NOAA Technical Report NOS CO-OPS 39

NOS Procedures for Developing and Implementing Operational Nowcast and Forecast Hydrodynamic Model Systems

Silver Spring, Maryland
May 2003

noaa National Oceanic and Atmospheric Administration

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

VISION AND MISSION STATEMENTS
National Oceanic and Atmospheric Administration (NOAA)
Mission Goals:

- Protect, restore, and manage the use of coastal and ocean resources through ecosystem-based management approaches.
- Understand climate variability and change to enhance society's ability to plan and respond.
- Serve society's needs for weather and water information.
- Support the Nation's commerce with information for safe, efficient, and environmentally sound transportation.

Vision: To move NOAA into the 21st Century scientifically and operationally, in the same interrelated manner as the environment that we observe and forecast, while recognizing the link between the global economy and our planet's environment.

Mission: To understand and predict changes in the Earth's environment and conserve and manage coastal and marine resources to meet our Nation's economic, social, and environmental needs.

NOAA's National Ocean Service (NOAA's NOS)

Vision: To be the Nation's principal advocate for coastal and ocean stewardship through partnerships at all levels.

Mission: To support and provide the science, information, management, and leadership necessary to balance the environmental and economic well-being of the Nation's coastal resources and communities.

NOS' Center for Operational Oceanographic Products and Services (CO-OPS)

Vision: A Nation where everyone has ready access to tide, current, water level, and other coastal oceanographic products and services required for informed decision making.

Mission: To provide the National infrastructure, science, and technical expertise to monitor, assess, and distribute tide, current, water level, and other coastal oceanographic products and services necessary to support NOAA's Strategic Plan.

NOS' Office of Coast Survey (OCS)

Vision: Customers have accurate and timely information to navigate and manage U.S. coastal waters.

Mission: Acquire, integrate, and manage the Nation's marine information for nautical charting and coastal applications.

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Mark Vincent, Kurt Hess, John Kelley

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noaa **National Oceanic and Atmospheric Administration**

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EXECUTIVE SUMMARY

This document details the procedures for developing and implementing **O**perational Nowcast and **F**orecast Hydrodynamic Model **S**ystems (hereafter OFS) by NOAA's National Ocean Service (NOS). These systems consist of the automated integration of observing system data streams, hydrodynamic model predictions, product dissemination and continuous quality control monitoring. State-of-the-art numerical hydrodynamic models driven by real-time data and model forecast guidance will form the core of these end-to-end systems. The OFS will perform nowcast and short-term (0 hr. - 48 hr.) forecast predictions of pertinent parameters (i.e., primarily water levels and currents and in some cases salinity, temperature, waves, etc.) and disseminate the results to users.

OFS will be implemented in critical ports, harbors, estuaries, Great Lakes and coastal waters of the United States and will join NOAA's NOS operational oceanographic capabilities to form a national backbone of real-time data, tidal predictions, data management and operational modeling. This national backbone will serve a broad base of users that rely on NOS' product suite for informed decision making. In addition to improving the safety and efficiency of commercial shipping and recreational boating, other direct applications of this information include: improving national security; proactively preventing, mitigating and responding to natural hazards and oil spills; facilitating safe, efficient and quality recreational use of coastal waters; aiding search and rescue, forensic and law enforcement operations; improving coastal flood warnings; facilitating coastal management and stewardship; as well as providing opportunities for basic research.

NOS' implementation of these systems will support NOAA's mission goals of:

- Protect, restore, and manage the use of coastal and ocean resources through ecosystem-based management approaches;
- Serve society's needs for weather and water information;
- Support the Nation's commerce with information for safe, efficient, and environmentally sound transportation;

and is consistent with the missions, visions and ongoing collaborations of NOS' Office of Coast Survey (OCS) Coast Survey Development Laboratory (CSDL) and Center for Operational Oceanographic Products and Services (CO-OPS). In addition, these goals complement proposed components of the Coastal Integrated Ocean Observing System (IOOS) and the identified role of a national backbone of observations, data management and modeling (Ocean.US, 2002). NOS has been a leader in research, development and implementation of OFS for NOS' Physical Oceanographic Real-time Systems (PORTS®). Success with these systems has led to developing long-term strategies for the implementation of OFS.

INTRODUCTION

Objective

This document details the procedures for developing and implementing Operational Nowcast and Forecast Hydrodynamic Model Systems (OFS) by NOAA's National Ocean Service (NOS). The OFS consist of the automated integration of observing system data streams, hydrodynamic model predictions, product dissemination and continuous quality control monitoring. State-of-the-art numerical hydrodynamic models driven by real-time data and model forecast guidance will form the core of these end-to-end systems. The OFS will perform nowcast and short-term (0 hr. - 48 hr.) forecast predictions of pertinent parameters (i.e., primarily water levels and currents and in some cases salinity, temperature, waves, etc.) and disseminate the results to users via the internet. Products will include plots of key parameters and model fields in standardized oceanographic formats. OFS will be implemented in critical ports, harbors, estuaries, Great Lakes and coastal waters of the United States and will join NOAA's NOS operational oceanographic capabilities to form a national backbone of real-time data, tidal predictions, data management and operational modeling. This national backbone will serve a broad base of users that rely on NOS' product suite for informed decision making. In addition to improving the safety and efficiency of commercial shipping and recreational boating, other direct applications of this information include: improving national security; proactively preventing, mitigating and responding to natural hazards and oil spills; facilitating safe, efficient and quality recreational use of coastal waters; aiding search and rescue, forensic and law enforcement operations; improving coastal flood warnings; facilitating coastal management and stewardship, as well as providing opportunities for basic research.

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NOS has been at the forefront of developing, implementing and maintaining operational oceanographic observing systems (i.e., the Physical Oceanographic Real-time System (PORTS®) and National Water Level Observation Network (NWLON)). This has facilitated NOS' role as a leader in research and development of prototype forecast systems such as those for New York Harbor, Chesapeake Bay, Galveston Bay and several other water bodies. In 1999, the Chesapeake Bay Operational Forecast System (CBOFS) was the first system to be declared operational at NOS.

The New York/New Jersey Operational Forecast System (NYOFS) joined the operational ranks in February 2003 and the Houston Galveston Bay system is targeted for operational status during 2003. The success of these early systems has lead to strategic planning for the development and implementation of numerous other forecast systems by NOS. In addition, parallel research by other regional partners will lead to systems that may be selectively transitioned to operational status at NOS.

NOS must ensure that these systems: meet the needs of constituents; are scientifically sound and operationally robust; and are authoritative in the face of potential legal challenges. To accomplish these objectives, this document provides formal NOS procedures for the development and implementation of operational nowcast and forecast hydrodynamic model systems. All NOS operational forecast systems should be developed and implemented in adherence to the procedures contained in this document.

Development and implementation of these OFS is a collaborative endeavor between NOS' OCS/CSDL and CO-OPS. The research and development tasks will primarily be conducted by CSDL while the operations and maintenance tasks will be the responsibilities of CO-OPS.

The remainder of this section will provide definitions of key terms, and an introduction to the required procedure phases, teams and documents. Subsequent sections will provide a detailed discussion of the requirements of each phase.

Definitions

The integration of automated data streams, model simulations, product dissemination and quality control monitoring, will constitute an *Operational Nowcast and Forecast Hydrodynamic Model System*. For succinctness, these will usually be referred to as an *Operational Forecast System(s) (OFS)*. Model systems will be declared *operational* only after they have undergone the rigorous evaluation and audit procedures defined in this document, and have been implemented in an operational environment with continuous quality control monitoring.

The *hydrodynamic models* used will be state-of-the-art, multi-dimensional, time-dependent models that solve the conservation equations for mass, momentum and other pertinent parameters. Products of the models will include high resolution spatiotemporal fields, and time series at specific locations of interest to users. Common inputs (boundary conditions) to these models may include: water surface elevation, temperature and salinity at the open boundaries; heat, water and momentum (wind stress) fluxes at the surface; and river fluxes along the lateral boundaries. Product parameters may vary between systems, but will almost always include water levels and currents which are important for marine transportation. Some systems may include other parameters such as water temperature, salinity, density, and surface waves.

Several distinct categories of model simulations may be conducted during the development and operations phases (i.e., *hindcast, nowcast*, *forecast* and, *on-demand cast*). During the early development stage, *hindcast* model simulations will be performed using static archived data sets. These simulations are typically done for model calibration and validation. *Nowcasts* use data sets

generated primarily from recent real-time data to simulate the present conditions of the waterbody. Each *nowcast* is typically intialized from the results of the previous simulation and typically covers a time frame of up to one hour. *Forecast* simulations are also typically initialized from the most recent nowcast and generally extend 24 to 48 hours into the future. For forecasts, observational data are not available for forcing, therefore boundary conditions are constructed from various combinations of predictions (i.e., tidal harmonics), persistence of recent conditions and forecast model guidance products (winds, subtidal water levels) from larger scale models run by NOAA's National Weather Service (NWS) or NOS. In certain operational cases (i.e., oil spills, search and rescue, forensic investigations) *on-demand cast* simulations may be conducted that could span several of these simulation modes.

Procedure Phases

These procedures are designed to provide a logical, efficient process that results in the development of an accurate, manageable and robust NOS OFS that meets the needs of constituents. Technical oversight, user outreach, documentation and formal reviews are key components of the process. Details of each phase are provided in subsequent sections. The procedural phases are:

- Selection of the Target Waterbody
- Needs, Requirements, and Proposed Solution
- Development of the Quasi-Operational Forecast System
- Implementation of the Operational Forecast System
- Operations, Maintenance, and Enhancements.

Teams

The development and implementation of an OFS within an integrated national backbone will be a collaborative NOS process requiring administrative guidance, technical review, technical expertise, and outreach to the primary user groups. The following teams or groups will facilitate this process:

Technical Review Team - The Directors of CO-OPS and OCS will appoint an OFS Technical Review Team (TRT) to: implement the Directors' objectives for OFS and provide routine authorizations and oversight during the development and implementation processes of an OFS. The team will ensure adherence to the procedures contained in this document and be responsible for providing written authorization for each standard phase of the process.

The TRT will be comprised of the following five standing members: the Deputy Director of CO-OPS, the Chief of OCS/CSDL, the Chief of the OCS/CSDL Marine Modeling and Analysis Programs (MMAP), the CO-OPS Chief Scientist, and the CO-OPS OFS Program Scientist. The TRT will utilize the considerable expertise of other NOS staff, and may add other members to the team if needed.

System Design and Implementation Team- At the beginning of the process for a proposed OFS, the TRT will assemble a System Design and Implementation Team (SDIT). The SDIT will be lead by the CO-OPS OFS Program Scientist and will typically be comprised of approximately seven members.

In general, the model developers (i.e., CSDL and/or external developers) will provide two representatives to the team (i.e., a lead and oversight developer). For quality assurance and the efficient transfer of technology, the oversight developer should have recent experience in the successful implementation of an NOS OFS. Remaining members of this team will be drawn from CO-OPS and CSDL (and possibly external partners) with expertise in operational oceanography or meteorology, information technology, data acquisition, numerical modeling, and the project water body. Due to their knowledge of the local water body and contacts with users, the PORTS® Site Representative and/or the Regional Navigation Manager should be members of the team and be instrumental in facilitating communication with users.

Although the model developers will perform much of the detailed setup, the remainder of the team will provide significant input, review and oversight. The entire team is responsible for ensuring the efficient development of an NOS OFS that will accurately and reliably meet the needs of the intended user groups.

Key Users and Evaluators (Users) - The Key Users and Evaluators (hereafter Users) are select members of the commercial shipping, port operations, recreational boating, hazardous material spill response, military and homeland security, and search and rescue communities that will use the guidance products provided by the OFS. Using the PORTS® Site Representative and/or the Regional Navigation Manager to facilitate communications, the SDIT will coordinate with select members of these groups throughout the project. Important contributions of the Users will include providing needs and requirements at the beginning, and feedback and comments during the design process. Users will also be asked to evaluate the quasi-operational system products during the final evaluation stage.

Resulting Documents

For each phase (and in some cases stages) the SDIT will prepare a specific concise technical document. These will be reviewed by the TRT to determine if the phase has been successfully completed. Based upon the review of each document, the TRT will issue memorandums authorizing advancement to the next phase/stage.

The following documents will be generated, reviewed and approved during the development and implementation of an OFS:

- *Needs, Requirements and Proposed Solution Plan*
- *Description and Skill Assessment of the Hydrodynamic Model*
- *Description and Skill Assessment of the Quasi-Operational Forecast System*
- *Operational Forecast System Implementation Plan*

- *Description of the Operational Forecast System and Standard Operating Procedures Plan*
- *SDIT Memorandum Recommending Operational Status*
- *TRT Memorandums of Authorized Action (for each phase/stage)*
- *Director of CO-OPS Memorandum of NOS Operational Status*
- Communications Plan (i.e., *Press Release, CO-OPS Project Handout* etc.)
- *Annual Operations and Skill Report*

Information required for the major documents is detailed in the appropriate procedural phase sections.

Application to Forecast Systems already in Development

In some cases existing experimental systems from NOS or other external collaborating institutions may be identified for implementation as an NOS OFS. The procedures and documents defined herein should be followed for these systems wherever possible. Any deviations and modifications permitted will be determined by the TRT. The TRT and SDIT will review the state of development of the existing experimental system. The TRT will decide which procedures have been successfully completed, and which procedures need to be completed before the system gains NOS acceptance. In certain cases, extensive retrofitting and revision of systems may be required.

National Operational Coastal Modeling Program Strategic Plan

Each individual OFS will be a component within a national backbone of operational oceanographic capabilities including real-time observations, tidal predictions, data management, and operational modeling. The Directors of CO-OPS and OCS, and the Steering Committee of the National Operational Coastal Modeling Program (NOCMP) with assistance from the TRT, will promulgate a *NOCMP Strategic Plan* to guide this objective. This document will serve as a foundation for other relevant NOS planning documents and include a framework of the proposed number, locations, schedules, objectives, standards, development, operations, and partnerships for NOS OFS through Fiscal Year 2008. Completion of this document will be a priority of the Directors, Steering Committee and TRT, and will be revised and extended as needed.

To achieve maximum efficiency in development and benefits to constituents, the *NOCMP Strategic Plan* will be closely coordinated with the strategic planning for other NOS operational oceanography programs (PORTS® Program, National Water Level Observation Program, National Current Observation Program etc.).

PROCEDURE PHASES

Phase 1: Selection of the Target Water Body

This phase initiates the potential development of an NOS OFS for a waterbody. Using the NOCMP Strategic Plan as a guide, the TRT, with guidance from the Directors of CO-OPS and OCS, will select the next water body to be considered. At this point the TRT will select the core members of the SDIT and provide them with a *TRT Memorandum of Authorized Action* to evaluate the merits of an OFS for the specified water body.

Phase 2: Needs, Requirements, and Proposed Solution

The objective of this phase is to identify the oceanographic guidance needs and requirements, to examine potential OFS solutions, and to identify the resources required to implement them. The SDIT will summarize this information in the *Needs, Requirements and Proposed Solution Plan* which will be submitted to the TRT. The TRT, with guidance from the Directors of CO-OPS and OCS, will review this document and respond with an official memorandum (*TRT Memorandum of Authorized Action*) approving a course of action (options include no further action, referring the issue to other providers, or further NOS involvement). If the TRT authorizes further NOS involvement, the SDIT will initiate Phase 3 of the procedure. Additional members may be added to the SDIT in this case.

- When preparing the *Needs, Requirements, and Proposed Solution Plan*, the SDIT will obtain feedback from representatives of the Users such as: ship pilots, port facility operators, U.S. Navy, U.S. Coast Guard Search and Rescue, NOAA HAZMAT, National Weather Service (NWS) marine forecasters, marine resource managers, and recreational boaters. During this outreach, the SDIT will relay examples of NOS nowcast and forecast hydrodynamic modeling systems in other waters to illustrate NOS capabilities. The purpose of this outreach and coordination is to ensure that the SDIT will clearly define the Users' needs and requirements for nowcast and forecast oceanographic guidance and to gain initial support for developing an NOS OFS. Once the requirements are clearly defined, the SDIT will evaluate whether an OFS is the appropriate solution to meet the Users' needs. When warranted, the SDIT will recommend alternative solutions or no further action. If an OFS is the selected solution, the SDIT will generate the general specifications and resources required for the proposed system. The following information will be included in the *Needs, Requirements and Proposed Solution Plan*;

- objectives of the OFS (i.e., Users, needs, requirements)
- recommended action

and if development and implementation of an NOS OFS is the proposed action;

- model requirements (i.e., model domain, horizontal and vertical grid resolution, model selection, boundary conditions etc.)
- dissemination requirements (proposed products)

- observational data requirements (i.e., existing, proposed, internal and external)
- data/information acquisition requirements (i.e., existing, proposed, internal and external)
- skill assessment procedures (i.e., Hess et al., (2003), NOS (1999) or other accepted CSDL and CO-OPS procedures that are applicable to the system
- hardware, software and connectivity requirements
- development, programming and software engineering requirements
- personnel requirements
- budget resources
- schedule.

Phase 3: Development of the Quasi-Operational Forecast System

The development of the Quasi-Operational Forecast System Phase is composed of two sequential stages: Setup and Evaluation of the Hydrodynamic Model and Construction and Evaluation of the Quasi-Operational Forecast System.

Stage 1: Setup and Evaluation of the Hydrodynamic Model

The SDIT will use the *Needs, Requirements and Proposed Solution Plan* as a guide during the setup of the Hydrodynamic Model. During this stage there will be significant interaction and feedback between the model developers and other members of the SDIT in order to identify and incorporate necessary refinements at an early stage. Feedback from key Users should also be obtained at this stage. This stage allows the SDIT to understand the merits and limitations of the selected modeling method before major investments of time and resources are made.

Typically, only archived data/information sets (i.e., hindcast) will be used during this stage to conduct model testing, refinement and calibration/validation. All skill assessment tests should adhere to standard CSDL and CO-OPS procedures that are relevant to the system (e.g., NOS (1999), Hess (2003), etc.).

The SDIT will summarize the results of this stage in the *Description and Skill Assessment of the Hydrodynamic Model*. This document will include information regarding the model description, references, configuration, required inputs and outputs, and hindcast calibration skill. The SDIT will present this Plan to the TRT. If the TRT approves this documentation, it will issue a *TRT Memorandum of Authorized Action* for the SDIT to initiate development of a Quasi-Operational Forecast System for the waterbody.

Stage 2: Construction and Evaluation of the Quasi-Operational Forecast System

In this stage, the Hydrodynamic Model will be converted to the Quasi-Operational Forecast System by establishing the connections to automated inputs. To facilitate efficient development, robust operations, and future upgrades, the Quasi-Operational Systems must strictly conform to CSDL/CO-OPS standardized templates and operational inputs wherever practicable. Any deviations from the standard templates must be extensively justified and approved by the SDIT and TRT.

The nowcast and forecast cycle simulations of the Quasi-Operational System will be run in an automated mode for at least six months, while its reliability, skill, and products are evaluated. Skill assessment of the nowcast and forecast model outputs must be conducted following standard or accepted CSDL and CO-OPS procedures (e.g., NOS (1999), Hess (2003)) that are appropriate to the waterbody and the objectives of the OFS.

In order to obtain feedback from the SDIT members and Users, the system products will be displayed on a restricted access project web site. The SDIT is encouraged to present the results at scientific conferences and in journals in order to obtain feedback from peers outside of NOS. The SDIT will also notify Users of the availability of the Quasi-Operational forecast products and to select volunteers to evaluate the system. The SDIT will use the results of this feedback in making refinements to the system.

The SDIT will prepare the *Description and Skill Assessment of the Quasi-Operational Forecast System*. This will include information regarding the model description, operational inputs and outputs, and an evaluation of the nowcast and forecast skill. The SDIT will present this Plan to the TRT. If the TRT approves the Quasi-Operational Forecast System and its documentation, it will issue an *TRT Memorandum of Authorized Action* for the SDIT to initiate the implementation phase.

Phase 4: Implementation of the Operational Forecast System

Stage 1: Preparation of the Implementation Plan

The SDIT will prepare the *Operational Forecast System Implementation Plan* which will detail the tasks, staff assignments, schedule and resources needed to transition the system to operational status. The TRT must approve this plan to authorize the migration to operations.

Stage 2: Migration to the Operational Environment

As noted, the Quasi-Operational System will be efficiently developed using CSDL/CO-OPS standardized templates and operational inputs. Therefore, in most cases, migration to the CO-OPS operational environment will not require major retrofitting of the system

Using the strategy provided in the *Operational Forecast System Implementation Plan*, the SDIT will install and migrate all required system programs, software, and hardware to the CO-OPS operational environment. A critical distinction must be understood here: although the system will be functioning in an operational environment at this time, it is still not an Operational Forecast System.

Stage 3: Final Evaluation, Documentation, and Training Requirements for the Quasi-Operational Forecast System in an Operational Environment

Evaluation of the system in an operational environment will be conducted for a minimum of three months. Since the system skill has already been established in previous phases, the purpose of this stage is to evaluate the system reliability, prepare final documentation, and train the staff responsible for operational maintenance and monitoring.

After the migration has been completed, two sequential one-month audits of the Quasi-Operational Forecast System will be conducted by the SDIT. During these audit periods the timeliness and reliability of inputs and outputs will be monitored by the SDIT. Each of the audit periods will include a rigorous formal testing of all contingencies, recovery/diagnostic procedures and system status indicators (i.e., flags). If notable technical difficulties are identified, modifications and retesting will be required.

During the testing, the SDIT will prepare *The Description of the Operational Forecast System and Standard Operating Procedures Plan*. The purpose of this important document is to describe the operational details of the total forecast system (including all operational inputs and products), and the methodology for operating, maintaining and troubleshooting the system.

Upon successful completion of the audit periods, and the preparation of *The Description of the Operational Forecast System and Standard Operating Procedures Plan*, the SDIT will provide training to the Continuous Operational Monitoring System (CORMS) staff (Gill et al., 1997). When this is complete, the CORMS staff will initiate monitoring of the forecast system and follow all procedures prescribed in the above document. This test monitoring will continue for a period of one month.

When all of the above steps have been successfully completed, the *SDIT Memorandum Recommending Operational Status* will be prepared stating:

- the forecast system has been developed following CSDL and CO-OPS procedures and standards;
- the forecast system has been successfully migrated, audited and documented;
- the CORMS and other operational staff have been sufficiently trained;
- a one month period following full standard operational procedures and monitoring has been successfully completed;
- a recommendation that the system should receive NOS operational status on a specified date and time.

Stage 4: Declaration of Operational Status

The SDIT will present the memorandum to the TRT for their review and approval. If the TRT approves the memorandum, they will prepare a *Director of CO-OPS Memorandum of NOS Operational Status* for the forecast system. This memorandum will state that the forecast system has been developed in accordance with NOS procedures, include any pertinent disclaimers, and announce the date and time that the system officially becomes NOS operational. This document must be approved and signed by the Director of CO-OPS. At the specified date and time, the system will become an NOS Operational Forecast System and products will be made available to the public.

Stage 5: Communications Plan

An important component of these procedures is routine outreach and communication with the Users. This will be expanded on just prior to and after the system obtains operational status.

The SDIT will prepare a brief (approximately one page) text press release for submittal to and processing by NOAA's public relations staff. A one page (front and back) CO-OPS project handout with a concise project overview and supporting graphics will also be prepared.

The PORTS® Site Representative and/or the Regional Navigation Manager will facilitate communications with the key User groups and arrange for presentations of the operational system. This will include training of key Users on the use of the system products. Outreach and communication with Users will be an ongoing function of the OFS Program.

Phase 5: Operations, Maintenance, and Enhancements

The normal operations, maintenance, and monitoring of the OFS will be conducted by CO-OPS staff. The CO-OPS OFS Program Scientist will be the primary technical point of contact for the system. Continuous monitoring of the system will be provided by CORMS. Quality control monitoring, emergency repairs and troubleshooting, will follow the procedures established in *The Description of the Operational Forecast System and Standard Operating Procedures Plan*.

Routine maintenance, trouble shooting and required minor modifications to the system will be conducted by CO-OPS staff following established version control procedures. CSDL staff will continue to provide technical assistance on major issues when needed. Major modifications will require the approval of the SDIT and TRT, and must be thoroughly tested and documented prior to implementation.

An *Annual Operations and Skill Report* will be prepared at the end of each operational year. The report will detail the system reliability and skill during the past year. CO-OPS staff will be responsible for documenting and reporting the system reliability while CSDL staff will document the system skill using procedures consistent with those used in assessment of the Quasi-Operational Forecast System (e.g., NOS (1999), Hess (2003)). The TRT will review this report and issue a *Memorandum of Authorized Action* that will specify what improvements or retrofitting, if any, are necessary to be completed to continue NOS operational status.

ACKNOWLEDGMENTS

This report is a product of ongoing collaboration in operational oceanography between NOS' CO-OPS and OCS/CSDL. Kurt Hess and Kathryn Bosley are credited for an earlier version of this document (NOS, 1999). Valuable suggestions and insight were provided by numerous staff members of CSDL and CO-OPS.

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APPENDIX

APPENDIX: Check List for National Ocean Service (NOS) Procedures for Developing and Implementing Operational Forecast Systems (OFS)

This table provides a sequential check list of the primary tasks, documents, and memorandums required to develop and implement an NOS OFS. Additional information on requirements for documents and phases is provided in the main report.

PHASE	STAGE	ACTION, DOCUMENT* or MEMORANDUM*	DATE COMPLETED
1. Selection of the Target Water Body		Selection of the Water Body to be considered by the Technical Review Team (TRT) with guidance from the Directors of CO-OPS and OCS	
		Selection of core members of the System Design and Implementation Team (SDIT)	
		*TRT Memorandum of Authorized Action**	
2. Needs, Requirements and Proposed Solution		User outreach and coordination	
		Identify needs and requirements	
		Identify proposed solution	
		Needs, Requirements and *Proposed Solution Plan**	
		*TRT Memorandum of Authorized Action**	
		Selection of remaining members of the SDIT	
3. Development of the Quasi-Operational Forecast System	Stage 1: Setup and Evaluation of the Hydrodynamic Model	Setup and hindcast calibration/validation of the Hydrodynamic Model	
		User outreach and coordination	

PHASE	STAGE	ACTION, DOCUMENT* or MEMORANDUM*	DATE COMPLETED
		*Description and Skill Assessment of the Hydrodynamic Model**	
		*TRT Memorandum of Authorized Action**	
	Stage 2: Construction and Evaluation of the Quasi-Operational Forecast System	Connection of the system to automated data/information streams using standardized CSDL/CO-OPS templates	
		Skill assessment of the nowcast and forecast systems in an automated mode (i.e., semi-operational)	
		User outreach and coordination	
		Presentation to the scientific community (i.e., conferences, journals)	
		*Description and Skill Assessment of the Quasi-Operational Forecast System**	
		*TRT Memorandum of Authorized Action**	
Phase 4: Implementation of the Operational Forecast System	Stage 1: Preparation of the Implementation Plan	*Operational Forecast System Implementation Plan**	
		*TRT Memorandum of Authorized Action**	
	Stage 2: Migration to the Operational Environment	Migration to operational environment	

PHASE	STAGE	ACTION, DOCUMENT* or MEMORANDUM*	DATE COMPLETED
	Stage 3: Final Evaluation, Documentation and Training Requirements for the Quasi-Operational Forecast System in an Operational Environment	*Description of the Operational Forecast System and Standard Operating Procedures Plan**	
		Two one month audits by SDIT	
		CORMS training	
		One month CORMS monitoring	
		*SDIT Memorandum Recommending Operational Status**	
	Stage 4: Declaration of Operational Status	*Director of CO-OPS Memorandum of NOS Operational Status**	
	Stage 5: Communications Plan	*Press Release** (one page text)	
		*CO-OPS Project Handout** (one page front and back, text and graphics)	
		Presentations to Users	
Phase 5: Operations, Maintenance and Enhancements		*Annual Operations and Skill Report**	
		*TRT Memorandum of Authorized Action**	