NOAA Technical Report NOS CO-OPS 029

Systems Development Plan: CORMS II

Silver Spring, Maryland

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noaa National Oceanic and Atmospheric Administration

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

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. 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.

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Thomas Bethem, Janet Burton and Michael Evans

March 2001

noaa National Oceanic and Atmospheric Administration

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EXECUTIVE SUMMARY

The Continuous Operational Real-Time Monitoring System (CORMS) is a manned quality control support system implemented in April, 1998 which provides 24 hour a day, 7 day a week quality control monitoring of water level, current, and other marine environmental information. It is the focal point of operations within the Center for Operational Oceanographic Products and Services (CO-OPS). In addition to data monitoring, CORMS provides real-time monitoring of all main computer-based system components associated with the real-time systems and the processes that run on them. It also provides the watch standing personnel with the ability to communicate when necessary, around the clock, with operational standby technical personnel. The two primary program areas monitored by CORMS are the Physical Oceanographic Real-Time System (PORTS) and the National Water Level Observation Network (NWLON). The primary input to CORMS is from real-time water level, current, and other marine environmental sensors, which are deployed nationwide in many U.S. ports and waterways as a part of PORTS and NWLON. The primary purpose of CORMS is to ensure the availability and accuracy of real-time data provided by the CO-OPS that is used for navigational safety and the protection of life and property.

The current system, referred to as CORMS I, provides quality control of sensors and data for discrete 6-minute samples. The availability, accuracy, and quality of CORMS I data is for the most recent 6-minute sample. When completed and fully operational , the system proposed in this plan, CORMS II, will provide more robust, complete and synthesized information to the watch standing personnel in the form of guidance or directives based upon the current and historical data. This synthesizing of data and information and resulting "instructions" for the watch standing personnel will be possible through the use of a rule-based software approach. The benefits will be (1) to monitor more sites/systems without compromising quality; (2) to make better decisions based on information that has already been summarized and mapped against existing rules and directives; and (3) to ensure more consistent actions and/or non-actions are taken by the watch standing personnel.

1 INTRODUCTION

1.1 Background

The Center for Operational Oceanographic Products and Services (CO-OPS) has the responsibility for the health of their operational computer-based systems that provide real-time data in support of navigational safety to local users. In meeting this responsibility, CO-OPS has implemented the Continuous Operational Real-Time Monitoring System (CORMS) to provide 24 hour a day, 7 day a week monitoring and quality control of its data. CORMS is intended to identify invalid and erroneous data and information before application of the data by real-time and near real-time users.

The CORMS takes input from two National Oceanic and Atmospheric Administration (NOAA) systems, the Physical Oceanographic Real-Time System (PORTS) and the National Water Level Observation Network (NWLON), aggregates the information at NOAA's Silver Spring, Maryland Headquarters, and displays the results to its users, primarily CORMS watch standing personnel.

The current system, referred to as CORMS I, provides quality control of sensors and data for discrete 6-minute samples. The availability, accuracy, and quality of CORMS I data is for the most recent 6-minute sample. When completed and fully operational, the system proposed in this plan, CORMS II, is intended to be a robust operational system that provides real-time monitoring and quality control of relationships among data; incorporates thoughtful ergonomic and human factors design principles; and provides appropriate levels of decision aiding and embedded intelligence to system users. Based upon completed system requirements and pre-design activities, the CORMS II design will employ a rule-based software approach. The benefits of CORMS II will be (1) to monitor more sites/systems without compromising quality; (2) to make better decisions based on information that has already been summarized and mapped against existing rules and directives; and (3) to ensure more consistent actions and/or non-actions are taken by the watch standing personnel.

CO-OPS contracted the Requirements/Analysis Activities and the Pre-Design of CORMS II to the Rensselaer Polytechnic Institute (RPI). The contract was terminated due to budget shortfalls prior to completing a detailed design and the delineating software engineering development steps. This System Development Plan tries to apply the RPI's findings in planning the Detailed Design and Implementation of CORMS II.

This plan (1) describes the objectives and benefits of CORMS II; (2) defines the system level requirements for CORMS II; (3) documents the system environment under which CORMS II will reside; (4) identifies the required resources to successfully implement CORMS II; and (5) provides a schedule for the completion of the system.

1.2 Objectives

- To analyze real-time and near real-time data and information
- To determine data completeness

- To measure data quality
- To identify invalid or suspect data to its users
- To generate statistics for evaluating system performance
- To provide decision making information to its users

1.3 Benefits of CORMS II

- Coupled with the existing benefits of CORMS I, CORMS II will provide the ability to monitor more sites/systems without compromising quality

- Coupled with the existing benefits of CORMS I, CORMS II will provide the ability to make better decisions based on information that has already been summarized and mapped against existing rules and directives

- Coupled with the existing benefits of CORMS I, CORMS II will ensure more consistent actions and/or non-actions are taken by the watch standing personnel

1.4 Assumptions and Constraints

1.4.1 Budget

The undertaking of the development and implementation of CORMS II comes at a time when CO-OPS has experienced a funding shortfall and must place this project, as well as others, within a context of austerity Only limited funding is available at this time for contracting support for CORMS II. In addition, this project is competing for resources with many other operational activities. It is assumed that these conditions will not change until well into the first quarter of FY 01.

1.4.2 Commercial-Off-the-Shelf (COTS) Software

It is assumed that based upon documents produced by the Rensselaer Polytechnic Institute (RPI), a COTS product can be selected to satisfy the requirements of CORMS II. If it is found that there is no COTS product which can satisfy the requirements, this will have considerable impact on the project. Without the benefit of a COTS package, the development of CORMS II would be cost prohibitive to CO-OPS at this time.

1.4.3 Resources

It is assumed that the majority of the tasks associated with CORMS II will be contracted activities. CO-OPS personnel will take a leading and active role in the planning and execution of these tasks. Two contractors will be hired for the project. One contractor will begin work in June, 2000 and the second in November, 2000.

1.4.4 Infrastructure

It is assumed that most of the hardware, communications, and interfaces to external systems now used in CORMS I will be preserved and that very little additional infrastructure will be needed for CORMS II.

1.4.5 Reliance on external systems

CORMS II assumes the full and complete support for the development of the National PORTS Database.

2 EXISTING SYSTEM

The existing CORMS system is a combination of UNIX workstations, a NT PC and a network designed for efficient data transfer. It is a web-based system that uses both Intranet and Internet applications to accomplish CORMS functionality.

In its most basic sense CORMS can be broken down into hardware, software, and networks.

2.1 CORMS Hardware

CORMS is not just one computer. It is a small network of computers working together to complete a common task. There are two Silicon Graphics workstations, one NT PC and some communications equipment. The following table describes the CORMS hardware and its function.

Device	Configuration	Function
Silicon Graphics Octane	CPU: 2x175 MHZ MEM: 128 Mbyte DISK: 12 Gig. DISPLAYS: 2 21in.	Serves as the primary display for the CORMS system.
Silicon Graphics O2	CPU: 1x200 MHZ MEM: 128 Mbyte DISK: 4 Gig. DISPLAY: 1 17in.	Serves as the CORMS communications server. All data that is ingested by CORMS gets deposited on this machine.
Gateway NT Workstation	CPU: 1x200 MHZ MEM: 64 Mbyte DISPLAY: 1 17in	Serves as the primary access to the NWLON database. Serves as the CORMS e-mail interface.

The CORMS hardware is installed in custom furniture specifically designed for 24x7 operations. See Figure 1.

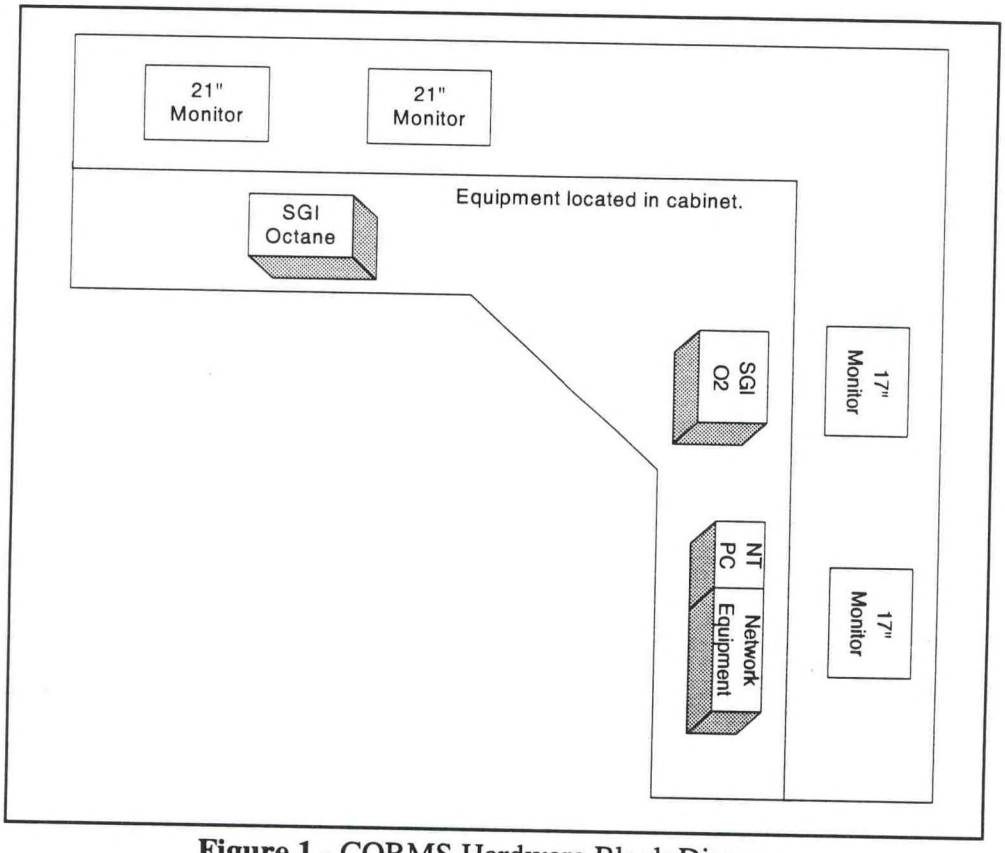


Figure 1 - CORMS Hardware Block Diagram

2.2 CORMS Software

CORMS is a combination of Commercial-Off-the-Shelf (COTS) software and in-house custom software. The software is divided into two separate components: (1) data ingestion and (2) data display.

2.2.1 Data Ingestion Software

The data ingestion software is a suite of bourne shell scripts which call other scripts, Fortran, and C programs. For each PORTS, there is a main script which spawns the appropriate processes for that PORTS when data arrives. It is important to remember that there is one controlling process for each PORTS.

The data ingestion software is responsible for

- determining when new data arrives;
- separating the data into the appropriate data and flag directories;
- determining if no data arrives;
- signaling the data display when new data is ready to be displayed;
- archiving the CORMS data.

2.2.2 Data Display

The CORMS data display is created through a combination of bourne shell scripts, C++, Perl, HTML, COTS real-time web plug-in (DataViews), and CGI programming. The CORMS operator views the CORMS displays through the use of a web browser.

The following describes the functions performed by each type of software.

Language	Function
bourne shell scripts	Provides login/logout for a CORMS Operator; provides process control
C++	Provides flow control for interaction with real-time plug-in
HTML & CGI	Provides all CORMS display pages
DataViews Plug-in	Provides the main CORMS display

2.3 CORMS Network

The CORMS network is made up of multiple 56 kbps Internet circuits which all reside on the same Internet backbone. See Figure 2. Each PORTS site has its own dedicated 56 kbps circuit. For a given site, the circuit has its origin at the location of the Data Acquisition System (DAS) for the given PORTS and its endpoint at the local point-of-presence of the network provider. All the circuits are provided by MCI/UUNET. Since all the circuits are on the same backbone, data transfers are seamless and reliable.

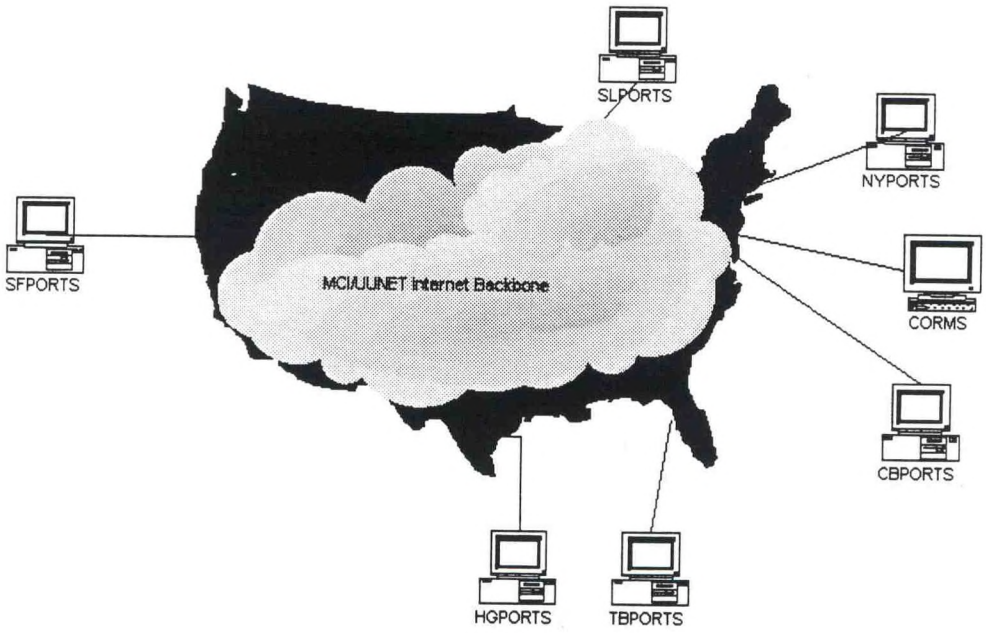


Figure 2 - CORMS Network Diagram

2.4 System Operation

Every six minutes, PORTS data is collected from the PORTS sensors installed at that site by the Data Acquisition System (DAS) for that location. At the DAS, various programs are run to evaluate the quality of the data and to set the quality control flags based on the results of that evaluation. The data is packaged into the PORTS Uniform Flat File Format (PUFFF) and transferred using FTP, via the MCI/UUNET communication link, to TESTPORT, a PC running SCO UNIX which is responsible for collecting data from each PORTS DAS. TESTPORT and the CORMS systems are located at NOAA Headquarters in Silver Spring, MD, in SSMC II. From TESTPORT, the data is transmitted to the CORMS communication server, cormscomm, which is currently a Silicon Graphics O_2 workstation.

The NWLON data is acquired, every hour, from NWLON sites via satellite to Wallops, VA. From Wallops, the data is transferred to the NWS Gateway which in turn is passed to the CO-OPS NWLON data ingestion platform, the Operational Platform for the Acquisition of Water Levels (OPAWL). OPAWL executes various routines to determine the quality of the data and set the appropriate quality control flags. The data along with the flags are placed into the NWLON Database. Every hour, a query is performed on the NWLON database to extract quality control data.

This data is transmitted to the CORMS communication server.

The CORMS communication server acts as the repository for the data received from either PORTS or NWLON. Through various CORMS programs, sensor status information, error tolerances, and quality control flags are processed to generate an appropriate display of information which is presented to the CORMS watchstanders via a web application running on the CORMS display server, a Silicon Graphics Octane workstation. This display of information provides the CORMS watchstanders with what is needed in order to monitor the quality of the data. With both the real-time and near real-time data, CORMS identifies error or failure modes, generates statistics to assess system reliability, and generates reports.

3 REQUIREMENTS

The requirements describe the functionality to be provided with CORMS II, as well as the context and constraints within which the system will operate, and the criteria against which the system will be evaluated.

Eleven different categories of requirements have been identified. When CORMS II is completed and fully operational, it is expected that all the requirement categories will be satisfied. However, for the initial implementation of CORMS II, it is expected that only the requirement categories marked with an asterisk will be satisfied.

- *System Requirements - These are requirements related to CORMS II core functionality—the set of tasks, activities, functions, interactions, modeling, and display capabilities which must be provided by the next generation CORMS.

- *Information Requirements - These requirements define the nature and type of information to be handled by CORMS II. Such requirements include identifying the nature, type, volume, and size of different types of input data, process data, output data, interface and display information, as well as the nature and type of decision aiding to be provided by the system.

- *Task Requirements - These requirements are CORMS II needs which stem from the tasks that are to be supported and performed by CORMS II.

- *Operational Requirements - These are the requirements that result from the operating environment, culture, and expectations within which CORMS II operates. These operational requirements include those associated with the PORTS and NWLON environments, different marine and sensor technologies, as well as NOAA, public, and commercial expectations for CORMS functionality and performance.

- *Organizational Requirements - These are the requirements related to needs of the CORMS-II host and parent environment; those related to U.S. federal emergency management policy, procedures, and organizations; those related to U.S. federal agency software policies, procedures, and organizations; as well as the personnel, labor, certification, training and information needs of organizations which administer, govern, regulate, or interface with

NOAA and the CORMS II system.

- *Technical Requirements - These requirements are dictated by CORMS II's technological needs—hardware, software, database, network, interface, display, storage and processing requirements for CORMS II.

- Human Factor Requirements - These include requirements for CORMS II human-computer interaction, including requirements for personnel knowledge, skills and abilities; human and automated task performance; performance evaluation; and for CORMS II watchstander workload and vigilance levels.

- Ergonomic Requirements - These include requirements for human and technology engineering in order to enhance human use and performance with computers. Such requirements include those for workstation display brightness, color, contrast, and size, as well as requirements for keyboards, workstation surfaces, workstation seating, lighting, heating and ventilation.

- *System Performance Requirements - These are requirements that describe the needs for CORMS II system and subsystem response levels under varying operating conditions. These requirements also include assessments of performance/accuracy tradeoffs, system load and loading, system traffic, and needs for system monitoring, assessment, and performance evaluation.

- *Use and User Requirements - These requirements are compilations of user requirements, and the uses to which they would put the CORMS II, derived from intended users of CORMS II, watchstanding personnel, CORMS supervisory personnel, and different system users, developers, system maintenance personnel, and troubleshooters. The primary CORMS II system users are the CORMS-II watchstanders. CORMS II secondary users include CORMS standby personnel and system maintenance personnel.

- *Schedule, Resource, and Budget Requirements - These are the CORMS II needs that are associated with project budgets, schedules, and resource requirements.

Detailed requirements from the RPI Requirements and Analysis Documentation for each of these categories are provided in Appendix A. For each requirement, the following information is provided:

- Type — the category into which the requirement falls
- Description — the sub-category into which the requirement falls
- Definition — a concise explanation of the requirement
- Test Method — the evaluation required to determine requirement compliance
- Priority — the status of importance for the requirement
- Source of Origin — the reference from which the requirement was determined

All requirements described are numbered individually and sequentially, which provides requirements identification and traceability.

The test method for each requirement defines the type of system evaluation required in order to ensure that a given requirement has been satisfied. The test methods identified are inspection, demonstration, audit, and survey. See Section 5.3 for definitions of these test methods.

Priorities attached to each requirement are to be developed at a later date, and will represent three levels: high, medium, or low. High priority means the requirement should be incorporated in the first CORMS II release. Medium priority means the requirement is necessary but can be deferred to a later release. Low priority means the requirement is desirable but not critical.

CORMS II requirements were determined using many different sources: interviews with CORMS users and operators, CORMS supervisory personnel, CO-OPS personnel, NOAA personnel, and PORTS users. Requirements were also gathered from other sources such as existing literature, CORMS and other real-time system standard operating procedures, real-time environmental monitoring system specifications, and international and national standards. A bibliography of sources is provided in Section 8.

4 SYSTEM DESIGN

4.1 System Development Strategy

Any development strategy is contingent upon several factors. The four main factors that were considered when selecting a development strategy were:

- PROJECT SIZE, DURATION AND COST
  - Measured as Small (-) or Large (+)
- PROJECT STRUCTURE (PROBABILITY OF REQUIREMENT MODIFICATIONS)
  - Measured as Structured (-) or Unstructured (+)
- USER TASK COMPREHENSION (HOW WELL THE TASK IS UNDERSTOOD)
  - Measured as Complete (-) or Incomplete (+)
- DEVELOPER TASK PROFICIENCY (DEGREE OF EXPERIENCE)
  - Measured as High (-) or Low (+)

When measuring the contingencies, the more negative the measurement, the more the project lends itself to a straight forward "acceptance" or "linear" strategy. This means you know where you are going and you have a clear goal in mind without the need to re-assess as you go. Conversely the more positive the measurement the more the project lends itself to an "iterative" or "experimental" strategy.

CORMS II will require several areas of expertise; encompass, minimally, two large external systems; and require a multi-year effort. The requirement analysis has revealed the high probability of requirement modifications since the organization is entering new territory in automated and decision based systems. The user comprehension is somewhat incomplete as some of the recent development meetings have proven to be brain storming sessions rather than a verbalization of clear definable requirements. In addition, the organization lacks expertise in the integration of sub-systems other than a PORTS (Physical Oceanographic Real Time System).

The negatives generated by looking at the contingencies clearly suggest for most of the developmental work, an iterative or experimental developmental strategy should be used. This means that the development will be more like a series of prototypes with iterations of "requirement sign offs". In this way, the development will stay on track while still providing freedom to prove concepts and demonstrate designed components along the way. This strategy does not lend itself to total out sourcing. However, for those components that can be partitioned, where requirements are more clear and understood, and where the task can be structured, contractors could be used.

Adopting an iterative development strategy does not, and can not mean abandoning any sound software engineering (SE) practices. It only means using the SE tools in a different way. Using this approach generates a series of "completed" systems rather than just one. The challenge is to continually keep in mind the long range goals and reduce the amount of disposable system product while building.

4.2 Data Inputs

4.2.1 Most Recent 6-minute Data

Data is pushed to the CORMS I every 6 minutes over the MCI/UUNET commercial communication network through the TESTPORT platform (PC) in the PORTS Uniform Flat File Format (PUFFF).

4.2.2 National PORTS Database

The National PORTS Database (NPDB) is one of the two primary data sources with which CORMS II will interface. The NPDB is a Sybase relational database and serves as the real-time archive for all PORTS observational data. Every six minutes, data for each PORTS site, along with the appropriate data quality indicator flags, is received from TESTPORT and ingested into the database. Future additions to the database will include historical current circulation surveys, current data analysis quality, and nowcast/forecast model data output. The PORTS InfoHub is currently the public interface to the NPDB and can be accessed via the internet at ports-infohub.nos.noaa.gov.

4.2.3 National Water Level Observation Network Database

The National Water Level Observation Network Database (NWLON/DMS) is one of the two primary data sources with which CORMS II will interface. The NWLON/DMS ingests water level data from about 189 gauges installed along the coasts of the United States. Every hour, data is received via a NOAA internet gateway from a GOES satellite receiving station in Wallops, VA. The data is quality controlled upon ingestion and the data, along with appropriate quality control indicator flags, is loaded into a Sybase relational database. The CO-OPS web server is currently the public interface to the NWLON/DMS and can be accessed via the internet at co-ops.nos.noaa.gov.

4.2.4 Internal CORMS II database(s) for storing rules/directives used by the COTS package

It is anticipated that the selected COTS package will require an internal database that will minimally (1) store interim results of an analysis; (2) store any directives/rules necessary for the COTS package to function; and (3) store statistics and performance results.

4.2.5 Watch Standing Personnel Interactive Inputs

It is expected that CORMS II will interact with the watch standing personnel and will be capable of accepting input from them via keyboard entries and/or mouse clicks.

4.3 Data Processing and Analysis

Incoming data will already be "processed". That is, incoming data will be in engineering units and presented in a working format. The "analysis" that will occur in CORMS II will take place within the selected COTS package. There is no plan to write custom in-house analysis routines for CORMS II.

4.4 Data Outputs

4.4.1 Visual Outputs

Visual outputs will be generated in tabular and graphical form to communicate the directives and guidance necessary for the watch standing personnel. Most of the visuals will be generated by the COTS package selected.

4.4.2 Knowledge Base

A Knowledge Base will be considered as a natural output generated by the COTS package.

4.5 System Hardware/Software - See 1.4.4 (Assumptions)

4.6 Application Software

As was described in the "Assumptions and Constraints" section 1.4, the cornerstone of CORMS II will be the successful selection of a COTS software package. CO-OPS does not have the resources to develop extensive in-house software. This activity will be the most important and challenging since the knowledge about the specialized field of decision support is lacking within the organization and there is a myriad of products and services available to address decision support. The very scope of possible solutions is daunting.

There will be a need for some "enabling" software to tie the COTS with the other system components.

5 SYSTEM IMPLEMENTATION

5.1 System Installation

CORMS II will be installed at the NOAA Headquarters Silver Spring, MD campus site in office space in SSMC II provided by NWS, Office of System Operations (OSO). The installation will co-exist with CORMS I and will include all the components of CORMS I which include (1) the CORMS I hardware platforms; (2) communication links (LAN, WAN, land line, etc.); (3) software (COTS and In-House); and (4) a collection of system equipment racks, work tables, and voice communication equipment. Selected individuals will participate in an internal review of CORMS II prior to becoming operational.

5.2 System Operation and Maintenance

A CORMS Standard Operating Procedures (SOP) manual exists which guides CORMS operators and users in the operation of CORMS I. Included in the manual are a Users Manual, a Maintenance Manual, and a System Operating Manual. Procedures and policies for using CORMS I and what actions need to be taken as a result of a CORMS I finding are included as well. This manual will be modified and updated to reflect the additional capabilities to be provided by CORMS II.

5.3 Test and Evaluation

A Test and Evaluation Plan will be provided to evaluate CORMS II. All requirements provided in Section 3 will be tested. Test methods for each requirement will be more fully described in the CORMS II Test and Evaluation Plan. At that time, priorities for CORMS II requirements will

also be identified. The test methods currently identified are:

- Demonstration - exercising the functionality described so as to show the referenced capability
- Inspection - viewing the functionality described so as to prove the referenced capability
- Audit - reviewing published documentation, policies, and procedures for compliance with requirements
- Survey - gathering, analyzing, and reviewing user, management, and technical personnel data and opinions

6 RESOURCE REQUIREMENTS

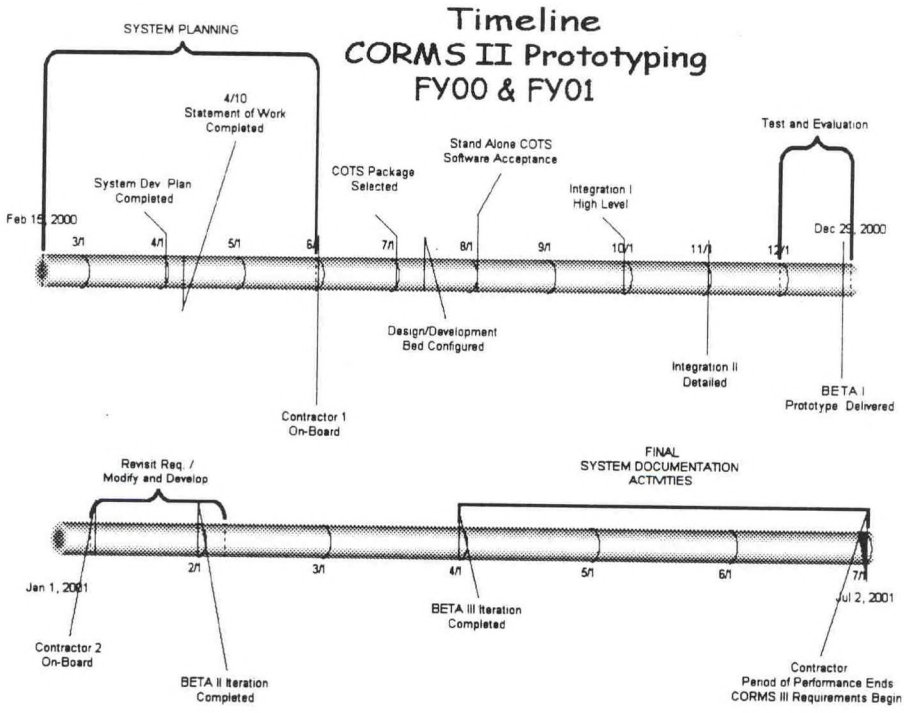
6.1 Personnel

Project Manager ..... Thomas Bethem
Project Management Support ..... Janet Burton
CORMS I Manager ..... Mike Connolly
Implementation Manager ..... Mike Evans
Information Systems Division Support ..... 9 Staff Months
Two (2) Contractors ..... 16 staff months

6.2 Budget

FY 00	51K	(contracts)
FY 01	130K	(contracts)

7 PROGRAM SCHEDULE AND MILESTONES



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APPENDIX A: REQUIREMENTS MATRIX FOR CORMS II

REQUIREMENTS FOR CORMS-II

1/10/00

Key: **Modification in response to NOAA comment.**
New requirements modification.
Requirements clarification needed.

Req. #	Requirement Type	Description	Operationalization	Test	Priority	Source
0.1	**System Requirements**	♦ **CORMS-II system Level requirements**				
0.1.1		• CORMS-II system level requirements	• CORMS-II shall continuously gather real time and near real time data and information.	• Inspection & demonstration		• SOP, 1
0.1.2		• CORMS-II system level requirements	• CORMS-II shall monitor and analyze real time and near real time data and information	• Inspection & demonstration		• SOP, 1
0.1.2.1		• CORMS-II system level requirements	• CORMS-II shall input data via standard interface from, but not limited to, the following systems: a) National PORTS Data Base (NPDB) b) Physical Oceanographic Real-Time System (PORTS), and the c) National Water Level Observation Network Data Management System (NWLON DMS)	• Inspection & demonstration		• SOP, 1
0.1.3		• CORMS-II system level requirements	• CORMS-II shall determine data availability and data accuracy.	• Inspection & demonstration		• SOP, 1
0.1.4		• CORMS-II system level requirements	• CORMS-II shall generate system reliability and performance statistics.	• Inspection & demonstration		• SOP, 1
0.1.5		• CORMS-II system level requirements	• CORMS-II shall provide decision support to watchstanders monitoring data quality	• Prototype demonstration		• NOAA/T.B./ Watchstanders /K.F, R.R
0.1.6		• CORMS-II system level requirements	• CORMS-II's data quality decision support shall indicate problems, diagnoses, and corrective actions.	• Inspection & demonstration		• ANSI/ HFES-HCI 200, 1998 ISO 9241 part 10-17, Laffey, et al., 1988

Req. #	Requirement Type	Description	Operationalization	Test	Priority	Source
0.1.7		• CORMS-II system level requirements	• CORMS-II shall monitor its own operation to continue to operate in the event of a partial system failure.	• Inspection & demonstration		• Laffey, et al., 1988
0.1.8		• CORMS-II system level requirements	• CORMS-II shall provide recommendations that suggest the best course of action for given conditions.	• Inspection & demonstration		• Laffey, et al., 1988
0.1.9		• CORMS-II system level requirements	• CORMS-II shall incorporate a flexible reasoning strategy that provides the best recommendation possible under the given time constraints.	• Inspection & demonstration		• Laffey, et al., 1988
0.1.10		• CORMS-II system level requirements	• CORMS-II shall be capable of reasoning with incomplete and uncertain information.	• Inspection & demonstration		• Laffey, et al., 1988
0.1.11		• CORMS-II system level requirements	• CORMS-II shall continue to operate (within reason) independent of any failure experienced within a participating system.	• Inspection & demonstration		• SOP, Appendix. B
0.1.12		• CORMS-II system level requirements	• CORMS-II data and information shall be available to a restricted set of users.	• Inspection & demonstration		• SOP, 5
0.1.13		• CORMS-II system level requirements	• CORMS-II shall demonstrate compliance with identified security objectives and benchmarks.	• Demonstration		• Watchstanders
0.1.14		• CORMS-II system level requirements	• CORMS-II shall provide a mechanism for updating its knowledge bases, given the dynamic nature of real time knowledge.	• Inspection & demonstration		• Laffey, et al., 1988
0.1.15		• CORMS-II system level requirements	• CORMS-II shall extend and accommodate future growth.	• Demonstration		• NOAA/M.C.

Req. #	Requirement Type	Description	Operationalization	Test	Priority	Source
1.1	**Information Requirements**	♦ **General display requirements**				
1.1.1		• General Display & Output requirements	• CORMS-II shall provide a) Graphic display of locations being monitored b) Text and graphic display of monitored data and analysis c) Text, aural and graphical display of decision support requirements concerning data and analyses being monitored.	• Demonstration		• NOAA/T.B, SOP 5, Appendix L/ Watchstanders / A.J, B.T/ 7/7/99/ K.F, R.R/8.11.99
1.1.2		• General Display & Output requirements	• CORMS-II shall provide display of appropriate information	• Demonstration		• SOP 5
1.1.3		• General Display & Output requirements	• CORMS-II shall provide status indicators for port-, and sensor-level information.	• Demonstration		• NOAA/M.C, Watchstanders B.T, A.J/ 7.7.99
1.1.4		• General Display & Output requirements	• CORMS-II's status indicators shall be easy to understand	• Demonstration		• NOAA/M.C, Watchstanders /B.T, K.F, R.R
1.1.5		• General Display & Output requirements	• The CORMS-II's status indicators shall utilize a) Distinguishable colors, b) Movement (e.g., flashing) icons, and c) Audio signals for status indicators	• Demonstration		• NOAA/M.C/ Watchstanders /A.J, B.T/ 7.7.99/ K.F, R.R/ 8.11/99
1.1.5.1		• General Display & Output requirements	• CORMS-II's status indicators shall identify problems if quality control flags do not work.	• Demonstration		• Watchstanders /KF, RR/ 8.11.99
1.1.6		• General Display & Output requirements	• CORMS-II status indicators shall have associated user message windows	• Demonstration		• NOAA/M.C/ Watchstanders /KF, RR/ 8.11.99/B.T/ 9.2.99

Req. #	Requirement Type	Description	Operationalization	Test	Priority	Source
1.1.7		• General Display & Output requirements	• CORMS-II shall support display of: a) real time data, b) near real time data, c) historical data, and d) data analysis.	• Demonstration		• NOAA/M.C, SOP Appendix I /Watchstanders /K.F, R.R/ 8.11.99
1.1.8		• General Display & Output requirements	• CORMS-II shall provide display of national PORTS information as well as detailed PORTS information simultaneously.	• Demonstration		• NOAA/M.C/ Watchstanders /K.F, R.R/ 8.11.99
1.1.9		• General Display & Output requirements	• CORMS-II information access shall minimize required access levels.	• Demonstration		• Watchstanders /K.F,R.R/8.11. 99/B.T/9.2/99
1.1.10		• General Display & Output requirements	• CORMS-II shall support display and generation of the following: a) CORMS-II morning report b) CORMS-II passdown log c) CORMS-II decision support audit trails d) Instant status report e) Related e-mail	• Demonstration		• Watchstanders /KF, RR/ 8.11.99/B.T /9.2/99
1.1.11		• General Display & Output requirements	• CORMS-II's morning report shall be electronically editable.	• Demonstration		• Watchstanders / KF, RR/ 8.11.99/B.T/ 9.2.99
1.1.11.1		• General Display & Output requirements	• The CORMS-II morning report shall be prepared by the night watch, summarizing problems during the last 24 hours, consistent with the CORMS-II Passdown log information.	• Demonstration		• SOP5, Watchstanders /AJ, BT/ 7.7.99/ KF, RR/8.11.99
1.1.12		• General Display & Output requirements	• The CORMS-II's passdown log shall be electronically editable, showing the problems faced by previous watchstanders.	• Demonstration		• Watchstanders / KF, RR/ 8.11.99/B.T/ 9.2.99
1.1.13		• General Display & Output requirements	• CORMS-II shall generate and distribute morning reports automatically at specified reporting intervals.	• Demonstration		• Watchstanders /KF, RR/ 8.11.99

Req. #	Requirement Type	Description	Operationalization	Test	Priority	Source
1.2.		♦ **Decision support requirements**				
1.2.1		• Decision support requirements	• CORMS-II decision support system shall inform the watchstanders of appropriate action when the following scenarios are encountered: a) Detection of erroneous data, b) data dissemination has been shut down, c) data fails an automated test, d) notices are received from the Tsunami warning center, e) the CORMS server suffers a major casualty, or f) a data receiving failure occurs.	• Demonstration		• NOAA/T.B/ M.C/ M.S/ Watchstanders /KF, RR/ 8.11.99/BT/ 9.2.99/ SOP, Section. 4
1.2.2		• Decision support requirements	• CORMS-II shall provide the following types of decision support: 1) error messages, 2) flags, 3) course of action, 4) notifications, 5) tracking, and 6) feedback.	• Demonstration		• NOAA/M.C
1.2.3		• Decision support requirements	• CORMS-II's decision support system shall reference applicable SOPs.	• Demonstration		• NOAA/M.C
1.3		♦ **Input Information requirements**				
1.3.1		• Input Information requirements	• CORMS-II shall accept the following types of input information: a) Text, b) Graphics, and real time and near real time data, c) Geographical information.	• Demonstration		• Watchstanders /BT, AJ/ 7.7.99/KF, RR / 8.11.99

Req. #	Requirement Type	Description	Operationalization	Test	Priority	Source
2.1	**Task Requirements**	♦ **CORMS-II functional requirements**				
2.1.1		• CORMS-II functional requirements	• CORMS-II shall provide Standard Operating Procedures (SOP's) in electronic format to watchstanders.	• Demonstration		• Project team
2.1.1.1		• CORMS-II functional requirements	• SOP's shall be used as the foundation for CORMS-II decision making.	• Demonstration		• Watchstanders /KF, RR/ 8.11.99/ BT/9.2.99
2.1.2		• CORMS-II functional requirements	• CORMS-II shall support:			
2.1.2.1		• CORMS-II functional requirements	• hourly checking of PORTS installation status, including review of all PORTS installations, insuring that the intervals of data are all 6 minutes, and that CORMS-II status indicators and data correspond,	• Demonstration		• SOP 5/ Watchstanders /KF, RR/ 8.11.99
2.1.2.2		• CORMS-II functional requirements	• Once per shift comparison of PORTS voice vs. text information for all PORTS installation,	• Demonstration		• SOP5 (ISD-RM001)/ Watchstanders /AJ, BT/7.7.99
2.1.2.3		• CORMS-II functional requirements	• On an hourly basis, review of NWLON DMS and OPAWL to ensure they are operational and up-to-date,	• Demonstration		• SOP 5 (ISD-RM002, 011)/ Watchstanders /KF, RR/ 8.11.99
2.1.2.4		• CORMS-II functional requirements	• Notification of discrepancies and errors in its data comparison activities,	• Demonstration		• SOP5, Watchstanders /BT, AJ/ 7.7.99/KF, RR/8.11.99

Req. #	Requirement Type	Description	Operationalization	Test	Priority	Source
2.1.2.5		• CORMS-II functional requirements	• Error notifications in aural, visual, and movement status indicators,	• Demonstration		• SOP5, Watchstanders /BT, AJ/ 7.7.99/KF, RR/8.11.99
2.1.2.6		• CORMS-II functional requirements	• Once per day monitoring of satellite station transmissions,	• Demonstration		• SOP 5 (ISD-RM003), Watchstanders /KF, RR/ 8.11.99
2.1.2.7		• CORMS-II functional requirements	• notification of breakdowns in communication that occurred between sensors and the collection points,	• Demonstration		• SOP5, Watchstanders / KF, RR/ 8.11.99
2.1.2.8		• CORMS-II functional requirements	• daily quality checks of basic sensor information including DPAS station number, the DCP being used, and the sensor being reported, and	• Demonstration		• SOP 5 (ISD-RM007, 008), Watchstanders / AJ, BT/ 7.7.99/KF, RR/8.11.99
2.1.2.9		• CORMS-II functional requirements	• water level predictions.	• Demonstration		• SOP5, Watchstanders / AJ, BT/ 7.7.99/KF, RR/8.11.99

Req. #	Requirement Type	Description	Operationalization	Test	Priority	Source
3.1	**Operational Requirements**	♦ Monitoring	• CORMS-II shall provide detection and notification capability.	• Demonstration		• NOAA/M.S
3.2		♦ Notification	• CORMS-II shall provide the following levels of notification and decision support: a) Alerts, b) Alarms, and c) Recommendations.	• Demonstration		• Project team
3.3		♦ Monitoring	• CORMS-II shall monitor real-time and near real-time environmental data on a 24 x 7 basis.	• Demonstration		• SOP1, 2
3.4		♦ Assessment	• CORMS-II shall assess monitored data for its impact on data quality and appropriate information display.	• Demonstration		• SOP 3
3.5		♦ Decision Support	• CORMS-II shall provide decision support to watchstanders in support of 24 x 7 watchstanding.	• Demonstration		• SOP4, B,
3.6		• Reporting	• CORMS-II shall provide report generation capability.	• Demonstration		• SOP 5
3.7		♦ Interface Support	• CORMS-II shall interface with PORTS and NWLON sensors.	• Demonstration		• SOP B

Req. #	Requirement Type	Description	Operationalization	Test	Priority	Source
	Organizational Requirements					
4.1		• Allocation of authority	• Authority in CORMS-II shall be defined and allocated based on CORMS-II SOP's and organizational structure.	• Audit		• NRC, 1997, Greenberg &Baron, 1993,
4.2		• Allocation of responsibility	• Allocation of responsibilities in CORMS-II shall be defined and allocated based on SOP's and in accordance with existing contracts.	• Audit		• NRC, 1997, Greenberg&Baron, 1993,
4.3		• Personnel policies	• Personnel policies in CORMS-II shall be defined according to the SOP's and in accordance with existing contracts.	• Audit		• NRC, 1997
4.4		• Labor management relations	• Labor management relations for CORMS-II shall be determined according to existing contract.	• Audit		• NRC, 1997,
4.5		• Legal liability	• Legal liability shall be determined according to the NOAA organizational and legal policies.	• Audit		• NRC, 1997
4.6		• Safety policies	• Safety policies shall be determined according to NOAA safety policies and procedures.	• Audit		• NRC, 1997
4.7		• Efficiency policies	• Efficiency policies shall be determined based on CO-OPS SOP's and training procedures.	• Audit		• NRC, 1997
4.8		• Team management	• CORMS-II team management shall be determined according to the SOP's and NOAA organizational policy.	• Audit		• NRC, 1997 Greenberg&Baron, 1993
4.9		• Team communication	• CORMS-II shall promote communication among users, management, and technical personnel.	• Audit; user, management, and technical personnel survey		• NRC, 1997

Req. #	Requirement Type	Description	Operationalization	Test	Priority	Source
	Technical Requirements					
5.1		♦ **Hardware requirements**				
5.1.1		• Hardware requirements	• CORMS-II shall support use of commercial off-the-shelf (COTS) hardware.	• Inspection & demonstration		• ISO 9241, Part, 3,4,7,8,9
5.1.2		• Hardware requirements	• CORMS-II shall support integration of open hardware architecture standards.	• Inspection & demonstration		• ISO 9241, Part, 3,4,7,8,9
5.1.3		• Hardware requirements	• CORMS-II shall support integration of differing hardware platforms.	• Inspection & demonstration		• ISO 9241, Part, 3,4,7,8,9
5.1.4		• Hardware requirements	• CORMS-II shall support integration of varying network hardware architectures.	• Inspection & demonstration		• ISO 9241, Part, 3,4,7,8,9
5.2		♦ **Software requirements**				
5.2.1		• Software requirements	• CORMS-II shall support use of commercial off-the-shelf (COTS) software.	• Inspection & demonstration		
5.2.2		• Software requirements	• CORMS-II shall support integration of open software standards.	• Inspection & demonstration		
5.2.3		• Software requirements	• CORMS-II shall support integration of varying network software architectures.	• Inspection & demonstration		
5.3		♦ **System level response requirements**	• CORMS-II displays, to the extent possible, shall adhere to standard display response times.	• Demonstration		• ANSI/ HFS 100,1988, ISO 9241, part 10-17,
5.4		♦ **Network requirements**				
5.4.1		• Network requirements	• The CORMS-II network shall be designed for growth.	• Demonstration		• NOAA/M.C

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5.5		♦ **Database requirements**				
			• The PORTS database shall:			
5.5.1		• PORTS database	a) be accessible over the web , and	• Demonstration		• NOAA/M.C
5.5.2		• PORTS database	b) provide electronic links to appropriate sites.	• Demonstration		• NOAA/M.C
			• NWLON database shall			
5.5.3		• NWLON database	a) be accessible over the web	• Demonstration		• NOAA/M.C
5.5.4		• NWLON database	b) provide electronic links to appropriate sites.	• Demonstration		• NOAA/M.C
5.5.5		• Real time database	• .CORMS-II database shall monitor and respond to the changes in the external environment in a real –time manner	• Inspection		• Bestavros& Fay-Wolfe, 1997
5.5.6		• Real time database	• CORMS-II database shall detect errors based on current data, updated continuously.	• Inspection		• Bestavros& Fay-Wolfe, 1997
5.5.7		• Real time database	• CORMS-II's database shall maintain both logical and temporal integrity.	• Inspection		• Bestavros& Fay-Wolfe, 1997
5.6		♦ **Interface requirements**				
5.6.1		• Interface requirements	• CORMS-II shall provide a real time interface to NWLON DMS.	• Demonstration		• SOP B
5.6.2		• Interface requirements	• CORMS-II shall provide a real time interface to NPDB.	• Demonstration		• SOP B

Req. #	Requirement Type	Description	Operationalization	Test	Priority	Source
	Human Factors Requirements					
6.1		♦ **Personnel Selection**	• CORMS-II watchstanders shall be selected based on required knowledge, skills, and abilities.	• Inspection		• NRC, 1997
6.2		♦ **Personnel Performance**	• CORMS-II watchstander required knowledge, skills and abilities shall be articulated in NOAA policy and personnel procedure documents	• Inspection		• NRC, 1997
6.3		♦ **Personnel Training**	• CORMS-II hardware and software training shall be provided for watchstanders using the equipment.	• Inspection		• NRC, 1997
6.4		♦ **Performance appraisal**	• CORMS-II shall provide a variety of methods to track the performance of the watchstanders, including real-time monitoring on the job, specially designed simulation exercises, checklists, and annual written performance.	• Inspection		• NRC, 1997
6.5		♦ **Workload**	• CORMS-II shall provide a reasonable level of operator workload.	• Inspection		• NRC, 1997
6.6		♦ **Workload**	• CORMS-II watchstander workload shall be monitored for compliance with established NOAA standards	• Inspection		• NRC, 1997
6.7		♦ **Workload**	• CORMS-II watcstander workload standards shall be articulated in NOAA policy and procedure documents.	• Inspection		• NRC, 1997
6.8		♦ **Vigilance**	• CORMS-II shall provide monitoring and decision support to counter watchstander vigilance decrements.	• Inspection		• NRC,1997 ISO 10075, 1991
6.9		♦ **Vigilance**	• CORMS-II watchstander vigilance shall be monitored for compliance with established NOAA standards	• Inspection		• NRC, 1997

Req. #	Requirement Type	Description	Operationalization	Test	Priority	Source
6.10		♦ **Vigilance**	• CORMS-II watchstander vigilance standard shall be articulated in NOAA policy and procedure document.	• Inspection		• NRC, 1997
7.1	**Ergonomic Requirements**	♦ **Working Environment**				
7.1.1		• **Lighting**	• The CORMS-II watchstanding area shall provide satisfactory lighting conditions including contrast between the screen and the background environment, taking into account the watchstanders' vision requirements.	• Inspection		• ANSI/ HFS 100,1988,ISO 9241 part 6,
7.1.2		♦ **Seating**				
7.1.2.1		• **Seating**	• The CORMS-II watchstanding station work desk shall have a sufficiently large, low-reflectance surface and allow a flexible arrangement of the screen, keyboard, documents, and related equipment.	• Inspection		• ANSI/ HFS 100,1988,ISO 9241 part 6,
7.1.2.2		• **Seating**	• The CORMS-II watchstander's work chair shall be stable and allow the operator easy freedom of movement and comfortable position	• Inspection		• ANSI/ HFS 100,1988,ISO 9241 part 6,
7.1.3		• **Sound and noise**	• The CORMS-II watchstanding area noise and sound emitted by equipment shall not distract the watchstanders attention from their duties.	• Inspection		• ANSI/ HFS 100,1988,ISO 9241 part 6,
7.1.4		• **Thermal conditions**	• The CORMS-II watchstanding area equipment shall not produce an amount of heat that could cause discomfort to operators.	• Inspection		• ANSI/ HFS 100,1988,ISO 9241 part 6,
7.1.5		• **Thermal conditions**	• An adequate level of humidity shall be established and maintained.	• Inspection		• ANSI/ HFS 100,1988,ISO 9241 part 6,

Req. #	Requirement Type	Description	Operationalization	Test	Priority	Source
7.2		♦ **Human-computer interaction**				
7.2.1		• Display requirements	• CORMS-II screen characters shall be clearly formed, of adequate size and spacing between characters and lines.	• Inspection & Demonstration		• ANSI/ HFS 100,1988, ISO 9241 part 3,
7.2.1.1		• Display requirements	• CORMS-II screen images shall be stable, with no flickering or other forms of instability.	• Inspection & Demonstration		• ANSI/ HFS 100,1988, ISO 9241 part 3
7.2.1.2		• Display requirements	• CORMS-II brightness and the contrast between the characters and the background shall be easily adjustable by the operator and also be easily adjustable to ambient conditions.	• Inspection & Demonstration		• ANSI/ HFS 100,1988, ISO 9241 part 3
7.2.1.3		• Display requirements	• The CORMS-II's screen shall be swivel and tilt easily and freely to adapt to the needs of the operator.	• Inspection & Demonstration		• ANSI/ HFS 100,1988, ISO 9241 part 3
7.2.1.4		• Display requirements	• The CORMS-II's screen shall be free of reflective glare and reflections liable to cause discomfort to the user.	• Inspection & Demonstration		• ANSI/ HFS 100,1988, ISO 9241 part 3
7.2.2		• **Keyboard requirements**	• The CORMS-II keyboard shall be tiltable and separate from the screen to allow the watchstanders to obtain a comfortable working position avoiding fatigue in the arms and hands.	• Inspection & Demonstration		• ANSI/ HFS 100,1988, ISO 9241 part 3,
7.2.2.1		• Keyboard requirements	• The CORMS-II's space in front of the keyboard shall be sufficient to provide support for the hands and arms of the operator.	• Inspection & Demonstration		• ANSI/ HFS 100,1988, ISO 9241 part 3,
7.2.2.2		• Keyboard requirements	• The CORMS-II's keyboard shall have a matte surface to avoid reflective glare.	• Inspection & Demonstration		• ANSI/ HFS 100,1988, ISO 9241 part 3,
7.2.2.3		• Keyboard requirements	• The CORMS-II's keyboard arrangement shall	• Inspection		• ANSI/ HFS 100,1988, ISO

Req. #	Requirement Type	Description	Operationalization	Test	Priority	Source
			facilitate the use of the keyboard.			9241 part 3,
7.2.2.4		• Keyboard requirements	• CORMS-II key characteristics shall facilitate the use of the keyboard.	• Inspection & Demonstration		• ANSI/ HFS 100,1988, ISO 9241 part 3
7.2.2.5		• Keyboard requirements	• CORMS-II key symbols shall have adequate contrast and be legible from the design working position.	• Inspection & Demonstration		• ANSI/ HFS 100,1988, ISO 9241 part 3
7.2.3		• **Mouse requirements**	• The CORMS-II's mouse shall be located under fingers and coincident to finger motion.	• Inspection & Demonstration		• ANSI/ HFES-HCI 200, 1988, ISO 9241 part 10-17,
7.2.4		• **Software Interface**				
7.2.4.1		• Software Interface	• CORMS-II interface shall consist of a graphical user interface.	• Inspection		• Head. J. A., 1997
7.2.4.2		• Software Interface	• CORMS-II interface design shall encourage interaction between the watchstanders and the information being displayed	• Inspection		• Head. J. A., 1997
7.2.5		♦ **Use of color and sound**				
7.2.5.1		• Use of color and sound	• CORMS-II screen design colors shall emphasize important information.	• Inspection		• Marcus, 1995
7.2.5.2		• Use of color and sound	• CORMS-II screen design colors shall identify subsystems and structures.	• Inspection & prototype demonstration		• Marcus, 1995
7.2.5.3		• Use of color and sound	• CORMS-II screen design colors shall portray natural objects realistically.	• Inspection & prototype demonstration		• Marcus, 1995
7.2.5.4.		• Use of color and sound	• CORMS-II screen design colors shall enhance comprehensibility and appeal.	• Inspection & prototype demonstration		• Marcus, 1995
7.2.6		♦ **User expectations**				
7.2.6.1		• User expectations	• CORMS-II shall confirm user expectations by utilizing vocabulary familiar to users.	• Inspection & Demonstration		• ANSI/ HFES-HCI 200,1988

Req. #	Requirement Type	Description	Operationalization	Test	Priority	Source
7.2.6.2		• User expectations	• CORMS-II shall confirm user expectations by providing similar dialogues for similar tasks.	• Inspection & Demonstration		• ISO 9241 part 10-17, • ANSI/ HFES-HCI 200,1988
7.2.6.3		• User expectations	• CORMS-II shall confirm user expectations by minimizing cursor movement.	• Inspection & demonstration		• ISO 9241 part 10-17, • ANSI/ HFES-HCI 200,1988
7.2.6.4		• User expectations	• CORMS-II shall confirm user expectations by providing consistent dialogue behavior and appearance.	• Inspection & demonstration		• ISO 9241 part 10-17, • ANSI/ HFES-HCI 200,1988
7.2.7		♦ **User control**				ISO 9241 part 10-17,
7.2.7.1		• User control	• CORMS-II shall allow undo of last dialogue step/action.	• Inspection & Demonstration		• ANSI/ HFES-HCI 200,1988 ISO 9241 part 10-17,
7.2.7.2		• User control	• CORMS-II shall allow users to control response to system of external events	• Inspection & Demonstration		• ANSI/ HFES-HCI 200,1988 ISO 9241 part 10-17
7.2.7.3		• User control	• CORMS-II shall present input and output data under user control.	• Inspection & Demonstration		• ANSI/ HFES-HCI 200,1988 ISO 9241 part 10-17
7.2.7.4		• User control	• CORMS-II shall allow choices of different interaction levels.	• Inspection & Demonstration		• ANSI/ HFES-HCI 200,1988 ISO 9241 part 10-17,
7.2.8		♦ **Scrolling**				
7.2.8.1		• Scrolling	• CORMS-II's scrolling shall include vertical scrolling controlled by up and down cursor arrow keys,	• Inspection & Demonstration		• ANSI/ HFES-HCI 200,1988 ISO 9241 part 10-17,
7.2.8.2		• Scrolling	• CORMS-II's scrolling shall include horizontal scrolling controlled by left and right cursor arrow keys.	• Inspection & Demonstration		• ANSI/ HFES-HCI 200,1988 ISO 9241 part 10-17,
7.2.9		♦ **Error and help messages**				
7.2.9.1		• error and help messages	• CORMS-II shall display an error message after the user entry in which the error is detected.	• Inspection & Demonstration		• ANSI/ HFES-HCI 200,1988 ISO 9241 part

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7.2.9.2		• Feedback	• CORMS-II shall highlight and visually change icons and text signifying activation, and inform the user about the system-watchstander interaction.	• Inspection & Demonstration		10-17, • Head. J. A., 1997
7.2.9.3		• system individualization	• The CORMS-II administrator shall be able to customize the interface with special function keys, shortcuts, screen colors, and rate of information delivered per second.	• Inspection & Demonstration		• Head. J. A., 1997
7.2.9.4		• keying	• CORMS-II's keying shall not require recoding, changing, omitting, or including data based on special rules or logical transformation	• Inspection & prototype demonstration		• Galitz, 1989
7.2.10		• **Menus**				
7.2.10.1		• Menus	• CORMS-II menu screens shall consider the conflicting needs of both inexperienced and experienced watchstanders.	• Inspection & Demonstration		• ANSI/ HFES-HCI 200,1988 ISO 9241 part 10-17,
7.2.10.2		• Menus	• CORMS-II's menu selection shall provide efficient use of keystrokes.	• Inspection & Demonstration		• ANSI/ HFES-HCI 200,1988 ISO 9241 part 10-17,
7.2.10.3		• Menus	• CORMS-II menu screens shall promote error recognition.	• Inspection & Demonstration		• ANSI/ HFES-HCI 200,1988 ISO 9241 part 10-17,
7.2.11		♦ **Navigation**				
7.2.11.1		• Navigation	• CORMS-II watchstanders shall be able to decide which window and level they want to work in.	• Inspection & Demonstration		• Head. J. A., 1997
7.2.11.2		• Navigation	• CORMS-II watchstanders shall be able to easily navigate between choices for multitasking.	• Inspection & Demonstration		• Head. J. A., 1997
7.2.12		• **Options**				
7.2.12.1		• Options	• The CORMS-II interface shall provide alternative methods for options display.	• Inspection & Demonstration		• ANSI/ HFES-HCI 200,1988 ISO 9241 part 10-17,

Req. #	Requirement Type	Description	Operationalization	Test	Priority	Source
7.2.12.2		• Options	• The CORMS-II interface shall provide a means for selecting and deselecting options.	• Inspection & Demonstration		• ANSI/ HFES-HCI 200,1988 ISO 9241 part 10-17,
7.2.12.3		• Options	• The CORMS-II interface shall allow user to choice options and change options before activation.	• Inspection & Demonstration		• ANSI/ HFES-HCI 200,1988 ISO 9241 part 10-17
7.2.12.4		• Options	• The CORMS-II interface shall provide visual cues that menu options have been selected.	• Inspection & Demonstration		• ANSI/ HFES-HCI 200,1988 ISO 9241 part 10-17
7.2.13		• **Pointing**	• CORMS-II watchstanders shall be able to point to things on computer screen with free-roaming cursors.	• Inspection & Demonstration		• Levine & Ehrlich, 1995
8.1	**System Performance requirements**	♦ Homogeneity	• CORMS-II tasks shall be allocated to any node on CORMS-II network based on deadlines and availability of resources due to homogeneity.	• Demonstration		• Stankovic, 1988
8.2		♦ Survivability	• The CORMS-II network topology shall provide several shortest or optimal paths between the nodes, enabling easy routing of messages in the system.	• Demonstration		• Stankovic, 1988
8.3		♦ Scalability	• The CORMS-II network shall allow the computational power of CORMS-II network to be changed at any time without redesigning the nodes.	• Demonstration		• Stankovic, 1988
8.4		♦ Flexibility	• CORMS-II architectures shall be easily emulated by disabling some of the links in the chosen topology.	• Demonstration		• Stankovic, 1988
8.5		♦ Accuracy	• CORMS-II shall provide information within an identified accuracy envelope.	• Demonstration		• Watchstanders

Req. #	Requirement Type	Description	Operationalization	Test	Priority	Source
8.6		♦ Accuracy	• CORMS-II accuracy envelopes shall be identified in NOAA technical documentation.	• Demonstration		• Watchstanders
8.7		♦ Response time	• CORMS-II shall provide system responses within an identified response time envelope.	• Demonstration		• Laplante, 1992
8.8		♦ Response time	• CORMS-II response time standards shall be articulated in NOAA technical documentation.	• Demonstration		• Laplante, 1992
8.9		♦ Response/accuracy	• CORMS-II shall provide system response time and accuracy within an identified accuracy/response time envelope.	• Demonstration		♦ Laplante, 1992
8.10		♦ Response/accuracy	• CORMS-II accuracy/response time envelope shall be articulated in NOAA technical documentation.	• Inspection		• Laplante, 1992
8.11		♦ Performance metrics	• CORMS-II performance shall be assessed with appropriate performance metrics.	• Inspection		• Laplante, 1992
8.12		♦ Performance metrics	• CORMS-II performance metrics shall be articulated in NOAA technical documentation.	• Inspection		• Laplante, 1992
8.13		♦ Performance monitoring	• CORMS-II accuracy, response time and accuracy, response time performance shall be monitored for compliance with established NOAA standards.	• Inspection		• Laplante, 1992

Req. #	Requirement Type	Description	Operationalization	Test	Priority	Source

Glossary

ANSI HFS 100/1988	: American National Standards for Human Factors, Engineering of Visual Display Terminal Workstations.
ANSI HFES HCI 200	: American National Standards for Human Factors, Human Computer Interaction standards
ANSI SQL	: American National Standards for Structured Query Language
AJ	: Andrew Jakubowski (Watchstander)
BT	: Brian Thompson (Watchstander)
CORMS	: Continuous Real Time Monitoring System
COTS	: Commercial Of The Shelf
DCP	: Data Collection Platform
DPAS	: Data processing and Analysis System
FEMA	: Federal Emergency Management Agency
ISO 9241	: International Organization of Standardization, Ergonomic Requirements for Office Work with Visual Display Terminals.
ISO 10075	: International Organization of Standardization, Ergonomic principles related to mental workload general terms and definitions
JB	: NOAA: Janet Burton
KF	: Kyle Fuller (Watchstander)
MC	: NOAA: Mike Connolly
MS	: NOAA: Mike Szabados
NHC	: National Hurricane Center
NWLON DMS	: National Water Level Observation Network Data Management System
NPDB	: National Ports DataBase
NRC	: National Research Council
NOAA	: National Oceanographic and Atmospheric Administration
OPAWL	: Operational Platform for the Acquisition of Water Levels
PICS	: PORTS Imaging Component System
PORTS	: Physical Oceanographic Real Time Systems
PS	: NOAA: Peter Stone
RB	: NOAA: Richard Bourgerie
RR	: Reginald Ready (Watchstander)
SOP	: Standard Operating Procedures
TB	: NOAA: Tom Bethem

Req. #	Requirement Type	Description	Operationalization	Test	Priority	Source

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APPENDIX B: CORMS II STATEMENT OF WORK

Statement of Work

National Ocean Service
Center for Operational Oceanographic Products and Services
Information Systems Division

CORMS II
Continuous Operational Real-Time Monitoring System

March 1, 2001

This Statement of Work is for the further development of the CORMS I (Continuous Operational Real-Time Monitoring System), an existing computer based real-time quality control system for monitoring oceanographic instrument data.

- Staffing Levels Required: Two (2) senior level software engineers required to be scheduled as follows:

  Contractor 1: March 1 2001 - August 31 2001
  Contractor 2: September 4, 2001 - March 1 2002

- Must be available via GSA Schedule or Program

- Must work on site (NOAA Headquarters Silver Spring, MD.) full time (no telecommuting)

- Special skills needed: Experience in Decision Support Systems; Rule Based Systems; Artificial Intelligence or Knowledge Based Systems.

- The development work will be primarily integrating a COTS software solution.

Executive Summary

The Continuous Operational Real-Time Monitoring System (CORMS) is a manned quality control support system implemented in April, 1998 which provides 24 hour a day, 7 day a week quality control monitoring of water level, current, and other marine environmental information. It is the focal point of operations within the Center for Operational Oceanographic Products and Services (CO-OPS). In addition to data monitoring, CORMS provides real-time monitoring of all main computer-based system components associated with the real-time systems and the processes that run on them. It also provides the watch standing personnel with the ability to communicate when necessary, around the clock, with operational standby technical personnel. The two primary program areas monitored by CORMS are the Physical Oceanographic Real-Time System (PORTS) and the National Water Level Observation Network (NWLON). The primary input to CORMS is from real-time water level, current, and other marine environmental sensors, which are deployed nationwide in many U.S. ports and waterways as a part of PORTS and NWLON. The primary purpose of CORMS is to ensure the availability and accuracy of real-time data provided by the CO-OPS that is used for navigational safety and the protection of life and property.

The current system, referred to as CORMS I, provides quality control of sensors and data for discrete 6-minute samples. The availability, accuracy, and quality of CORMS I data is for the most recent 6-minute sample. The system proposed in this plan, CORMS II, will provide more robust, complete and synthesized information to the watch standing personnel in the form of guidance or directives based upon current and historical data. This synthesizing of data and information and resulting "instructions" for the watch standing personnel will be possible through the use of a rule-based software approach. The benefits will be (1) to monitor more sites/systems while making the watch standing less burdensome; (2) to make better decisions based on information that has already been summarized and mapped against existing rules and directives; and (3) to ensure more consistent actions and/or non-actions are taken by the watch standing personnel.

I. BACKGROUND

The Center for Operational Oceanographic Products and Services (CO-OPS) has the responsibility for the health of their operational computer-based systems that provide real-time data in support of navigational safety to local users. In meeting this responsibility, CO-OPS has implemented the Continuous Operational Real-Time Monitoring System (CORMS) to provide 24 hour a day, 7 day a week monitoring and quality control of its data. CORMS is intended to identify invalid and erroneous data and information before application of the data by real-time and near real-time users.

The CORMS takes input from two National Oceanic and Atmospheric Administration (NOAA) systems, the Physical Oceanographic Real-Time System (PORTS) and the National Water Level Observation Network (NWLON), aggregates the information at NOAA's Silver Spring, Maryland Headquarters, and displays the results to its users, primarily CORMS watch standing personnel.

The current system, referred to as CORMS I, provides quality control of sensors and data for discrete 6-minute samples. The availability, accuracy, and quality of CORMS I data is for the most recent 6-minute sample. The system proposed in this plan, CORMS II, is intended to be a robust operational system that provides real-time monitoring and quality control of relationships between data; incorporates thoughtful ergonomic and human factors design principles; and provides appropriate levels of decision aiding and embedded intelligence to system users. Based upon completed system requirements and pre-design activities, the CORMS II design will employ a rule-based software approach. The benefits of CORMS II will be (1) to monitor more sites/systems without compromising quality; (2) to make better decisions based on information that has already been summarized and mapped against existing rules and directives; and (3) to ensure more consistent actions and/or non-actions are taken by the watch standing personnel.

CO-OPS contracted the Requirements/Analysis Activities and the Pre-Design of CORMS II to the Rensselaer Polytechnic Institute (RPI). The contract was terminated due to budget shortfalls prior to completing a detailed design and the delineating software engineering development steps. This Statement of Work is being written in support of a contract to apply and continue the limited efforts of RPI in planning the Detailed Design and Implementation of CORMS II.

A. General Objectives of Existing CORMS I and the Proposed CORMS II

- To analyze real-time and near real-time data and information (CORMS I)
- To determine data completeness (CORMS I)
- To measure data quality (CORMS I)
- To identify invalid or suspect data to its users (CORMS I)
- To generate statistics for evaluating system performance (CORMS II)
- To provide decision making information to its users (CORMS II)

B. Proposed Benefits of CORMS II

- Coupled with the existing benefits of CORMS I, CORMS II will provide the ability to monitor more sites/systems without compromising quality

- Coupled with the existing benefits of CORMS I, CORMS II will provide the ability to make better decisions based on information that has already been summarized and mapped against existing rules and directives

- Coupled with the existing benefits of CORMS I, CORMS II will ensure more consistent actions and/or non-actions are taken by the watch standing personnel

C. Assumptions and Constraints

- Commercial-Off-the-Shelf (COTS) Software

  It is assumed that based upon documents produced by the Rensselaer Polytechnic Institute (RPI), a COTS product(s) can be selected to satisfy the requirements of CORMS II. If it is found that there is no COTS product(s) which can satisfy the requirements, this will have considerable impact on the project. Without the benefit of a COTS package(s), the development of CORMS II would be cost prohibitive to CO-OPS at this time.

- Resources

  It is assumed that the majority of the tasks associated with CORMS II will be contracted activities. CO-OPS personnel will take a leading and active role in the planning and execution of these tasks. Two contractors will be

hired for the project. One contractor will begin work in March, 2001 and the second in September, 2001.

- Infrastructure

  It is assumed that most of the hardware, communications, and interfaces to external systems now used in CORMS I will be preserved and that very little additional infrastructure will be needed for CORMS II. Silicon Graphics platforms running the IRIX operating system are used now.

D. Related Efforts

- Continual development of the National PORTS Database will be underway in Parallel with CORMS II development.

- Additional PORTS will be installed placing an increasing burden on the existing CORMS I.

II. CONTRACT TASKS TO BE PERFORMED

A. Tasks

Task (a): Search the market place for candidate Commercial-off-the-Shelf (COTS) software and prepare a list of at least 5 possible packages that can be further evaluated for subsequent selection. The initial search criteria will be whether the package generally satisfies the existing functional requirements and whether the cost of the package falls within a pre-determined budget window. Develop evaluation criteria for Task (b).

Task (b): Evaluate the COTS packages that were selected in Task (a) using criteria developed in Task (a) and make a recommendation for a final selection. The selection could include more than one package that would complement each other. Write an interface plan describing how this package will communicate with other data sources and CORMS I components as necessary.

Task (c): Configure a development platform for the rapid prototyping of CORMS II using an installed version of the selected COTS package and necessary tools and utilities.

Task (d): Test and evaluate the selected COTS package from Task (b) running as a stand alone application on the development platform configured in Task (c). The purpose of this evaluation is to test against vendor specifications and ensure satisfaction of requirements as it runs on the target platform. The contractor will write a test plan with acceptance criteria for the CORMS II prototype deliverable, defined in the requirements section of the CORMS II Systems Development Plan.

Task (e): Perform a first level integration. Using the interface plan developed in Task(b), interface the COTS package with the two primary data sources, the National PORTS Database (NPDB) and the National Water Level Observation Network Data Management System (NWLON/DMS). The level of integration will be driven by the COTS package but at this stage, communication with other data input sources needs to be established.

Task (f): Perform a detailed integration that will involve (1) creating an internal database for the COTS package if necessary; (2) populating the database with "rules" and/or "directives"; and (3) combining the first level integration done in Task(e) with the detailed integration. Document all components (hardware and software) associated with CORMS II.

Task (g): Perform extensive test and evaluation of all system components using the test plan written in Task (d).

Task (h): Implement CORMS II Beta I.

Task (I): Revisit the requirements and modify as necessary for the next Beta release. Implement Beta II.

Task (j): Revisit the requirements and modify as necessary for the next Beta release. Implement Beta III.

B. Methodologies / Approaches to Design and Development

- COTS Package Evaluation and Selection

  There will be about twenty working days scheduled for the market survey. This project assumes (1) extensive access to what is available through the Internet and (2) a contractor that has extensive experience in working in the field. Still, this will be a challenge. A concerted effort by the CORMS II team (including the contractor) will be required using all available electronic and hard copy information that could assist in selecting 3 to 5 candidates. Sufficient time needs to be spent by the contractor in developing the evaluation criteria (task (a)) and studying the requirements.

- Test and Acceptance

  All testing will be performed on the target platform using criteria and methods detailed in a written test plan created by the contractor with input from the CORMS II team. The project manager will have the responsibility of approving the test plan and the final acceptance of all CORMS II deliverables.

- Design Methodology /Strategy

  Rationale: Any development strategy is contingent upon several factors. The four main factors that were considered when proposing the CORMS II development strategy were:

  - PROJECT SIZE, DURATION AND COST
    - Measured as Small (-) or Large (+)
  - PROJECT STRUCTURE (PROBABILITY OF REQUIREMENT MODIFICATIONS)
    - Measured as Structured (-) or Unstructured (+)

- USER TASK COMPREHENSION (HOW WELL THE TASK IS UNDERSTOOD)
  - Measured as Complete (-) or Incomplete (+)
- DEVELOPER TASK PROFICIENCY (DEGREE OF EXPERIENCE)
  - Measured as High (-) or Low (+)

When measuring the contingencies, the more negative the measurement, the more the project lends itself to a straight forward "acceptance" or "linear" strategy. This means you know where you are going and you have a clear goal in mind without the need to re-assess as you go. Conversely the more positive the measurement the more the project lends itself to an "iterative" or "experimental" strategy.

The negatives generated by looking at the CORMS II contingencies clearly suggest for most of the developmental work, an iterative or experimental developmental strategy should be used. This means that the development will be more like a series of prototypes with iterations of "requirement sign offs". In this way, the development will stay on track while still providing freedom to prove concepts and demonstrate designed components along the way.

Adopting an iterative development strategy for CORMS II does not, and can not mean abandoning any sound software engineering (SE) practices. It only means using the SE tools in a different way. Using this approach generates a series of "completed" systems rather than just one. The challenge will be to continually keep in mind the long range goals and reduce the amount of disposable system product while building. It should be understood by the contractor that using this type of development strategy, requirements may change before and/or after each "iteration". To the extent possible, the number of changes and the complexity of the changes should be looked at as unforeseen required modifications rather than routine.

CORMS II will require several areas of expertise; encompass, minimally, two large external systems; and require a multi-year effort. The requirement analysis has revealed the high probability of requirement modifications since the organization is entering new territory in automated and decision based

systems. The user comprehension is somewhat incomplete as some of the recent development meetings have proven. In addition, the organization lacks expertise in the integration of sub-systems other than a PORTS (Physical Oceanographic Real Time System).

C. Period of Performance

This statement of work generally covers the time period from March 1, 2001 through March 1 2002. The specific period of performance will be documented on the contract.

D. Government-furnished Property

All necessary computer equipment, software, office supplies, office space, copy facilities etc. will be supplied by the government.

III. REPORTING REQUIREMENTS AND DELIVERABLES

A. Technical Reporting (Interim and Final)

There is a requirement for the following technical reports:

1. Evaluation Criteria for selection of the COTS package (for Task (b)) from 3-5 candidates. (Memo to project manager based on team input)

2. Written recommendation for COTS package final selection. Summary of findings and justification for selection by mapping benefits/features to criteria for selection. (Memo to project manager based on Team input)

3. Interface plan (for first level) describing how the COTS package will initially interface with existing data sources like the NPDB and the NWLON/DMS. (Example format and content will be provided by government)

4. Topology/schematic graphic of development platform and configuration. Visio® document. Visio provided by the government.

5. Summaries of all test results from the initial installation on the target platform and all subsequent integration and full system tests. (Memo to the project manager)

6. CORMS II Beta system maintenance manual. (Example format will be provided by the government).

7. CORMS II System Overview (Example format and content will be provided by government)

8. Detailed data flow of CORMS II and its interfaces with CORMS I. (Example format and content will be provided by government).

B. Management Reports (e.g. Quality, Progress, Cost)

Weekly reports and monthly summaries in WordPerfect to the TR are required. Formats will be provided. Notes from all meetings (formal and informal) attended by the contractor will be provided in WordPefrect to COTR.

IV. Review and Approval

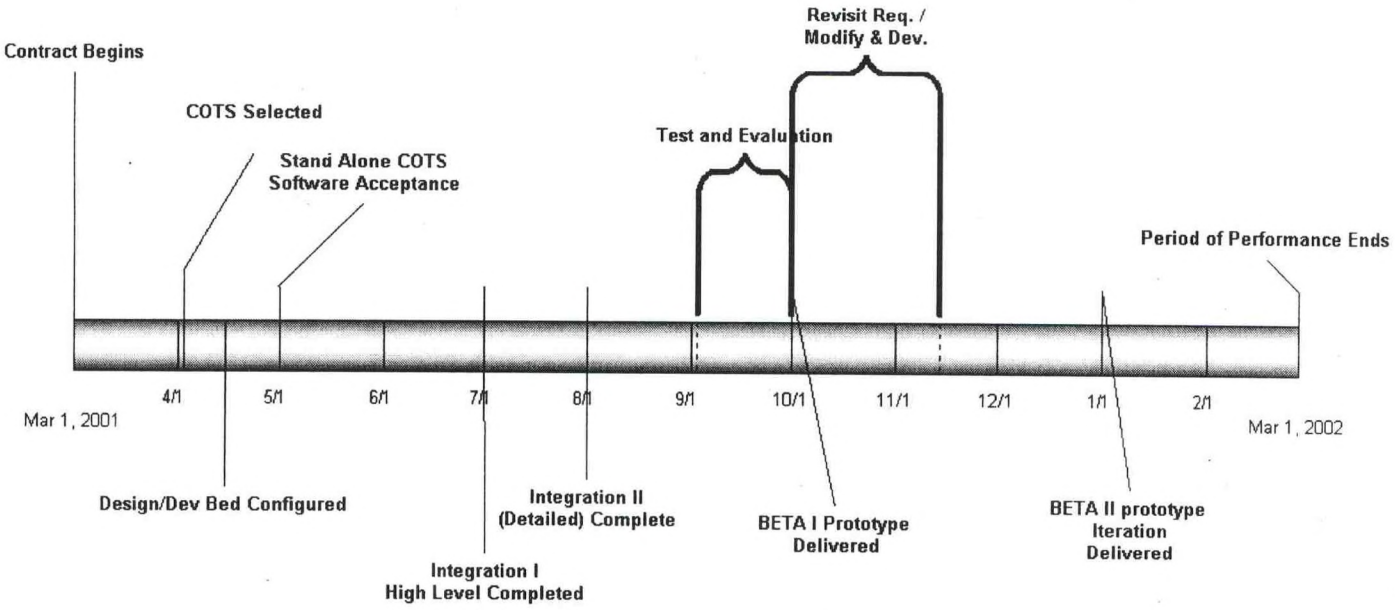
A. Interim and Final Approvals Required

All major project approvals will be made by the project manager unless formally delegated.

B. Method of Evaluation

The success of CORMS II will be determined by mapping the performance of the Beta system to the original user requirements and to the test and acceptance criteria. This mapping will be done in the test plan where all major requirements will have an associated test activity to verify and validate the requirement.

V. General Schedule for CORMS II Project



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