all times.

This document provides information and guidance so that data collection activities in marine measurement programs can be effectively planned, controlled, and reported. Recommendations are made on the type and organization of activities needed for collecting data compatible with the intent of such programs.

The guidance in this document is general; it can be used to develop a DQA plan for any type of measurement program. It is presented in a logical sequence for developing a DQA plan. Once a DQA plan is completed and has been reviewed by management, it becomes an integral part of the measurement program and provides a systematic way to control the uncertainty of the collected data.

2.2 National Water Level Network Requirements

The National Water Level Observation Program provides basic tidal datums to determine U.S. coastal marine boundaries and for nautical chart datums. It also provides support for NOAA's tsunami and storm surge warning programs, climate monitoring, coastal processes and tectonic research. The Program contributes to safe vessel navigation and the increased efficiency of maritime transportation. In the Great Lakes the Program supports water management and regulation, navigation and charting, river and harbor improvement, power generation, scientific studies and adjustment for vertical movement of the Earth's crust in the Great Lakes Basin.

The Program's operational component is the National Water Level Observation Network (NWLON). The NWLON consists of approximately 170 water level measurement stations distributed along U.S. coasts, in the Great Lakes and connecting channels, and in the U.S. territories and possessions. One hundred forty stations are considered "long-term control" and "primary" stations. These have been in operation at least 19 years, are still in continuous operation and transmit data in near-real-time. Data are transmitted every hour via GOES, NOAA's suite of Geostationary Operational Environmental Satellites, to CO-OPS for quality control, analysis and dissemination. In addition to these near-real-time records, the Program's on-line archives also include historical data from secondary and tertiary stations, i.e., those with records lengths from 18 years down to only a few weeks.

Each of these stations requires a primary Data Collection Platform (DCP) with either a self-calibrating acoustic ranging sensor, a pressure sensor, or a float coupled to a shaft angle encoder. Ancillary data, such as wind velocity, barometric pressure, air and water temperature, and conductivity are very often installed as well. Many of the components found in these systems are dated. Replacements or maintenance service is becoming increasingly difficult to obtain, and newer components recently brought to market need to be evaluated. One of the very first requirements of OSTEP will be to test and evaluate potential replacements for the existing Next Generation Water Level Measurement System (NGWLMS) DCPs.

2.3 National PORTS™ Program Requirements

The PORTS™ is a program of the National Ocean Service that supports safe and cost-efficient navigation by providing ship masters and pilots with accurate real-time information required to avoid groundings and collisions. PORTS™ includes data acquisition and dissemination systems that provide real-time observations (six minute updates) of water levels, currents, and other oceanographic and meteorological data from bays and harbors. Data is delivered to the maritime user community in a variety of user friendly formats, including telephone voice response and the Internet. Telephone voice access to accurate real-time water level information allows U.S. port authorities and maritime shippers to make sound decisions regarding loading of tonnage (based on available bottom clearance), maximizing loads, and limiting passage times, without compromising safety.

The National PORTS™ Program requires measurements tied to accepted standards traceable to NIST where possible, which provide a high level of accuracy to meet the dual role of maritime commerce and marine resource management decision support. Individual measurements may be used directly in decision support or may be part of analysis and model synthesis of additional information. It is in the area of model synthesis that the most stringent measurement requirements arise. For example, water level measurements throughout an estuary must be related to the same vertical reference system to better than 1 centimeter accuracy to meet reasonable (~100 m3/s) transport calculations using a model. Current measurements must be to an accuracy of a few centimeters/second in order to accurately compute tidally averaged transports of salt, heat, nutrients, biomass, etc.

At a minimum, the OSTEP must support field reference standards for the following oceanographic and marine meteorological variables (and derived quantities):

- Current (water transport or volume flow);
- Pressure, temperature and conductivity (salinity and density);
- Water level (tidal height and directional wave spectrum);
- Air temperature and relative humidity
- Atmospheric visibility,
- Atmospheric pressure, and
- Wind speed and direction,

OSTEP shall provide quality assurance of PORTS™ information for which NOS will accept the legal liability for its use in navigation safety applications.

2.4 National Current Program Requirements

The National Current Program has requirements similar to the National PORTS™ Program except that the systems are often deployed in a self contained, internally recording mode. The special requirements for this application include but are not limited to the following:

- Bottom platform must survive intense fishing, anchoring, and storm damage pressures,
- Internal power must be highly reliable,
- Rapid deployment may be required,
- Moorings must be survivable in severe weather, current, fishing, and shipping conditions and not degrade the measurements, and
- Deployments shall not be dependent on diver deployment or recovery;

2.5 OSTEP Data Management & Network Requirements

There is a critical requirement for a computer based data and information management infrastructure to support OSTEP. The OSTEP will generate volumes of data as a result of short and long term testing and validation activities. How well this data and information is managed will ultimately determine the usefulness of the facility and the overall success of OSTEP. Data, and the information it brings to the scientist and the engineer must be managed in a way that (1) makes results available immediately and/or on demand, (2) can be recalled in an efficient manner with little effort; (3) can be disseminated using a variety of mediums to all legitimate requesters and (4) can be further processed, quality controlled, analyzed and archived using standard formats and COTS (commercial off the shelf) software.

To form the foundation of the required data management infrastructure and to subsequently address these requirements, the following are required components of OSTEP:

- A suite of hardware and software forming the OSTEP database subsystem. This subsystem will be the repository of any and all data and information generated by but not limited to (1) instrument test activities, (2) comparison tests; (3) pre-deployment check out, (4) long term quality assurance testing; (5) computer and telecommunications equipment testing and (6) vendor bench mark tests.

- The OSTEP database subsystem will require unencumbered access from local users at the OSTEP as well as from locations throughout the United States. To illustrate the requirement using a possible OSTEP use scenario, consider a vendor supplied instrument being evaluated at the OSTEP. Local engineers and computer specialists on site, during the test, will need immediate access to the results from the field and later in the office. The vendor may want to monitor these results from their San Francisco office and be displayed for headquarters in Silver Spring simultaneously. A network topology that addresses these types of scenarios is a requirement.

- The OSTEP central acquisition and computing facility will be located at the FOD building in Chesapeake, Virginia. The on-line and continuous running Data Acquisition System (DAS), instrument interfaces (radio, land line, network), a separate NT file server, a voice response system, remote voice access computer and associated peripherals will all reside at FOD.

- Incoming data from one or more instruments, and from one or more sites, will be stored on the DAS and subsequently forwarded to the file server as flat files.

- The OSTEP data management responsibilities will end at the time the file server database is populated. Any request for OSTEP historical data or information by local or federal third parties will be made through the OSTEP data manager. Files will be made available as flat, PUFFF (PORTS™ Uniformed Flat File Format) files with associated documentation. Any requests for real or near real time OSTEP data will be taken up by the OSTEP data manager as well as the OSTEP managers locally on a case by case basis. OSTEP will not take on the role of interfacing with other data management systems and will not be the primary data and/or information distributer. OSTEP will make available any and all data to approved parties in a general purpose format.

- Communications in addition to acquisition will include internet, land line dial-in, FOD LAN access and voice.

2.6 Field Site Environmental Requirements

The field site selected in the Hampton Roads region of Virginia near the entrance to Chesapeake Bay is shown in Figure 1. Figure 2 shows the Chesapeake Bay Bridge Tunnel (CBBT) pier which

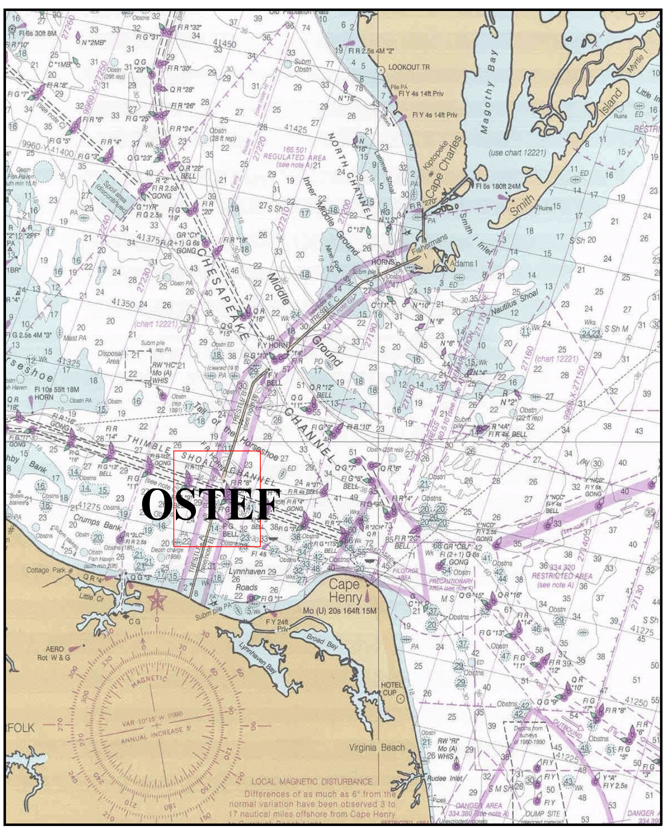

Figure 1

Figure 2

Figure 3

houses sensors and the DCP, and Figure 3 shows the housing, sensor wells and masts associated with the existing NWLON station.

The following attributes for the field site were desired:

- a wide range of density, wave, current, and water level changes to adequately cover typical conditions encountered in shallow coastal US estuaries;

- representative of conditions at the entrance to Chesapeake Bay to provide real-time information for nowcasting and forecasting transports using NOS' CBOFS;

- representative of conditions encountered by maritime commerce in the Hampton Roads area to establish a PORTS™ for life cycle test and evaluation as well as a marketing demonstration;

- simplify field logistics support to maintain a highly reliable and supportable field reference standard; and

- enable academic study to evaluate the scientific quality of the data sets obtained.

The first requirement is to ensure that comparison of systems under test and evaluation for deployment at PORTS™ and NWLON sites are exercised over as large a range of variables as possible. The test site will be instrumented with field reference standards.

There are some requirements may not be satisfied by this site. In that case, additional equipment which has been tested against the field reference standard should be deployed in the appropriate locations.

2.7 Test & Evaluation Plan Requirements

The tests conducted at the OSTEP shall be defined in Test & Evaluation Master Plans based on the capabilities of OSTEP and requirements of the project requiring the tests. A TEMP can be generated using a computer based tool such as that provided by the SAIC Automated Test Planning System (http://www.saic.com).

2.8 CO-OPS Information Systems Requirements

The Information Systems Division will use the OSTEF to test and evaluate software and hardware systems that will eventually be used in operations. These systems may be associated with NWLON, PORTS™, or current surveys. OSTEF offers a unique opportunity to run Information Technology (IT) systems in real time while interfaced with instrumentation in a non-operational mode. Operating system changes, algorithm modifications, and communication interfaces can all be tested and accepted prior to installation in the field. The IT test bed systems will be separate from the IT infrastructure OSTEP will require for acquiring and analyzing test data from sensors undergoing evaluation.

3.0 TECHNICAL APPROACH

Data collected for the OSTEP will be obtained from instruments with traceable calibrations. The Department of Defense specification MIL-STD 45662A describing traceability requires that:

1. Measuring and test equipment shall be calibrated utilizing reference standards whose calibration is certified as traceable to the NIST, has been derived from acceptable values of the natural physical constants, or has been derived by the ratio type of self-calibration techniques. Reference standards used in the calibration shall be supported by certificates, reports, or data sheets attesting to the date, accuracy, and conditions under which the results furnished were obtained.

2. Traceability is to relate individual measurement results to national standards or nationally accepted measurement systems through an unbroken chain of comparisons [3].

3. The ability to relate individual measurement results through an unbroken chain of calibrations to one or more of the following: (a) U.S. National Standards maintained by the NIST and the U.S. Naval Observatory; (b) fundamental or natural physical constants with values assigned or accepted by the U.S. NIST; (c) national standards of other countries which are correlated with U.S. national standards; (d) ratio type of calibrations; and (e) comparison to consensus standards.

OSTEP sensors shall be traceable in two ways - (a) traceable to NIST standards, and (b) traceable to consensus standards.

3.1 ISO 25 Accreditation Process

The National Voluntary Laboratory Accreditation Program requirements are documented in "Procedures and General Requirements" of the NVLAP by James L. Cigler and Vanda R.. White, May 1994 (NIST Handbook 150).

NVLAP programs are established:

- for public and private calibration and testing laboratories, manufacturer's in-house laboratories, university laboratories, and federal, state, and local government laboratories,

- to meet legal requirements, regulations or codes, and contract specifications, or to be recognized as demonstrably competent to meet the needs of its clients; and

- as the basis for guidance to facilitate agreements on mutual recognition of accreditation of laboratories between NVLAP and other accreditation organizations.

NVLAP accreditation is:

- based on evaluation of the facility's technical qualifications and competence for conducting specific test methods, measurements and services in specific fields of calibration or testing;

- granted only after thorough evaluation that the applicant has demonstrated that all NVLAP criteria have been met;

- acknowledged by the issuance of two documents to attest to that compliance: (1) a Certificate of Accreditation, and (2) a Scope of Accreditation which details the specific test methods, measurements and services for which a laboratory has been accredited.

A request to establish a Laboratory Accreditation Program (LAP) must be made to the Director of NIST and include:

- the scope of the LAP in terms of products, calibration services, or testing services proposed for inclusion;

- specific identification of the applicable standards and test methods, including appropriate designations, and the organizations or standards-writing bodies having responsibility for them;

- a statement of the perceived need for the LAP;

- a statement of the extent to which the requester is willing to support necessary developmental aspects of the LAP with funding and personnel.

3.2 Facility Organization & Staff Competencies

3.3 Test & Evaluation Process and Planing

The tests conducted at the OSTEP shall be defined in Test & Evaluation Master Plans based on the capabilities of OSTEP and requirements of the project requiring the tests. A TEMP can be generated using a computer based tool such as that provided by the SAIC Automated Test Planning System (http://www.saic.com).

A typical Test & Evaluation Master Plan (TEMP) is outlined below with the prefix TEMP to distinguish between outline sections and OSTEP plan sections:

TEMP 1.	Introduction
TEMP 1.1	Goals & Objectives
TEMP 1.2	Risk Assessment
TEMP 1.3	Minimum Acceptable Operational Performance Requirements
TEMP 1.4	Systems Under T&E Description
TEMP 1.5	Critical Technical Parameters
TEMP 2.	Integrated Test Program Summary
TEMP 2.1	Master Schedule
TEMP 2.2	Management
TEMP 3.	Developmental Test and Evaluation (DT&E)
TEMP 3.1	Overview
TEMP 3.2	Configuration Description

TEMP 3.3	DT&E Objectives
TEMP 3.4	DT&E Events, Scope of Testing, and Scenarios
TEMP 4.	Operational Test and Evaluation (OT&E)
TEMP 4. 1	Overview
TEMP 4.2	Critical Operational Issues
TEMP 4.3	Configuration Description
TEMP 4.4	OT&E Events, Scope of Testing, and Scenarios
TEMP 4.5	Live Evaluation by Users
TEMP 5.	T&E Resource Summary
TEMP 5.1	Test Articles
TEMP 5.2	Test Sites & Instrumentation
TEMP 5.3	Test Support Equipment
TEMP 5.4	Risks
TEMP 5.	External Contributors
TEMP 5.6	Operational Test Support
TEMP 5.7	Simulations, Models and Testbeds
TEMP 5.8	Special Requirements
TEMP 5.9	T&E Funding Requirements
TEMP 5.10	Manpower/Personnel Training
TEMP	Appendix A Bibliography
TEMP	Appendix B ACRONYMS
TEMP	Appendix C Points of Contact
TEMP	Attachments

3.4 Software Quality Assurance Process

All OSTEP data, analysis and results will pass through the software systems in place at the facility. To ensure these software subsystems adhere to applicable standards, procedures, and requirements, a software quality assurance process is required.

The Software Engineering Institute at Carnegie Mellon University, Pittsburg, Pennsylvania has developed a framework that describes the key elements of an effective software process. Among other things, this framework addresses the software quality assurance process. This process, called the Capability Maturity Model for Software (CMM) provides a clearly defined, evolutionary and disciplined path for software developers to follow. CMM is used throughout the industry and is recognized as an accepted and proven model to adopt when defining the software process.

3.5 Total Quality Assurance Process

The DQA plan for a marine measurement program specifies the Total Quality Assurance Process for the data collection and processing systems, personnel, and facilities are to be used to obtain the data to meet the program objectives. The plan includes an uncertainty statement about the data to be collected and details the procedures to be used to achieve the allowable error objective of the measurement program. Procedures to be considered in developing the plan are related both to the planning and operations portions of the measurement program.

3.5.1 General Considerations

The DQA plan should:

- Parallel the course of events in the measurement program. The measurement program plan should provide the sequence of events. For many programs, the DQA and measurement program plans can be merged into a single document.

- Serve as a management tool for control of the measurement program. Thus, the program management must review the DQA plan.

- Identify existing organizational procedures appropriate for the program. (The use of existing procedures decreases the need to commit unnecessary resources, and organizational personnel involved in the DQA plan will most likely be familiar with them.)

4.0 FACILITY MANAGEMENT

4.1 Facility Management Organization

The relationship of OSTEP within CO-OPS is shown in the organization chart in Figure 4.

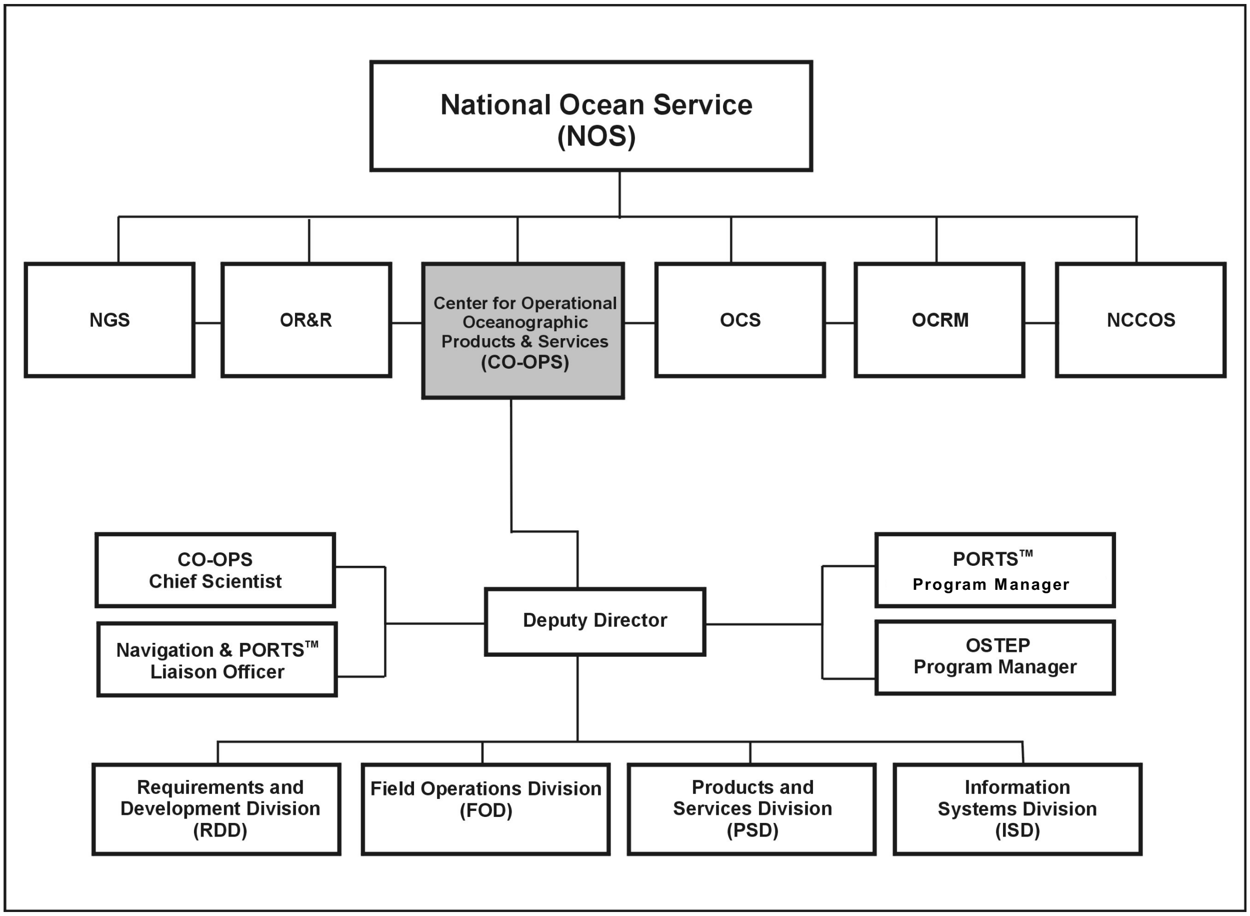

Figure 4

4.2 Facilities Description

The creation of the OSTEP Facility (OSTEF) at the Chesapeake Bay Bridge & Tunnel is the largest initial OSTEP expenditure It is required to advance the state of sensors and systems used by CO-OPS, to demonstrate a continuously developing expertise in the acquisition of oceanographic and meteorological data, and to provide a quantitative selection method for PORTS™ and NWLON sensors which balances sensor accuracy, performance, and cost.

The OSTEF is planned to be a field reference test site, primarily for new or existing sensors used in CO-OPS programs. Existing sensors will be inter-compared with each other for observational differences, for failure modes and their remedies, and for effects of manufacturer hardware and software modifications. New sensors will be compared to existing sensors in a non-operational setting, in co-operation with manufacturers and users. It is anticipated that the facility will also be valued and utilized by other NOAA elements (NWS, NDBC, and NOAA's Environmental Research Laboratories), NOS cooperative institutes (NOS/ODU CICPO, NOS/University of New Hampshire Joint Hydrographic Center) and other federal, state, and educational organizations. Cost reimbursement will be negotiated on a case-by-case basis.

The six parameters presently observed within PORTS™ and NWLON will be observed at the OSTEF. These parameters, and the methods available to sense them, include:

- water levels (acoustic, pressure, float & shaft angle encoder, laser, and microwave)
- currents (acoustic doppler profilers)
- wind speed and direction (rotor)
- barometric pressure
- water and air temperature (thermistor)
- conductivity (inductive toroid)

Sensors proposed for PORTS™ and NWLON to be studied at OSTEF are:

- bridge air gap (GPS, microwave, laser)
- atmospheric visibility (light scattering, intelligent digital CCD camera)
- side-looking ADCPs
- water quality parameters including oxygen, turbidity, and fluorometry for chlorophyll and harmful algal blooms)
- surface current mappers (CODAR, marine radar)

Additional systems to be evaluated include:

- communications (phone, fixed frequency and spread spectrum VHF radio modems, underwater acoustic modems)
- DCPs (Sutron, Vitel and others as follow-ons to the NGWLMS DCPs)

Full duplicate, but not identical, sensors are proposed at the OSTEF. Observation of the same parameter by dissimilar sensors provides a robust standard against which other devices may be compared, and at the same time permits a comparison of the two primary sensors. For example, PORTS™ makes use of both RDI and Sontek ADCPs. These devices have similar performance specifications but there are some rather significant manufacturing differences, including: a) a Sontek three transducer configuration while RDI has four, b) acoustic data processing (RDI broadband vs. Sontek narrowband), c) Sontek transducers individually replaceable vs. RDI monolithic assembly, etc.. It is reported (Roerbaek, 1999) that the Sontek is able to obtain a current profile which reaches closer to the surface while the RDI profile is more precise. Both an RDI and a Sontek ADCP will be towed at the Naval Surface Warfare Center/Carderock Division.tow tank, providing a calibration traceable to NIST, and then installed at the OSTEF as primary sensors. These observations will provide a valuable field reference for side-looking ADCPs, CODAR, and other water velocity sensors while permitting a side by side comparison of the RDI and Sontek devices.

For budget and planning purposes, the OSTEF has been considered as simply another PORTS™ installation, and the budget template for PORTS™ FY 2001 has been used. Just as proposed for new PORTS™, contractor support will be required at the OSTEF. CO-OPS/FOD in Chesapeake lacks the personnel resources to fully support the OSTEF (demonstrated by the $1M NWLON maintenance backlog also proposed for FY 2001 funding). The $150K contractor cost applied to the other sites may appear high for this small "OSTEF PORTS™". It is justified by the requirement for more frequent deployments and recoveries, the wider variety of instruments, and the need to maintain a functional status required for external (paying) users. For these same reasons, the requirement for the purchase of a full suite of spare components is proposed for the OSTEF. It is anticipated that the contractor support will be commingled with the CO-OPS support. It is desirable to provide CO-OPS personnel the opportunity to work with the newest technology whenever possible, and to utilize the contractor support for the standard maintenance efforts.

Since OSTEF sensors will be replaced or re-configured more frequently than those in a standard PORTS™ installation, the use of OSTEF sensors for operational purposes must be approached with caution. However, to enhance the benefits of CO-OPS's OSTEP effort and to support the co-operative nature of the facility, it is vital that resultant data sets be readily available. It is proposed that a separate and unique DAS be installed for OSTEF, and that OSTEF data be archived within the National PORTS™ Database and accessible through the PORTS™ InfoHub, perhaps in a time delayed mode. The proposed budget allows for these costs, which total almost 20% of the proposed OSTEF total. CORMS QC shall only be required for those sensors which will provide real-time data.

4.3 Test Equipment

4.3.1 Field Oceanographic Reference Systems

The field oceanographic reference systems must be recognized at the finest available field oceanographic and marine meteorological systems for the measurement of temperature, conductivity, pressure, water velocity, water level (tidal and waves), wind velocity, air temperature, relative humidity, and atmospheric pressure. It is recommended that vendors of systems be notified of NOS' intent to select reference systems of the highest accuracy and reliability and to calibrate them to an accredited NIST standards transfer process. Vendors should be encouraged to compete for the selection of reference standard.

SeaBird Electronics supplies conductivity, temperature, and pressure (Parascientific) sensors of a very high quality. The choice of conductivity, temperature, and pressure sensors must meet the UNESCO standards for the determination of salinity and density of seawater using electrical conductivity.

Acoustic Doppler current profilers developed by RDI Inc and SonTek have been calibrated in the laminar tow basin and used in PORTS™ applications. SonTek has to date provided the instruments with the lowest error especially near the surface in bottom mounted applications. SonTek supplies Acoustic Doppler Velocimeters which can be accurately calibrated in the laboratory against Laser Doppler Velocimeters (Voulgaris, 1997).

The determination of water level requires reference sensors which can provide both long term accuracy relative to a vertical Geodetic reference system as well as high sampling rate to determine directional wave characteristics. A trade study should be conducted with input from the Advisory Panel to select the proper water level reference system(s).

Marine meteorological measurements should be conducted using equipment calibrated by the National Weather Service for the purpose.

4.4 Staff Position Descriptions

4.4.1 Technical Manager

The Technical manager must have an advanced degree in Physical Oceanography, Engineering Fluid Dynamics, or Physics with a strong emphasis on theoretical and experimental geophysical fluid dynamics.

4.4.2 Quality Assurance Manager

The Quality Assurance Manager must have a degree in Logistics Engineering, Systems Engineering, or Quality Assurance Engineering with training and experience in Total Quality Management.

4.4.3 Facility Operations Manager

The Facility Operations Manager must have a degree in Business Administration and experience with facility operations.

4.4.4 T&E Staff

The Test and Evaluation Staff should consist of an Electrical Engineer and a Mechanical Engineering with experience with ocean sensing and data acquisition systems.

4.4.5 IT Staff

OSTEP requires sufficient personnel to perform the following functions:

- Network Management
- Database Management
- System Administration
- Software development and integration

It is assumed that any hardware support personnel would be acquired through a contract.

It is a requirement for the IRM staff to have the necessary education, training, technical knowledge and experience to provide the necessary support for their assigned functions. In general, the following minimum selection criteria will be used:

- College or University Trained - Bachelors Degree
- A Computer Science or related major

- Sufficient experience to perform the functions - minimally 4-5 years of practical experience

Depending upon the selection pool, some functions could be combined. An on-going training program will be required and sufficient backups put in place.

4.5 Financial Management

The OSTEP shall be financially serviced through the Eastern Administrative Service Center in Norfolk, with oversight provided by CO-OPS management.

4.6 Advisory Board

The Advisory Board should be comprised of representatives from the following:

- Woods Hole Oceanographic Institution, MIT
- Rosenstiel Institute of Oceanography, University of Miami
- Department of Oceanography, University of Washington
- Scripps Oceanographic Institution, University of California San Diego
- NOAA's PMEL and AOML
- NESDIS/National Oceanographic Data Center
- Instrument Manufacturing Community Representatives
- Software Engineering Institute, Carnegie Mellon University
- Maritime Commerce representative(s)
- Marine Resouce community representative(s)

5.0 REFERENCES

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Cigler, James L., and V. R. White, "National Voluntary Laboratory Accreditation Program, Procedures and General Requirements", NIST Handbook 150, 1994

Roerbaek, K., "Intercomparison between Acoustic Doppler Current Profilers", Proceedings of the IEEE Sixth Working Conference on Current Measurement, March 11-13, 1999, pp. 198-203.

Voulgaris, G. and J. Trowbridge, WHOI, 1997. "Evaluation of the ADV for Turbulence Measurements" submitted to Journal of Atmospheric and Oceanic Technology.

"Guide to Meteorological Instruments and Observing Practices", Fourth edition, WMO - No. 8 TP. 3, 1971. Secretariat of the World Meteorological Organization, Geneva, Switzerland.

APPENDICES

Appendix I

Schedule

The schedule for the establishment of the OSTEP must be event based. The establishment of the OSTEP capabilities to underwrite legal liability is more important than meeting arbitrary milestones. The major constraints on the schedule for events are the following:

- Funding
- Availability of Full Time Equivalents to hire personnel
- Availability of Division management personnel
- Availability of partner personnel

The schedule must be revised when a work breakdown structure for the Facility establishment is completed.

Year 1
- acquire local contractor services
- acquire and install duplicate OSTEF sensors
- implement OSTEF
- begin acquisition of CO-OPS new sensors to be tested
- begin pursuit of NIST certification

Year 2
- begin installation and testing of CO-OPS new sensors
- begin OSTEP database development
- obtain NIST certification
- begin partner & gov agency new sensor test discussions

Year 3
- implement and populate new sensor database
- accept partner & gov agency new sensor test
- begin private sector sensor test discussions

Appendix II

New Sensors

A variety of new sensors are desired and/or poised for inclusion in the suite of PORTS™ instruments. Plans for new programs such as Coastal GOOS call for additional sensed parameters, and both PORTS™ and NWLON are well positioned to serve as the "backbone" for these programs. With the ability to integrate new sensors quickly (either as approved PORTS™ devices or ancillary observations for distribution on the CO-OPS InfoHub), CO-OPS will maintain a leadership role in these new programs.

Several commercially available sensors have made significant progress in transitioning from research instruments to operational devices. They are briefly described here.

Side-looking Doppler Profilers

A SonTek side-looking ADP has been installed and appears to be operating well at Shinnecock Inlet NY (for examples of the side-looking ADP data available in real time see the web site http://www.LIShore.org/shinnecock/latest.htm.). Cost to procure and install a SonTek SL ADP is estimated at $40K. RDI has a two year $400K Phase 2 SBIR to develop a side-looking profiler, but also offers a 600KHz device recently developed for a Japanese firm, available for approximately $30K.

Current Mapping Using Radar

Radar devices for the observation of surface currents have the potential to greatly enhance the CO-OPS current analysis effort. Such instruments have applications in a PORTS™ and the routine mapping of tidal currents. They are also ideal for event-driven current mapping activites such as hazardous materials spills and search and recovery efforts. CODAR installations in Monterey Bay, Rutgers LEO-15, Texas, and San Francisco have demonstrated an operational status and impressive data value from these devices.

NOAA's ETL Remote Sensing Laboratory owns two CODAR systems and is tasked with technology transfer to an operation environment. They have expressed interest in a cooperative demonstration. The cost to procure and install a CODAR system is estimated to be $250K, and CO-OPS received funding in FY 2000 to procure and manage the operation of a system in the Gulf of Fonseca. The Navy's NRL plans to evaluate a HIFAR system built by MetraTek (http://www.metratek.net), and they have expressed interest in partnering. They also have interest in further development of a fine scale current mapping system using standard low-cost marine microwave radar units.

Of the three systems (CODAR, HIFAR, and standard low-cost marine microwave radar), CODAR is the only commercially available unit. The CODAR system is compact, portable, and has the ability to be quickly installed for "quick response" efforts.

Offshore Water Level Measurements Using GPS

Precise centimeter level offshore water level measurements related to a recoverable reference framework (ellipsoid) can be obtained from a GPS system placed on a floating platform (buoy, barge, boat, etc.). These GPS-derived water level time series are used to compute tidal datums and harmonic constituents to support hydrographic surveys, maintenance dredging projects, verification of numerical models, calibration of satellite altimeters, and mapping sea surface variability.

Most of the hardware required for this test is in hand or has been identified. A radio modem communications system is needed, costing about $10K.

Underwater Acoustic Modems for ADCPs

Acoustic modems for the underwater transfer of ADCP data can eliminate the cost and failures associated with cabling. A new modem developed by LinkQuest (http://www.link-quest.com) offers low power consumption, low error rates and high data transfer rates. It has successfully been interfaced to off-the-shelf ADCPs. The cost to procure a pair of modems for testing is approximately $12.4K. The manufacturer offers demonstrations at little or no cost in the southern California area.

Benthos also offers a recently developed acoustic modem and has expressed a willingness to participate in trial deployments.

Bridge Air Gap

Air gap sensors are available off the shelf from Saab and Miros (a microwave sensor with wave observation capability, see http://www.miros.no) . They have also recently been developed by Lockheed (a laser sensor developed through a CRADA) and Technology Services Corporation (a microwave sensor developed through a SBIR). The TSC sensor was developed in support of a Phase 1 SBIR, which does not require prototype development so the device is not NOAA property. One or more of these devices should be evaluated for inclusion in PORTS™. The most comprehensive test would involve the comparison of several sensors.

RDI ADCP Wave Sensor

RDI has recently released software which provides observations of wave period, amplitude and direction from a standard ADCP. This results in a wave sensor that is probably more robust than most existing wave gauges (since the instrument doesn't reside on the ocean's surface) while providing current profiles. Existing and potential PORTS™ customers have requested wave observations. Tests to examine this new software and compare the resulting data to existing accepted wave sensor data should be conducted.

Appendix III

OSTEP Budget

The primary OSTEP facility has been identified as a rectangular area with a SE corner located at 36 56.5N 076 04.8 and a NW corner at 36 59.8N 076 09.0. The rectangle is very nearly centered about the Chesapeake Bay Bridge tunnel crossing the Thimble Shoal Channel.

An existing NWLON and PORTS™ station is already in place on the South Island of the Chesapeake Bay Bridge Tunnel (CBBT). A suite of dual sensors at this location will be installed and operated just as planned for all other new PORTS™ installations. The redundant sensors will; 1) serve as a reference for the evaluation of new instruments, 2) serve as a test bed for long term stability and reliability of the existing sensors used for PORTS™, 3) permit the removal of individual sensors for frequent calibration while maintaining an operational test facility, 4) ensure continuation in the event of instrument failure.

This PORTS™ reference facility will contain two water level gauges, two CT sensors, two anemometers, two barometers, two visibility sensors, and two DAS and radio communications systems. Comparison of similar sensors from different manufacturers will be conducted within this redundant sensor umbrella while serving as references for new instruments. For example, data from the inter-comparison of a 1200 KHz RDI and a 1500 Khz Sontek upward-looking current profiler (as redundant sensors) will serve as ground truth for side-looking doppler profilers and radar current mappers.

The cost to install and operate such a system is about $540K, as detailed in the attached Excel spread sheet. The same contractual assistance planned for other PORTS™ installations will be used for the installation and operation of the OSTEP facility, and will be expanded as necessary (and resources allow) to assist in additional OSTEP activities.

The cost of creating and operating an OSTEP varies with the extent to which devices are tested, and the desire of manufacturers to cooperate in the tests for promotion of their products. For example, LinkQuest will provide a pair of acoustic modems at no cost for a short trial period, but the ability of the device to operate for six months with an acceptable power draw, no corrosion, etc. would not be determined by the short demonstration test.

As with any program, there will be insufficient funds for a full realization of the program. Expectations and funding levels will be matched by seeking external cooperation where possible and reducing the extent of tests.

Project	Cost
OSTEP Field Reference Facility	$540K
Evaluate Belfort & Cossonay visibility sensors	$20K

Project	Cost
HF Radar	$30K
Compare SonTek & RDI side-looking current meters	$70K
Evaluate air gap sensors	$35K
Evaluate LinkQuest and Benthos acoustic modems	$30K
Offshore water level using GPS	$15K
RDI ADCP wave sensor evaluation	$25K
OSTEP Hardware/Software/Computers/Communications	$35K
Total	$800K

OSTEF- (FY 2001 Price List) 11/8/2000

	Hardware Costs	Installation Costs	Annual O & M Costs	
CBBT - Existing Water Level & Met Station				
Water Level Measurement System			$6,250	
Meteorological Sensors (WS/WD/AT/BARO)			$500	
Current Measurement System (ADCP)	$40,000	$13,000	$12,000	ADCP Cable Length (m)
ADCP Cable Length (m) 1000	$8,000			1000
Conductivity Sensor			$1,000	
Visibility	$8,000	$1,000	$1,000	
LOS Radio Telemetry System	$2,000	$200	$200	
CBBT - Redundant sensor suite at CBBT				
Water Level Measurement System	$17,500	$10,250	$6,250	
Meteorological Sensors (WS/WD/AT/BARO)	$3,700	$1,000	$500	
Current Measurement System (ADCP)	$40,000	$13,000	$12,000	ADCP Cable Length (m)
ADCP Cable Length (m) 1000	$8,000			1000
Conductivity Sensor	$2,800	$2,000	$1,000	
Visibility	$8,000	$1,000	$1,000	
LOS Radio Telemetry System	$2,000	$200	$200	
PORTS Data Acquisition System				
Data Acquisition and Dissemination System	$33,000			
Voice Data Response System	$15,000		$2,200	
Stand Alone PICS	$15,000		$1,200	
Installation/Maintenance/Communications costs		$6,500	$8,150	
PORTS Data Telemetry Systems				
Base Station Radio Installation	$4,000	$3,000	$6,500	
PORTS Local Operations			$115,250	
Spare Sensor Hardware				
Water Level Measurement System	$17,500			
Meteorological Sensors (WS/WD/AT/BARO)	$3,700			
Conductivity Sensor	$2,800			
Current Measurement System (ADCP)	$40,000			ADCP Cable Length (m)
ADCP Cable Length (m) 1000	$8,000			1000
LOS Radio Telemetry System	$2,000			
Base Station System	$4,000			
PORTS Annual Capital Reserve (10% of Hardware Costs)			$28,500	
TOTAL ESTIMATED COSTS	$285,000	$51,150	$203,700	
TOTAL COST - INSTALLATION AND O&M FOR 1 YEAR	$539,850			