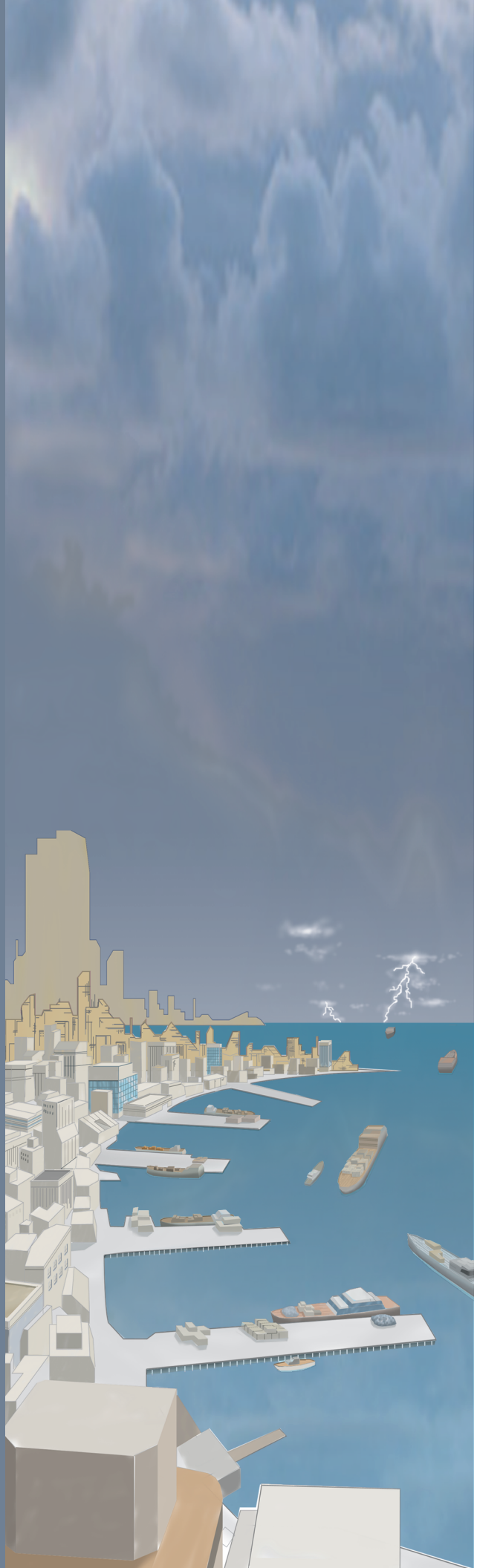


Real Time Tide and Current Data Systems in United States Ports

Implementation Status
Safety and Efficiency Needs
Expansion Plan

A Report to Congress

July 2000

OUR SEAS AND OUR SKIES

OF EXCELLENCE AT NOAA

Real Time Tide and Current Data Systems In United States Ports

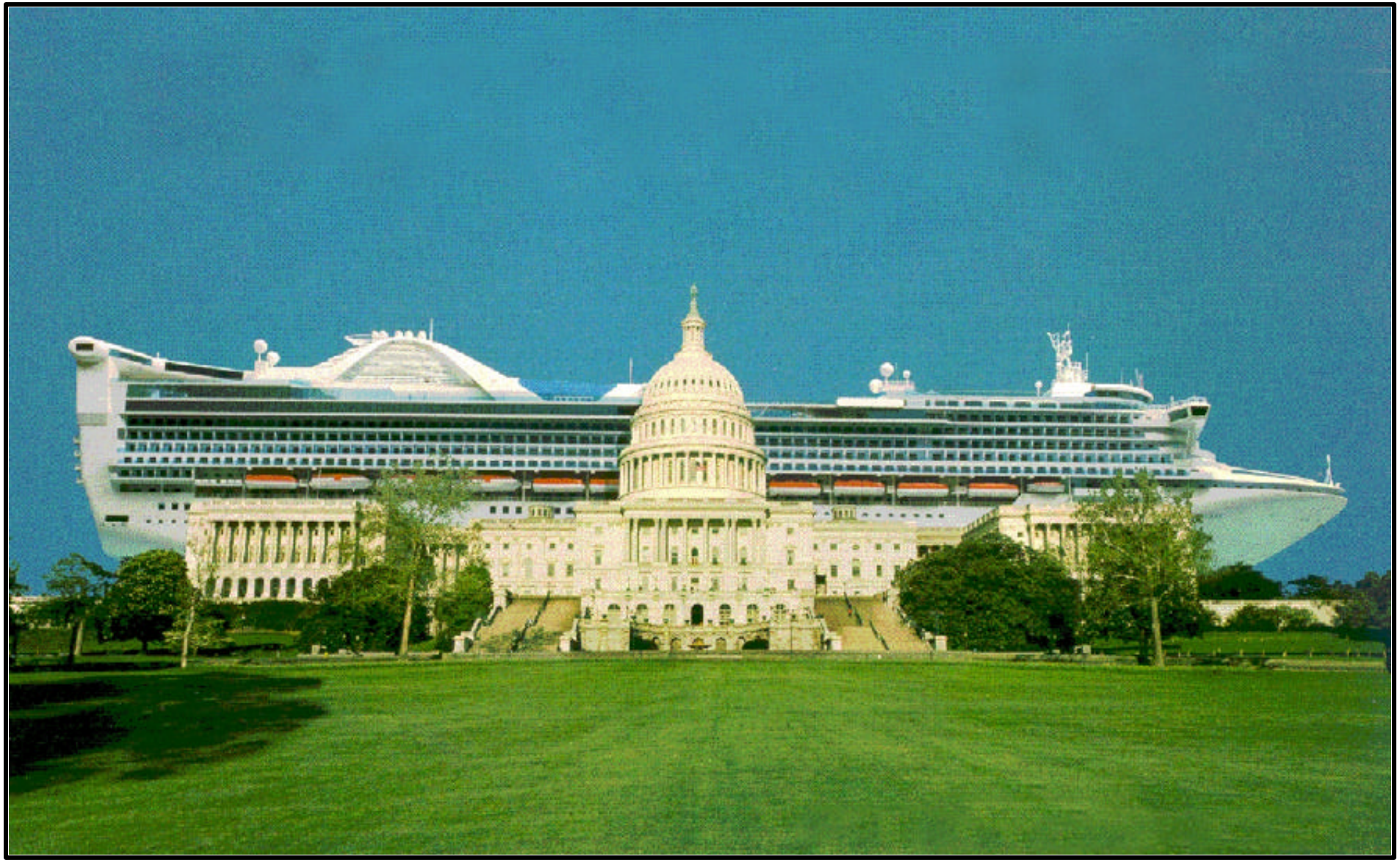
Implementation Status
Safety and Efficiency Needs
Expansion Plan

A Report to Congress

July 2000

OUR SEAS AND OUR SKIES

OF EXCELLENCE AT NOAA



The size of all types of commercial shipping has grown significantly, underscoring the critical importance of accurate real-time environmental information provided by PORTS[1]. U.S. Capitol building and ship are shown at the same scale.

C O N V E Y A N C E

Dear Members of Congress:

This report is jointly submitted in response to the requirements of the Hydrographic Services Improvement Act of 1998 regarding the status of implementation of real-time tide and current data systems in United States ports. It provides a general discussion of the significant existing safety and efficiency needs in United States ports that could be met by increased use of those systems, and a process for expanding those systems to meet those needs, including an estimate of the cost of implementing those systems in locations of priority determined by local port organizations.

In an era of increasing need, the National Oceanic and Atmospheric Administration (NOAA) and the United States Coast Guard (USCG) have set new priorities to provide improved vessel traffic management and navigation support services for the commercial mariner. Both agencies are also taking advantage of off-the-shelf technologies, improved inter-agency working relationships, and partnerships with the private sector in order to meet those needs. Our shared objective is to support vigorous economic activity in our ports and waterways, while simultaneously ensuring those activities are conducted in a manner that is environmentally responsible and protects public safety. In dynamic and physically complex coastal waterways, our national economic efficiency and safety goals require that mariners have access to real-time environmental information needed to make sound navigational decisions.

The Physical Oceanographic Real-Time System (PORTS™) is one of NOAA's vanguard improvements in providing environmental information to the marine community. PORTS provides real-time tide, current, and meteorological information to improve navigational decision-making and maximize a port's safety and economic performance. The USCG and other agencies are developing new vessel traffic management technologies and strategies in which PORTS information can play a critical role.

The current NOAA and USCG approach of working hand in hand with the commercial maritime community ensures the best use of limited Federal funds. We work collectively to create systems and policies to support rapidly expanding uses of our ports and waterways.

Respectfully,

Admiral James M. Loy
Commandant,
United States Coast Guard

D. James Baker
Under Secretary for Oceans and Atmosphere
Department of Commerce

C O N T E N T S

SECTION PAGE

I. INTRODUCTION 1

Document Overview 1
Importance of the Federal Government in Navigation Safety 2

II. DESCRIPTION 5

Objectives 6
Partnerships 8
Data Quality and Liability 10
Research and Development 11

III. IMPLEMENTATION STATUS 13

Operational PORTS and PORTS Lite 13
PORTS Under Development 15
Potential Near-Term Installations 16
PORTS Installation Process 17

IV. SAFETY AND EFFICIENCY NEEDS 19

Existing Uses of PORTS 19
Indications of Future Need for PORTS 22
Future Ports and Waterways Management, and Vessel Traffic Management Information Systems 23

V. EXPANSION PLAN AND COST TO IMPLEMENT FUTURE PORTS 31

Planned PORTS Implementations 31
Out Year Planned PORTS Implementations 31
PORTS Outlook 32

REFERENCES AND ENDNOTES 35

T A B L E S

TABLE PAGE

1. **PORTS Locations** 13

2. **Estimated Costs (Non-Federal Funds) for Planned PORTS Installations** 31

3. **Estimated Costs (Non-Federal Funds) for PORTS That Are Under Discussion** 32

4. **Ports From Which Inquiries Have Been Received** 32

F I G U R E S

FIGURE PAGE

1. **Projected Growth in Commercial Maritime Commerce** 3

2. **PORTS Elements** 5

3. **Exxon Valdez Size Spill Along the East Coast** 8

4. **PORTS Federal and Local Partnership** 9

5. **CORMS Operation** 11

6. **PORTS In Place, Requested, and Inquired** 16

7. **PORTS Information Distribution** 19

8. **Typical PORTS Information Page** 20

9. **AIS Based VTS** 24

10. **Typical AIS Navigation and Traffic Display** 25

11. **PORTS Data Delivered Via AIS in Tampa Bay** 25

12. **Factors Determining Under Keel Clearance** 26

13. **Environmental Factors Influencing Under Keel Clearance** 27

TERMS AND ACRONYMS

AIS	Automatic Identification System
ATON	Aids to Navigation
CRADA	Cooperative Research and Development Agreement. A CRADA is a legal agreement between a Federal laboratory and a nonfederal party to conduct specified research or development efforts that are consistent with the missions of the Federal laboratory (see 15 USC§ 3710a(d)(1)). The Federal Technology Transfer Act of 1986 (Public Law 99-502) authorized Federal laboratories to enter into CRADAs (15 USC§ 3710a(a)(1)). The primary purpose of the act is to encourage the transfer of commercially useful technologies from Federal laboratories to the private sector and to make accessible unique technical capabilities and facilities. CRADAs are structured to offer the nonfederal partner an opportunity to leverage its resources with those of the Federal laboratory by sharing costs of research for the development of products. The nonfederal partner may provide funds, personnel, services, equipment, facilities, intellectual property, or other resources needed to conduct a specific research or development effort. The Federal laboratory may provide similar resources but may not directly provide funds to the nonfederal CRADA partner.
CFS	(NOAA) Coastal Forecast System
CORMS	Continuous Operational Real-time Monitoring System
DGPS	Differential Global Positioning System
DOC	Department of Commerce
DOT	Department of Transportation
DUKC	Dynamic under keel clearance (system). An Australian developed computer-based system that is delivering substantial economic benefits where installed.
ECDIS	Electronic Chart Display and Information System. An ECDIS is an electronic chart navigation device that meets the standards established by the International Maritime Office and the International Electrotechnical Commission. ECDIS uses precise navigation systems and provides a continuously updated position display. ECDIS also provides navigational alarms and facilitates voyage/transit planning using data in the electronic chart and operator entered information.
ECS	Electronic Chart System
EEZ	Exclusive Economic Zone in coastal waters of the U.S.
ENC	Electronic Navigation Charts
Global Alliances	As used in this report, agreements between companies to act as partners in shipping on a regional or global basis.

GIS	Geographic Information System
GPS	Global Positioning System
GTBMAC	Greater Tampa Bay Marine Advisory Council
Intermodalism	The idea of a seamless transportation capability involving a convenient, rapid and efficient connection of different choices of shipping, rail, and trucking, and air transport that allows a company well inland to move goods quickly and efficiently. This includes the ideas and coordination to ensure cooperation among operators of all modes of transport.
IALA	International Association of Lighthouse Authorities, the international coordinating body for ATON service providers.
IHO	International Hydrographic Organization, which has as an executive agent the International Hydrographic Bureau, IHB.
IMO	International Maritime Organization
Just-in time	A service concept predicated on the ability and promise of the shipping company to deliver a product just-in-time for an assembly line that needs the product for a manufacturing process. The company can therefore avoid the costs associated with stockpiling inventory for the assembly line.
LA/LB	Los Angeles/Long Beach Harbor
MLW	Mean Low Water, a hydrographic datum for operations that is defined as the mean of all low waters over a considerable period of time. It is derived independently from a long series of observations.
MLLW	Mean Lower Low Water, a hydrographic datum for operations that is defined as the mean of the lower of the two low waters of each day over a considerable period of time.
MSO	(USCG) Marine Safety Offices
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NWLON	National Water Level Observation Network, a network of 160 plus permanent monitoring stations in U.S. coastal waterways that continuously measure water levels and other environmental parameters.
OR&R	NOAA, NOS Office of Response and Restoration
OSPR	(State of California) Office of Oil Spill Prevention and Response
OSTEP	Ocean Systems Test and Evaluation Program
PAWSS	(USCG) Ports and Waterways Safety System

POISE	Port Operations Information for Safety & Efficiency. POISE is a Web site being evaluated for establishment and continual operation by the U.S. Coast Guard. The URL is www.uscg.mil/safeports.
PORTS	Physical Oceanographic Real-Time System
Sail planning	More commonly referred to as voyage planning, transit planning, and passage planning with transit planning being narrower in scope such as moving from the first sea buoy to the dock. It is the process of planning the track and schedule of a ship from one port to another, taking into account the atmosphere and ocean conditions, loading of the ship and other factors.
T&E	test and evaluation
UKC	under keel clearance
URL	universal resource locator
USACE	United States Army Corps of Engineers
USCG	United States Coast Guard
Vessel Sharing	Where two or more companies share expenses of operating a vessel in return for a dedicated amount of cargo space on that vessel.
VTC	Vessel Traffic Center
VTS	Vessel Traffic Service. A service implemented by a competent authority, designed to improve the safety and efficiency of vessel traffic and to protect the environment. The service has the capability to interact with the traffic and respond to traffic situations developing in the VTS area.

SECTION I

INTRODUCTION

This document has been prepared pursuant to the Hydrographic Services Improvement Act of 1998 ("Act"). The Act requires that the Administrator of NOAA and the Commandant of the Coast Guard report to the Congress on:

1. the status of implementation of real-time tide and current data systems in United States ports;
2. existing safety and efficiency needs in United States ports that could be met by increased use of those systems; and
3. a plan for expanding those systems to meet those needs, including an estimate of the cost of implementing those systems in priority locations.

NOAA's real-time tide and current systems supporting safety, and efficiency of maritime commerce on our Nation's waterways consist of observational data from the Physical Oceanographic Real-Time System)[2] supported by the National Water Level Observation Program (NWLOP). PORTS has been built upon the National Water Level Observation Network (NWLON); a network of permanent monitoring stations. PORTS added improvements to field systems, sensor capabilities, communications, information systems, and operational procedures to ensure that the full value of oceanographic information is provided. This report describes PORTS in a context that includes NWLOP. It updates much of the information recently published in a National Research Council report[3].

PORTS implementation is a partnering effort based on extensive collaboration between NOS and local maritime communities to identify and satisfy user needs in order to improve safety and derive economic benefits. These partnerships have been very successful. PORTS began in 1991 as a demonstration project in Tampa Bay, Florida, and has proven the value of real-time environmental information to the marine navigation community. Subsequently, maritime users began to show interest and pursue funding to implement more PORTS. PORTS comes in a variety of sizes and configurations, each specifically designed to meet local user requirements, and to take into account very real geographic and hydrologic differences between waterways. Operational PORTS are located at Tampa Bay, Florida; San Francisco, California; Houston/Galveston, Texas; New York City/New Jersey (New York Harbor); and Narragansett Bay, Rhode Island. PORTS "Lite" are smaller installations, sometimes single stations, located at Nikiski and Anchorage, Alaska; Seattle and Tacoma, Washington; Soo Locks, Sault Ste. Marie, Michigan; Baltimore, Maryland, the Chesapeake Bay, New Haven, Connecticut, and Fall River, Massachusetts. Other installations are planned as discussed in this document.

The National Ocean Service (NOS) within NOAA is the lead Federal agency coordinating development, implementation, and quality assurance of PORTS. The United States Coast Guard (USCG) maintains close involvement in PORTS due to the importance of accurate real-time data to vessel traffic management and the prevention of maritime accidents. NOS and USCG are the two key Federal agencies responsible for providing real-time navigation information and products to commercial and recreational mariners in U.S. waters.[4]

Document Overview

Section I provides introductory and background information. Section II describes PORTS, its infrastructure and related systems, and benefits to waterway safety and efficiency. Section III details the current status of PORTS implementation in U.S. PORTS. Also in section III is an overview of the process through which an interested location acquires an operational PORTS. Section IV describes in general the most significant safety and efficiency needs at United States ports, provides specific examples, and discusses how increased use of PORTS installations could help satisfy these needs. Also discussed are examples of ways in which PORTS information is used by commercial mariners and the shipping industry to maximize port economic productivity and to improve waterway safety. Section V outlines a PORTS expansion plan with implementation cost estimates.

Importance of the Federal Government in Navigation Safety

Many factors contribute to vessel navigation accidents, such as environmental conditions, vessel characteristics, and an operator's lack of information about the waterway. These factors are of particular concern to Federal agencies charged with responsibility for the Nation's marine transit routes. All of these factors may influence how likely groundings and collisions are to occur[5]. Although there is a growing recognition of the positive role that can be played by industry and various levels of government, the Federal Government has a clearly established and preeminent role. For example, the U.S. Army Corps of Engineers (USACE) is responsible for surveying Federally maintained channels and waterways, and is also charged with channel design and maintenance[6]. USCG is responsible for vessel traffic management, for provision of navigational aids, and for general oversight of navigation safety. NOAA is responsible for the survey of U.S. waters in the EEZ, and also for the publication of nautical charts and environmental condition forecasts[7].

The Federal Government responsibilities also include ensuring the United States uniformly meets recognized international standards for navigation established by the International Hydrographic Organization, International Maritime Organization, and the International Association of Lighthouse Authorities.

The need for real time navigation products is great and rapidly increasing. U.S. water borne trade is the largest in the world and is projected to grow rapidly over the next ten years[8]. World maritime commerce has doubled in the last 50 years as suggested in Figure 1. Although Figure 1 is dated, larger ships are driving a booming maritime economy with trade, both foreign and domestic, currently growing at an annual rate of 6-9%[9]. The amount of cargo, especially petroleum, is growing faster than the number of ships in the world fleet[10]. Therefore, ships are getting larger, drawing more water, and pushing the channel depth limits to derive benefit from the last inch of cargo draft[11].

Also, one out of every six U.S. manufacturing jobs is linked to exports from our ports. U.S. trade in container cargo has also increased dramatically: 10% from 1996 to 1997[12]. Ninety-eight percent by weight of the Nation's international trade moves through U.S. ports and harbors, with the market for crude, petroleum products, and petrochemicals the largest in the world[13]. With this trade volume and the importance of maritime traffic, real-time environmental information to support vessel traffic management and services is essential in ensuring orderly improvements in maritime commerce from both safety and economic perspectives. Stakeholders agree with and support the need for improved information to mariners in our ports[14]. PORTS, by providing real-time environmental information, is an integral resource for current and future management of port traffic and to ensure maximized economic productivity coupled with adequate safety and environmental protection.

Containerization, intermodalism, global alliances, vessel sharing, and just-in-time delivery have shaped the container shipping industry into what it is today. And in doing so, they have set the stage for what I have suggested is the next great maritime transportation productivity gain: that of maximizing the loading—and movement—of ships in and out of American harbors at will. This cannot be realized, or even considered, without real-time knowledge of weather and environmental conditions from the atmosphere to the sea floor. And, knowledge of these conditions must be available in real-time—on board—for immediate position of the ship when the vessel is operating in a harbor, bay or coastal ocean[15]. (R. Woodill)

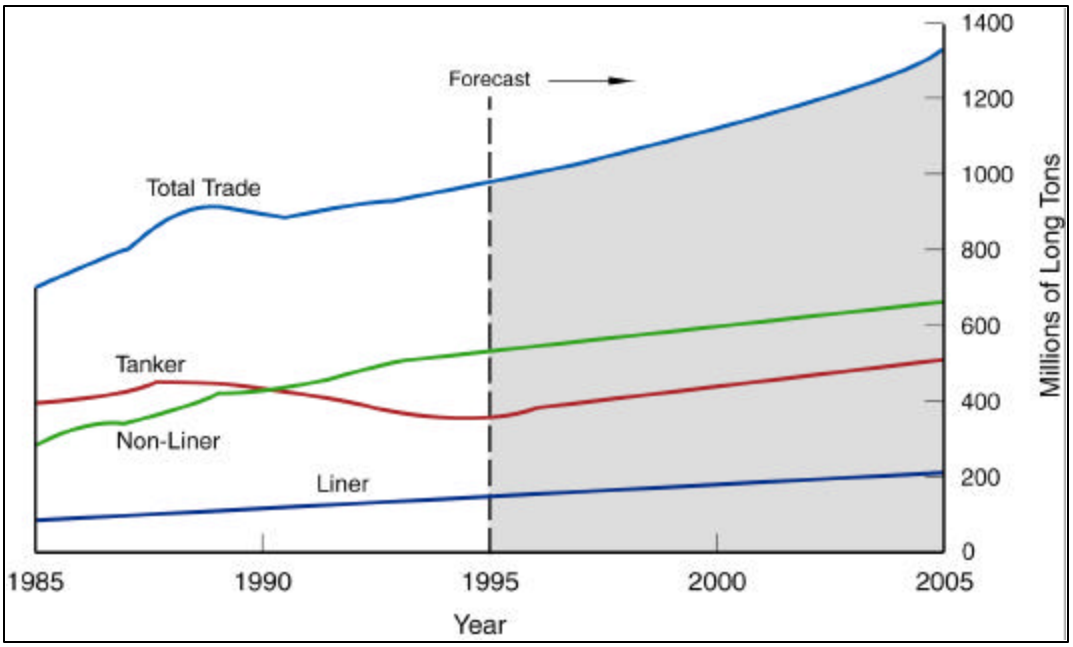


Figure 1. Projected Growth in Commercial Maritime Commerce[16]

Increased marine commerce, setting new records every year, generates increased risks to the coastal environment, making marine navigation safety a serious concern. A major challenge facing the Nation is to improve the economic efficiency and competitiveness of U.S. maritime commerce while also reducing the risks to life, property, and the coastal environment. This situation is complex and has national implications. Our need to remain economically competitive can not be allowed to overshadow the need to protect the coastal marine environment from damage caused by vessel groundings and collisions.

NOAA and USCG are revolutionizing U.S. marine navigation to prepare our coasts and waterways for the future and advance their sustainable use. NOAA, in its strategic plan to promote safe navigation, is taking steps towards sustainable use by working toward the following specific goals:

- Eliminate the hydrographic survey backlog of roughly 43,000 square miles of critical areas in ports and their approaches.
- Provide shoreline mapping for the approximately one third of the U.S. 95,000 miles of coastline that has never been mapped by NOAA and implement a shoreline mapping regimen for resurvey of critical areas on a five-year basis and non-critical areas on a ten-year basis.
- Complete the production of NOAA's electronic chart database. This database will include highly accurate Electronic Navigation Charts (ENC) for the entire U.S. coast, selected ENCs for inland navigable rivers; and the production of extremely detailed large-scale docking charts for the 100 most active commercial ports.
- Provide precise positioning information needed to support ENCs and to determine vessel dynamics in real time to support under keel clearances, and other navigational applications.
- Develop a proof-of-concept system to provide a selected port with the capability for real-time, sub-meter ship positioning for low visibility navigation.
- Implement PORTS in partnership with the local user community.
- Provide high-resolution predictions of all navigationally significant weather and oceanographic conditions through the NOAA Coastal Forecast System effort.

NOAA will also use a precise satellite-derived reference system as the basis for the Nation's nautical data and geographic positioning to facilitate a real-time, three-dimensional navigation picture of ship location as it moves through the waterway. This will be possible when the shipmaster calculates the horizontal location via the Differential Global Positioning System (DGPS) and determines the vertical location by calculating settlement and squat of the ship in the channel using PORTS information and ship data. To complete the three-dimensional picture, NOAA is producing electronic charts and providing PORTS information to support ship masters, pilots and the USCG.

In its vessel traffic management and navigation safety and services role, the USCG operates vessel traffic systems in select locations and provides the United States' Maritime Differential Global Positioning System, in addition to the world's largest Aids to Navigation System. USCG port safety oversight also includes setting under keel clearance guidance at the local level. By 2005, it is highly probable that merchant ships, fishing vessels, and recreational boats will safely use our coastal waters, electronically guided by space-based navigation and advanced information technologies[17]. Such systems will assist commercial shipping in maneuvering vessels with ever-increasing cargo sizes in and out of the Nation's ports and harbors safely and efficiently. PORTS is and will be a significant input to those systems.

Advanced navigation and information technologies also have applications to other NOAA strategic goals. For instance, real-time information about environmental conditions can support NOAA's goal to sustain healthy coasts. Tide, current, and meteorological data assists oil spill and hazardous materials response and provides critical information for use in risk assessment, environmental planning, and conservation efforts. The variety of applications bridges NOAA's two primary missions of Environmental Assessment and Prediction and Environmental Stewardship and highlights the tremendous potential and benefits of emerging navigation and information technology.

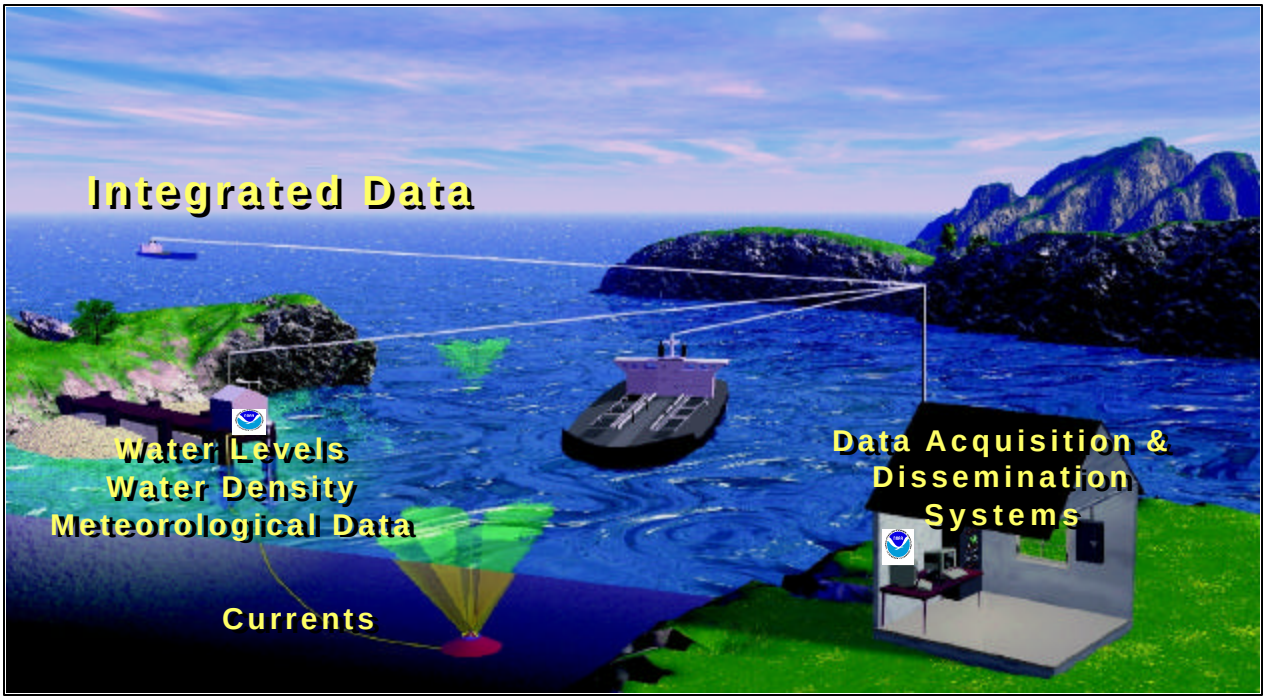
SECTION II

DESCRIPTION

PORTS is a decision support tool, unique at each site, that improves the safety and efficiency of maritime commerce and coastal resource management through the integration of real time environmental observations, forecasts, and other geospatial information. PORTS, begun in 1991 as a demonstration project, has proven the value of real-time information to the marine navigation community. PORTS implementation is a partnership effort in consultation with the local harbor or waterway organizations, with the local community providing installation and operation costs. PORTS comes in a variety of sizes and configurations, each specifically designed to meet local user requirements, and to take into account geographic and hydrologic differences between waterways. It uses off-the-shelf system components to the extent that needs can be satisfied, resorting to custom designs only where necessary. The largest PORTS installation (San Francisco) to date comprises over 26 separate instruments. The smallest (an Alaska station) consists of a single water level gauge and associated meteorological instruments (i.e., winds, barometric pressure, etc.). These smaller PORTS installations are referred to as PORTS "Lite." PORTS information is available from its web page at www.co-ops.nos.noaa.gov/d_ports.html.

Regardless of size, each PORTS installation provides information that allows shippers and port operators to maximize port throughput while maintaining an adequate margin of safety. PORTS measures and disseminates observations and predictions of water levels, currents, salinity, and many meteorological parameters (e.g., winds, atmospheric pressure, visibility) needed by the mariner, either to navigate safely or to take maximum responsible advantage of the available waterway depth. As depicted in Figure 2, PORTS collects an integrated set of environmental information and makes it available in real time to ships entering a waterway or port. PORTS is a critical component of NOAA's comprehensive navigation safety solution.

Figure 2. PORTS Elements



Objectives

NOAA's objectives for PORTS support its two-fold mission of environmental stewardship and environmental assessment and prediction. The objectives are to:

- Modernize and maintain NWLON.
- Institutionalize a national 24-hour per day, seven day per week data quality control system.
- Operate a national test and evaluation center for oceanographic instruments to support PORTS.
- Partner with private industry and the national port and harbor infrastructure to deploy and operate PORTS.
- Develop and place into operation the NOAA Coastal Forecast System to provide timely warnings and forecasts of fog, visibility, dangerous winds and waves, water levels, currents, and thermal structure needed by the commercial shipping industry, the general public, and a host of other coastal users.

The overall NOAA vision for PORTS is to:

- Promote navigation safety.
- Improve the efficiency of U.S. ports and harbors.
- Ensure the protection of coastal marine resources.

Navigation Safety

The real-time tide and current data provided through PORTS represents one component of the Federal integrated program to promote safe navigation. PORTS information, when combined with up to date electronic or digital nautical charts and precise DGPS information, provides the mariner with a clearer picture of the potential dangers that can threaten navigation safety. Efforts to promote safe navigation also depend on PORTS data being made accessible to the local maritime community. Several USCG vessel traffic management initiatives[18] provide the opportunity for PORTS to reach more local users as real-time measurements are included in waterway navigation systems. PORTS information is also available via its web site and via voice modem for mariners in the waterway.

Improved Economic Efficiency

Our Nation's waterfronts, ports, and harbors have historically been centers of rapid industrial and urban growth and are critical areas that support energy exploration, fishery production, commerce, and recreation. In 1991 alone, and considering only direct benefits, the commercial shipping industry supported 1.5 million jobs, provided $52 billion in personal income, and generated approximately $20 billion in Federal, state and local taxes. World trade is predicted to triple by 2020[19] with more and bigger ships operating within U.S. waters. The impact of the increase in world trade of tanker products including crude petroleum is also sobering. The projected increase in tanker trade in just four years from 1998-2002 will be 2-3%, whereas the fleet will only increase by 1-2%.[20] Therefore, shipping companies seeking to improve economic productivity are implementing new navigation systems aboard ships to maximize cargo load while reducing dangerous uncertainties in under keel clearances[21]. These systems require the availability of real-time tide and current data and other environmental information. The potential economic benefits are significant. For example, one foot of draft accounts for between $36,000 and $288,000 of increased revenue per transit for vessels in Tampa Bay[22].

The cargo transport throughput of U.S. ports and harbors depends on many factors, including marine environmental conditions. Wind driven currents can rapidly pile up or decrease water in a channel, changing the available depth. Real-time knowledge of the currents, water levels, winds, waves, visibility, and density of the water can decrease the turnaround time and increase the amount of cargo moved through a port and harbor by safely utilizing all available dredged channel depth.

As another example, consider the following. In the port of Oakland, California, an off-loading ship had 50 containers remaining when it ran out of time to depart based upon the tide level calculated in the historic manner. The pilot called PORTS and learned that the tide was higher due to river runoff and the ship had another hour to off-load the 50 containers. Those containers represented customers who received their "just-in-time" imports, possibly preventing an industry production line shutdown. At a minimum, this saved the costs, which would have been incurred by the transportation industry, of shipping the 50 containers overland from the ships' next port of call[23].

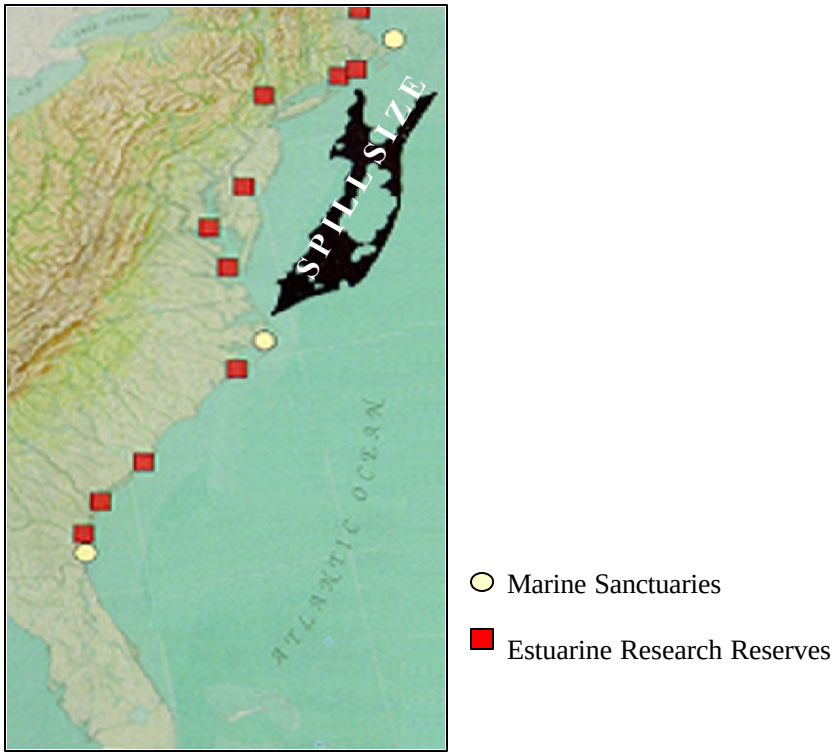
Coastal Resource Protection

Most ports are at the mouth of major estuaries that provide critical habitat for many important biological resources. Coastal waters provide nurseries and spawning grounds for seventy percent of the U.S. commercial and recreational fisheries. Commercial fishing employs over 350,000 people in vessel and shore-related fisheries work[24]. An additional seventeen million people participate in recreational saltwater fishing, spending $7.2 billion annually. Activities in and around these ports can greatly affect these critical resources. PORTS information assists shipmasters in navigating through the habitats and estuaries to arrive at port safely.

Real-time information also benefits community preparedness and response during severe weather events. Timely information about coastal flooding and surf conditions can help coastal communities develop better evacuation and hazard response plans, protect lives and property, and minimize impacts to sensitive habitats. In addition, PORTS also provides information that assists coastal communities with conservation efforts. Real-time physical characteristics such as currents, water levels, salinity, and meteorological variables in and around waterways has been used to document freshwater inflows into sensitive saltwater habitats and minimize environmental impacts from pesticide spraying, one of many sources of non-point source pollution.

Prevention of maritime accidents is a cost-effective measure for protection of coastal ecosystems. In 1996 alone, the NOS Hazardous Materials Response and Assessment Division responded to 69 major spills, including the release of 1.9 million gallons of caustic soda in Florida and a spill of 825,000 gallons of diesel fuel in Rhode Island. A major oil spill such as occurred with the Exxon Valdez can cost billions of dollars and destroy sensitive marine habitats critical to supporting coastal marine ecosystems. If that size spill were to occur along the mid-Atlantic coast, a large portion of the U.S. population and numerous critical environmental areas could be affected (see Figure 3). That was nearly the case in 1993 when the 634 foot tanker POTOMAC TRADER, maneuvering in New York Harbor using predicted tides tables, ran aground in Hells Gate. Had a real-time NOAA PORTS been in place, this near disaster could have been averted. The vessel master would have obtained real-time environmental information showing that a severe storm had caused an abnormally large tidal range and the recorded tide was over 3 feet less than the predicted tide. Fortunately, the vessel was a double-bottom tanker and none of its cargo of over 7,000,000 gallons of crude oil spilled into the harbor[25].

Figure 3. Exxon Valdez Size Spill Along the East Coast



Partnerships

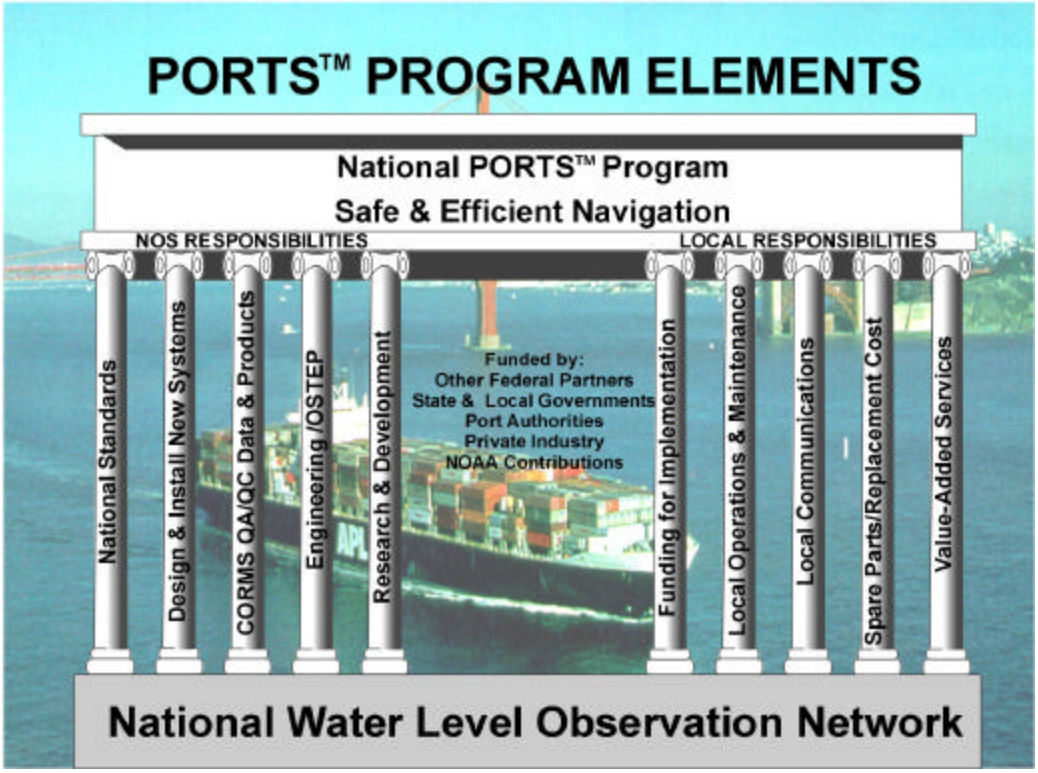
PORTS implementation is a cost sharing, partnering effort based on extensive collaboration between NOS and local maritime communities to identify and satisfy local needs in order to derive local economic and environmental benefits. These partnerships have been very successful. NOAA policy, starting with new installations, is to require that all costs to operate PORTS be provided by the local user community pursuant to and in compliance with congressional direction. This policy enables the Federal government to pay for those aspects that are national in scope (i.e. quality assurance) while allowing the user to pay for the local benefits derived from using PORTS. Absent clearly defined Federal end user needs, the local user community will pay for all future PORTS installation, operations and maintenance costs. At the same time, it is NOAA's intent that the Federal Government, NOAA in particular, will still be involved in the design and quality assurance of PORTS and PORTS information. The requirement for local sponsorship of PORTS operations and maintenance underscores the importance of user commitment to the partnership. The PORTS partnership is founded on the principle that there are both local and national responsibilities, as illustrated in Figure 4.

As an essential member of the PORTS partnership, the local sponsor's responsibilities include

- Design and installation costs, including the purchase of all equipment and contractor support.
- Local operating and maintenance costs, including repair and preventive maintenance for all locally resident instrumentation and computer equipment.
- Telephone lines and communications equipment costs for local distribution of PORTS information. Where possible, these costs could be minimized by "piggy-backing" on existing Federal infrastructure.

- Spare parts and supplies, and the amortized costs to replace each piece of equipment at the end of its expected useful life.
- Other value-added services if desired and as becomes available in the future, such as sail planning, tailored "ship loading" forecasts of water levels, and support for dynamic under keel clearance (DUKC) calculations.

Figure 4. PORTS Federal and Local Partnership



Federal Government responsibilities include

- *Development of PORTS National Standards.* Standardized data formats and baseline accuracy requirements enable the maritime community to utilize PORTS information with confidence and anticipate seamless transitions when transiting between ports. Standardization also enables manufacturers of digital charts, vessel traffic information systems, and other related private sector products to hold down equipment costs by not having to address variable or proprietary data formats.
- *Installation of PORTS*. Utilizing funds provided by the local user community, NOS designs and implements new PORTS. Installations are accomplished using, or in partnership with, private sector contractors as obtained by the local organization responsible for PORTS operation, with or without NOS assistance as desired by the local organization. Whenever possible, Federal installations (e.g. USCG Stations and USACE facilities) will be used, saving local funds. USCG facilities may assist in cost savings by providing data networks, space, electrical power, and communications lines. NOS also develops and maintains agreements with the local organization responsible for PORTS operation. These agreements detail operations and maintenance requirements and the responsibilities of each organization.

- *Quality Assurance*.
  - *Data Quality*. NOS is responsible for the accuracy of information products and services that it provides to ensure safe navigation. Conducting centralized data quality assurance through the Continuous Operational Real-time Monitoring System (CORMS) on a national scale is a necessary and appropriate Federal Government role, and a significant contribution to the PORTS partnership. CORMS ingests real-time information every six minutes from all sensors for each PORTS system, determines data quality, and evaluates each PORTS performance.
  - *Engineering/OSTEP*. NOS will begin an Ocean Systems Test and Evaluation Program (OSTEP) process with FY2001 funding, if appropriated, as the second required component of PORTS quality control and quality assurance. OSTEP staff will validate existing sensors and introduce new sensors to PORTS. OSTEP will develop and apply oceanographic measurement quality assurance processes to ensure that the instruments used in PORTS are providing safe and accurate information.
- *Research and Development.* There is an ongoing requirement for NOS to be involved in the research and development necessary to continuously improve the accuracy, reliability, and applicability of PORTS information. Research is conducted on sensor, communication, and product dissemination technology, as well as forecasting techniques. Research is conducted in partnership with academia and industry.

New PORTS Installation Process: The general partnership process to implement new PORTS typically includes the following activities[26]:

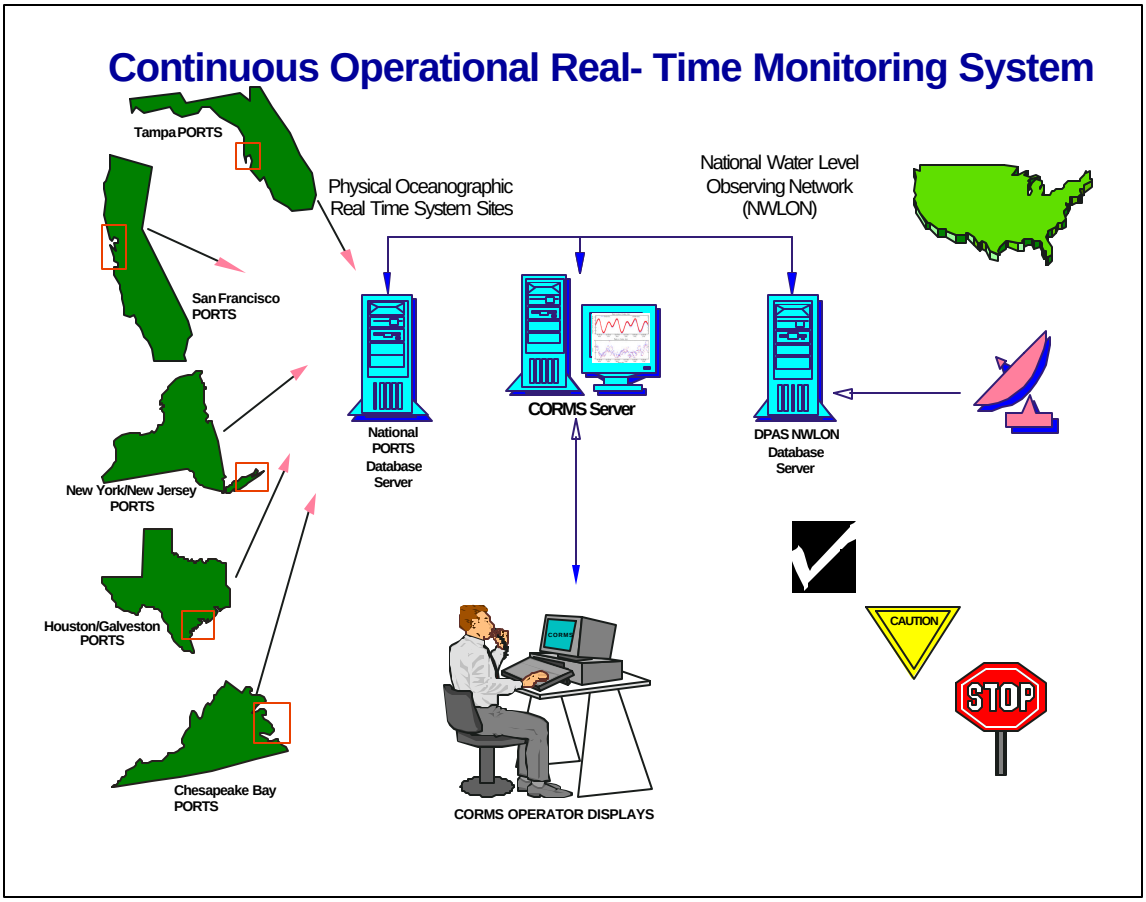
- Letter of request to NOS from a port organization, such as a Harbor Safety Committee.
- Visit by NOS to establish specific requirements.
- NOS, in cooperation with the local user community, validates the requirements and develops a preliminary design.
- Based on the user-approved design, NOS develops a proposed budget for approval by the local port organization. NOS works with the port organizations to develop the business plan for the new PORTS.
- A user agreement is developed and funds are provided to NOS to begin establishing the new PORTS.

Data Quality and Liability

The issue of liability (e.g., if a maritime accident should occur as a result of reliance on erroneous real-time PORTS information) has been a central concern for local sponsors due to the potentially enormous costs of a marine accident. NOS has established a rigorous quality control and quality assurance capability to ensure the accuracy of real-time data. Promoting quality assurance reduces the likelihood of maritime accidents resulting from inaccurate PORTS information.

The first element of this capability is CORMS, a centralized quality control and decision support system. As depicted in Figure 5, CORMS ingests real-time information every six minutes from all sensors for each PORTS system, determines data quality, evaluates each PORTS' performance, identifies and communicates the presence of suspect PORTS information to users that rely on the information to ensure navigation safety, and provides decision making information needed by maintenance crews to affect repairs.

Figure 5. CORMS Operation



NOS must ensure that PORTS data will help to prevent, and not cause, maritime accidents. CORMS is a 24 hour per day seven days a week operation to monitor PORTS information and notify any port or harbor site of difficulties with the data or the system. Implementing CORMS enables the maritime community to receive the most accurate real-time PORTS data possible, thus reducing the potential for maritime accidents. The implementation and operation of CORMS is critical for NOS to continue its involvement with PORTS, and for any PORTS to remain in operation.

OSTEP is the second component of the required PORTS quality control and quality assurance effort. Operated in partnership with the National Data Buoy Center, Old Dominion University, and Lockheed Martin Corporation, it helps to standardize systems across the country, ensure safety, and save money through testing and better integration of PORTS instruments and systems. OSTEP develops and applies oceanographic measurement quality assurance processes to ensure that the instruments used in PORTS are providing safe and accurate information. OSTEP objectives are to integrate and test field measurement systems, evaluate new technology for PORTS, provide development test and evaluation support, conduct lifecycle evaluation of a PORTS, and develop and maintain an effective end to end quality assurance process. New instrument technology will be evaluated at OSTEP before incorporation into PORTS, and system performance problems can be diagnosed at OSTEP, in cooperation with the local PORTS operator. Implementation of OSTEP is critical for NOS to design, integrate, test, and install new PORTS, even though the local port provides all costs for the systems.

Research and Development

NOS seeks to continuously improve the accuracy, reliability, and applicability of PORTS information. NOS has a Cooperative Research and Development Agreement (CRADA) with the Lockheed Martin Corporation to collaborate on the research and development necessary to improve PORTS technology[27]. The scope of the PORTS CRADA is comprehensive in that it addresses all research and development facets of a national PORTS program as defined by four broad objectives.

- Improvement of existing PORTS sensors, communications, and data acquisition subsystems to meet USCG Vessel Traffic Services (VTS) standards and/or validated vessel traffic management needs.
- Improvement of all quality assurance processes
- Improvement of interfaces between PORTS and marine traffic management systems
- Development of an expandable PORTS

NOS benefits from the CRADA because it has limited resources to fully conduct the research and development required to improve PORTS. In this partnership, NOS contributes the prototype PORTS technology, and the authority to set national standards for such information. Lockheed Martin contributes extensive expertise in developing large-scale maritime traffic management systems, as well as the necessary resources required to conduct such an effort. The existing and older PORTS prototype hardware and software may not be easily integrated with other emerging marine transportation management technologies[28]. The research conducted under this CRADA will lead to the development of a commercially available PORTS product for purchase by interested port and harbor organizations. A commercial PORTS product may provide the mariner with seamless independent access to an integrated suite of navigation safety information.

SECTION III

IMPLEMENTATION STATUS

This section addresses the implementation status of PORTS as the operational real-time tide and current information reporting system for our Nation's ports. At present, NOS assists in operating five existing PORTS and a number of PORTS Lite systems, as displayed in Table 1. For each full PORTS, a centralized "hub" computer system located at NOAA in Silver Spring, Maryland acts as the server that provides information over the Internet. Since PORTS Lite systems are single stand-alone stations, their information is obtained directly via cell telephone and modem.

In addition to the operational PORTS, NOS is working with local user communities throughout the U.S. to identify priority port areas with safety and efficiency requirements that need the installation and operation of PORTS technology. An NOS prerequisite for new PORTS development is an early agreement by local sponsors to provide non-NOAA (either local or from other sources) funding for PORTS costs, with a date set for a funding agreement to be accomplished. The local community is then extensively engaged in the determination of requirements and other phases of the development process.

PORTS Lite. In some estuaries and smaller waterways, full-scale PORTS technology may not be needed to satisfy the user requirements for real-time information. In these cases, NOS recommends the installation of a PORTS Lite. PORTS generally contains several current meters, one or more meteorological stations, and water level gauges at several locations, whereas a PORTS Lite installation can be as simple as a stand alone single point station with wind speed and direction, and a water level sensor. NOS is currently operating PORTS Lite and PORTS as indicated in Table 1.

Table 1. PORTS Locations

Operational PORTS	Operational PORTS Lite	PORTS Under Development[29]
Tampa Bay, Florida	Nikiski, Alaska	Jacksonville, Florida
San Francisco, California	Anchorage, Alaska	Los Angeles/Long Beach, California
Houston/Galveston, Texas	Seattle, Washington	Philadelphia, Penn./Delaware Bay
New York/New Jersey	Tacoma, Washington	
Narragansett Bay	Baltimore, Maryland	
	Chesapeake Bay	
	Soo Locks, Sault Ste Marie, MI	
	New Haven, Connecticut	
	Fall River, Massachusetts	

Operational PORTS and PORTS Lite

Site-by-site status of operational PORTS and PORTS Lite are described in the following paragraphs.

Tampa Bay. The prototype PORTS was installed in Tampa Bay in 1991. A 1980 collision with the Sunshine Skyway Bridge in which 35 lives were lost prompted the installation of this system. Because Tampa Bay is a regionally significant oil port with significant phosphate transport traffic, PORTS has been essential to safety. The port has no federal Vessel Traffic Service (VTS), but there is a state chartered and port sponsored Vessel Traffic Advisory Service (VTAS) which includes an Automatic Identification System (AIS) for ships. The Greater Tampa Bay Marine Advisory Council (GTBMAC) was formed by the local community to assume financial responsibility for the operations and maintenance of the Tampa Bay PORTS. GTBMAC currently uses the University of South Florida as the local operator. An agreement between GTBMAC and NOS is in effect for the continued operation and maintenance of the PORTS. The GTBMAC provides the funding and local management for the system. NOS continues to oversee the PORTS and provide real-time quality control of all PORTS information through CORMS. In the Tampa Bay system as well as in others, all measurement

systems are programmed to provide information at six-minute intervals starting on the hour, and telemeter information to the data acquisition system via line-of-sight radio.

San Francisco Bay. In 1995, NOS installed a demonstration PORTS in San Francisco Bay, initially to address freshwater monitoring needs in the upper Bay. It has since expanded into the lower bay to support safety of shipping. In January 1998, an agreement was signed between the State of California, Department of Fish and Game, Office of Oil Spill Prevention and Response (OSPR) and NOS for the operation and maintenance of the PORTS. Under this agreement, OSPR agreed to fund and manage the system and has selected the Marine Exchange of the San Francisco Bay as the local operator. NOS will continue to oversee the PORTS and provide real-time quality control of all PORTS data through CORMS. The San Francisco Bay PORTS is "an idea whose time has come—much better than relying on tide charts, which don't go far enough."[30] According to the San Francisco Marine Exchange, they "have received calls from almost every maritime area in the country asking how our system is working."[31]

Houston/Galveston. The Houston/Galveston PORTS was installed in 1996, and has been operated by NOS, with assistance from Texas A&M University at Galveston. In June of 1999, the Port of Houston Authority agreed to take the lead in assuming local responsibility for the operation and maintenance of the PORTS. An agreement is currently in development between NOS and the Port of Houston Authority to transfer responsibility for operations and maintenance to the local community. The PORTS centralized computer system is housed in the USCG VTS center at Houston at no cost to the local user. NOS continues to oversee the PORTS and provide real-time quality control of all PORTS data through CORMS. One of the major ways in which PORTS assists navigators in Houston is by providing information about currents for a critical 260-degree turn in the channel approaches of Bolivar Roads.

"After the October 1995 Bolivar Roads current meter installation, VTS began communicating current velocities when they reached critical levels, as determined by a local tugboat operating company representative. During February and March of 1996, only two groundings occurred at the Bolivar entrance. This is a 54.6% decrease in groundings when compared to the historical annual average of 4.4 during these two months".[32] (S. Ford and R. Bald)

New York/New Jersey. In 1996, NOS installed a demonstration PORTS in New York Harbor. Swift currents and a granite bottom in many of the navigable areas impede safe operations. NOS has established a well-defined partnership with the Port of New York/New Jersey. In October of 1998, NOS signed an agreement with the Maritime Association of the Port of New York & New Jersey through which the users will assume the full cost for operation and maintenance of the New York/New Jersey PORTS. Plans are being considered for PORTS information to be integrated into the VTS and to be distributed via the AIS transponder at a future date. PORTS information would also be used in a proposed DUKC system, as described in section IV. Tanker owners and others agree with the need for a VTS in New York[33]. NOS continues to oversee the PORTS and provide real-time quality control of all PORTS information through CORMS.

Narragansett Bay. The State of Rhode Island Department of Environmental Management signed an agreement for NOS to design, develop and implement a PORTS for the Narragansett Bay in 2000. The State of Rhode Island fully funded this effort using restoration funds resulting from a major oil barge spill. This installation represents the first fully user supported PORTS, in which the local maritime community defined its needs for decision support information and provided all the necessary funding for installation, operation and maintenance. A diverse group of users provided design input and, as a result, the system supports environmental monitoring in addition to safe and efficient navigation. This PORTS installation includes tide measurements, current measurements, meteorological information, and water density stations. These observations are made available in real time via a voice response system and remote text and graphic screens.

Chesapeake Bay. The Chesapeake Bay PORTS Lite was established in 1998 by utilizing existing NOS water level stations and meteorological sensors. Because this installation has been designated as the NOS PORTS development test site to support NOS needs for design testing and evaluations and for quality assurance tests, NOS will supplement the operation and maintenance of this system. Funding provided by the Maryland Port Administration will be used to install a radio communication system to link the entire Chesapeake Bay. NOS is working with the Virginia and Maryland pilots, the U.S. Navy, and USCG to determine the requirements for enhancement of the system and to secure local funding for this work. NOS has also developed a water level forecast system for the Bay which has been running in experimental mode for several years. NOS encourages the development of other value added applications to be used by PORTS, as demonstrated by improvements in development of this vessel traffic systems by the Northrop Grumman Corporation in cooperation with the U.S. Navy in Norfolk, Virginia. The Navy and Northrop Grumman have co-developed a Mid-Atlantic Regional Ports and Operations System to handle the ship traffic and berthing in Norfolk harbor. The Chesapeake Bay PORTS is a key input to the system providing valuable current and water level data. NOS has received a request to upgrade the Baltimore, Maryland PORTS Lite and eventually include it in the Chesapeake Bay system.

Nikiski and Anchorage, Alaska; Seattle and Tacoma, Washington; Soo Locks, Sault Ste. Marie, Michigan; Baltimore, Maryland; and New Haven, Connecticut. These PORTS Lite installations provide single station measurements of water levels and environmental information in areas with highly variable meteorological and oceanographic conditions. As with any PORTS Lite, the shipmaster or pilot can access the information via a cell telephone call to a voice response system connected to the gauges to obtain real-time measurements.

PORTS Under Development

The following PORTS and PORTS Lite are under development and scheduled to be fully installed contingent upon Congress appropriating the funding levels contained in the FY2001 President's request.

Delaware River and Bay, Including Philadelphia. The Maritime Exchange for the Delaware River and Bay has assumed the local lead for PORTS development in Delaware Bay. This waterway is a busy port for foreign trade, and is in the top five ports in the country for tonnage including petrochemical products. In concert with the local pilots association and USCG, the Maritime Exchange brought together the interested navigational community members and initiated the dialog with NOS. Through site visits and user feedback, NOS developed a proposal for a full-scale PORTS installation that will include tide measurements, current measurements, meteorological information, and water density stations. These observations will be made available in real time via a voice response system, text screens and a graphical interface. This proposal is under consideration by the local maritime community, which is now working to identify local funding for installation, operation, and maintenance of the system.

Los Angeles/Long Beach Harbor (LA/LB). The success of the San Francisco PORTS prompted the California OSPR to pursue a PORTS installation for Los Angeles/Long Beach Harbor. Although the tidal current is weak, the current can exceed one knot in the outer harbor at San Pedro under strong wind conditions. It has also been reported that ocean waves surging into the harbor are responsible for major ship movements and damage. The LA/LB Marine Exchange and USCG have worked with NOS to communicate the needs of the local maritime community. NOS has prepared a draft proposal which is now under consideration by the local maritime community.

Jacksonville, FL. A coalition of leaders of the Jacksonville maritime sector, including the Jacksonville Waterway Management Council, the Jacksonville Port Authority, the US Coast Guard, and the St. Johns Bar Pilot Association, has been working with NOS since early in 1999 to bring PORTS™ to this rapidly expanding port community. Recent surges in commercial marine traffic (primarily containers and cars), combined with significant munitions transport, produce the requirement for access to real-time environmental information. Planning proceeded during 1999 culminating with NOS production of a design document which

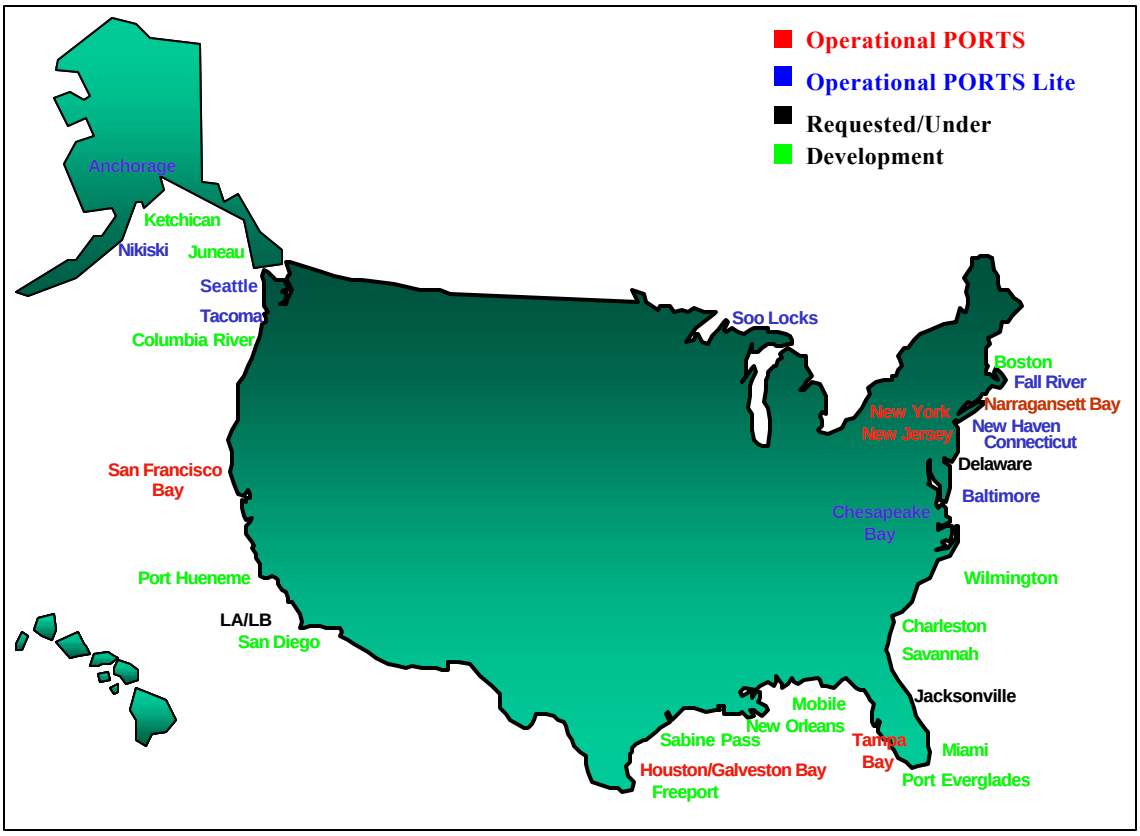
details a full scale PORTS™ including multiple tide, current, meteorological, and water density measurement stations. The local community is now working to identify funding for the installation, operation, and maintenance of this system.

Potential Near-Term Installations

The benefits of PORTS and PORTS Lite have generated interest in additional PORTS. New installations or upgrades to existing smaller installations are under discussion for: Port Hueneme, California; Wilmington, North Carolina; Jacksonville, Florida; Charleston, South Carolina; and New Orleans, Louisiana. Inquiries have been received about installations for Miami and Port Everglades, Florida; Sabine Pass, Louisiana; Freeport, Texas, the Columbia River in Washington State; Savannah, Georgia; San Diego, California; Juneau and Ketchican, Alaska; Boston, Massachusetts; and Mobile, Alabama. In a separate effort, the State of Connecticut wants to install full PORTS at locations throughout the state waterways as floodplain management tools.

Figure 6 depicts operational and potential near-term PORTS. In Figure 6, "Operational PORTS" and "Operational PORTS Lite" are those completely installed; "Requested/Under Development" PORTS involves official written requests from port organizations asking NOS to develop PORTS in their area; and "Inquiries" indicates that no official action has been taken, but NOS is discussing the requirements of a potential system with port organizations.

Figure 6. PORTS In Place, Requested, and Inquired



PORTS Installation Process

Specific steps are executed in developing a new PORTS installation, or when a major modification is proposed to any existing PORTS installation. These steps illustrate the extensive involvement of the local community in the PORTS development process and the sense of ownership that it engenders.

Requirement Analysis and Validation. An organization such as the Harbor Safety Committee of a port requests a PORTS installation from NOS. NOS works closely with the local community to assess the requirements for a PORTS. NOS documents these requirements and the local community's representatives approve and validate the NOS assessment of these requirements before any work proceeds.

Conceptual Design and Validation. NOS, working with a contractor, develops a conceptual design for the PORTS installation. This design includes the number and general type of sensors and their locations but not the final locations of equipment and their configuration. Preliminary cost estimates for installation and local operations and maintenance are developed into a budget by NOS and presented to the local community for approval before any additional work proceeds.

Detailed Design and Validation. NOS prepares a final architectural design known as the System Development Plan, SDP, for the local operator's review and approval, including final cost estimates for installation, ongoing maintenance, and local operations–essentially the cost side of a business plan. Also included is a trial period which details how NOS and the local users will know if the PORTS has been installed properly and if it is meeting the documented system requirements. At this point, the local users and sponsors of the PORTS sign an agreement that commits the local operator to support operations and maintenance costs for the PORTS, should the PORTS perform as described by the SDP. The local sponsor provides funds to support all implementation costs and the first year's operations and maintenance costs. The local commitment to the funding and the selected revenue generating mechanism completes the business plan for a PORTS installation. Federal funds are used by NOS to assist only in these design phases. If local funds are not available, the installation is delayed until funding is obtained.

Development and Installation. NOS or a contractor develops and installs the system with funds provided by the local sponsor. The length of time required for an installation depends upon the size and complexity of the PORTS.

Trial Period. NOS, in cooperation with the local users, operates the new PORTS in a demonstration mode to test and evaluate its performance. This trial period (typically one to three months) demonstrates that the new PORTS meets the documented user requirements and is performing as specified in the SDP. If PORTS does not meet the requirements, the PORTS Development Team reconvenes to resolve any issues.

Transition to Local Operation. At this point the local community accepts responsibility for local operation and maintenance after thorough indoctrination by NOS.

SECTION IV

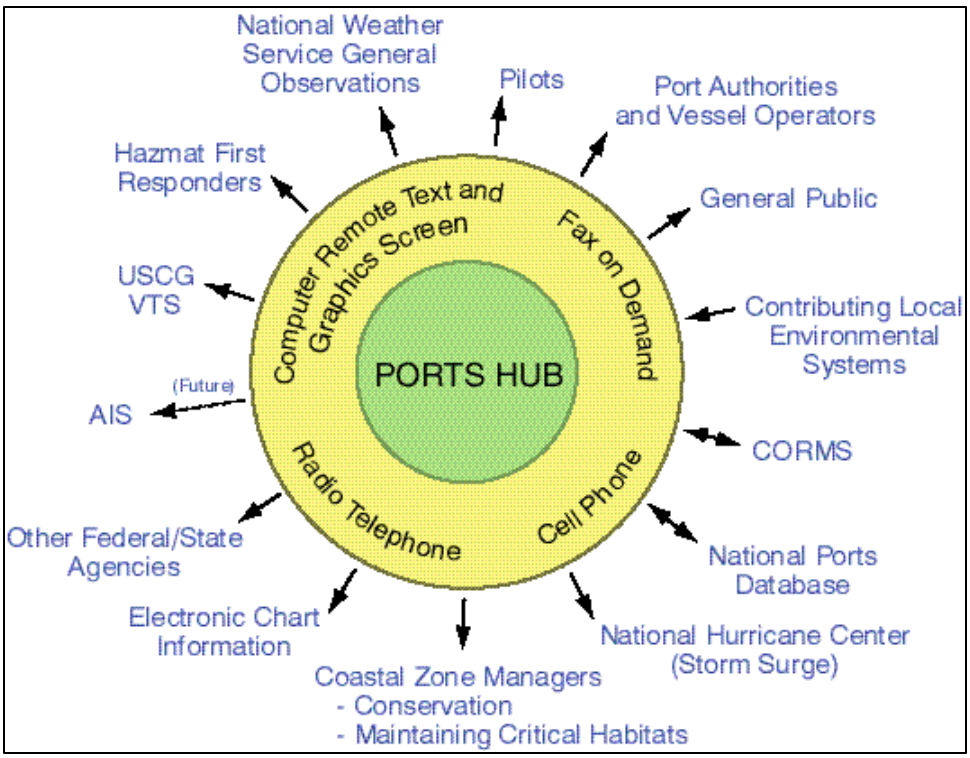
SAFETY AND EFFICIENCY NEEDS

Existing Uses of PORTS

United States' ports and waterways are becoming increasingly crowded with growing numbers of ever-larger commercial vessels and more numerous recreational vessels. This trend is not expected to change. Waterborne commerce is expected to increase significantly in years to come and the number of people living in the coastal zone is projected to increase to 75% of the U.S. population by 2010[34]. Typical costs for a PORTS are greatly dependent on the complexity of the port, the extent of the waterway, and the types of sensors required to collect the necessary information. This ensures that sensors are placed at critical locations and choke points where they will provide the most benefit. It is for this reason that close relationships must be established with the local user community in the design and installation. Plans and implementing costs for PORTS and PORTS Lite are discussed in Section V. This section describes the significant importance given to PORTS information by the USCG, shipmasters, maritime organizations, and the population as a whole. PORTS satisfies the safety and efficiency needs of the coastal population by providing environmental information to the activities shown in Figure 7 and described in the paragraphs that follow in addition to the examples of PORTS usage discussed in section II.

Figure 7. PORTS Information Distribution

Pilots, Vessel Operators, and Port Authorities. Safety and efficiency improvements can be achieved if pilots and



shipmasters have the correct environmental information to avoid collisions and groundings, to increase the amount of traffic and tonnage in waterways and harbors, and to develop loading plans at busy docks. It may also be possible to marginally reduce dredging costs for channel maintenance and channel deepening by using improved hydrologic information and DUKC systems to reduce the required pre-dredging safety margins. For example, the USCG has issued Under Keel Clearance (UKC) policies for the ports of Anchorage and Nikiski, Alaska that require vessel operators to calculate their UKC by utilizing each harbor's PORTS Lite

at Anchorage and Nikiski. Whether the PORTS information is passed to mariners by the USCG by VHF voice radio or telephone, or obtained directly from a NOAA Internet Web site, it is being used for at sea decision making by mariners.

USCG. Where available, Coast Guard Vessel Traffic Services and Marine Safety Offices (MSOs) utilize PORTS and PORTS Lite installations on a daily basis to provide services to mariners. Port safety or VTS personnel access the PORTS information from an Internet Web site, or a direct readout if the PORTS is co-located. PORTS information, like that shown in Figure 8 (from San Francisco), can be used by the USCG for activities such as planning and managing an oil spill response.

PORTS information significantly improves safety margins as demonstrated by an incident in the Carquinez Straits and Sacramento waterway towards Benicia and the Exxon refinery. In order for a tanker to land safely it must approach the piers in flood tide for the current to be in the correct direction. In this case, a tanker in the waterway correctly used the tide tables to time his arrival, but found that the tidal current had not yet shifted due to the increased river flow from rain. The ship was able to call PORTS, access the current meter information, and watch to see when the current values shifted to the opposite direction, allowing the ship to approach the pier safely[35]. (T. Richards)

Figure 8. Typical PORTS Information Page

```
              San Francisco Bay PORTS, NOAA/National Ocean Service
                        at 12:23 pm PST  February 18, 1999
------------ TIDES ------------------ CURRENTS -- (F)lood, (S)lack, (E)bb -----
Golden Gate      6.0 ft.,Rising : Golden Gate (predicted)  2.5 kts.(F), 047°T
Alameda          6.4 ft.,Rising : Oakland                  1.3 kts.(F), 185°T
Richmond         6.4 ft.,Rising : Richmond                 1.4 kts.(F), 325°T
Port Chicago     3.7 ft.,Rising : Benicia Bridge           ********************
Redwood City     7.5 ft.,Rising :
-------------------------------------------------------------------------------
               Spec.Grav. Salinity Water Tmp:                Spec.Grav. Salinity
Benicia Bridge   1.001      .1 psu    49°F  : Golden Gate     1.022    27.8 psu
Grizzly Bay      1.001      .1 psu    49°F  : Alameda         1.016    20.3 psu
Honker Bay       1.001      .1 psu    49°F  : Richmond        1.014    17.8 psu
-------------------------------------------------------------------------------
--- METEOROLOGICAL ---  Wind Speed/Dir           Air Press  Air Temp Water Temp
Golden Gate     13 knots from S  , gusts to  19   1017 mb     55°F      51°F
Alameda         14 knots from S  , gusts to  17   1017 mb     53°F      52°F
Richmond        10 knots from SSW, gusts to  22   1017 mb     54°F      51°F
Port Chicago    10 knots from S  , gusts to  20   1016 mb     55°F      49°F
Redwood City    10 knots from SSW, gusts to  15   1018 mb     58°F      52°F
Oakland         14 knots from SSW, gusts to  14
-------------------------------------------------------------------------------
 **** - Data not displayed as a result of quality control monitoring. For more
 information, go to http://www.co-ops.nos.noaa.gov/corms_status.html
```

The subjective nature of safety and efficiency data, as well as the lack of systematic mechanisms to collect such data, make it difficult to quantify. Since the first PORTS was installed at Tampa in 1991, there has not been enough statistical data collected to definitively quantify improvements in efficiency attributable to PORTS. However, the data does show that groundings in Tampa have declined dramatically (from 32 in the four years before the Tampa Bay installation to 14 for the four years after the installation)[36].

Hazardous Materials Response Teams. The PORTS program activities lie along a continuum that bridges NOAA's maritime safety and coastal resource management mandates. For example, in San Francisco the state Oil Spill Prevention and Response agency has agreed to fund the local operation of PORTS as both a prevention and a response tool. The agency is developing a strategic plan that builds on PORTS capabilities to deliver a range of waterways management, oil spill prevention and response, and other tools. The Bay area's local community has fully endorsed PORTS as a necessary system that will provide navigation information, oil spill prevention and response services, and environmental information.

An example of how PORTS information supports hazardous materials response is the Cape Mohican spill. On October 30, 1996, the M/V CAPE MOHICAN discharged an estimated 81,000 gallons of oil while at dry dock. Most of the oil was retained within the dry dock, however, an estimated 8,000 gallons was released into the waters of San Francisco Bay. Over the next few days, oil migrated throughout the central bay, eventually reaching the ocean shore outside of the Golden Gate. For oil and chemical spills in the marine environment, OR&R provides scientific and technical support to the USCG and other responders. One of OR&R's primary functions during a spill response is to model oil trajectories and make predictions regarding material movement over various time intervals. These models and predictions are used to support a variety of strategic spill decisions. The accuracy of these predictions is directly tied to the availability of reliable input parameters, including meteorological, tide, and current information. During the spill, the availability of real-time PORTS data improved the accuracy of oil spill trajectory predictions. This improvement in trajectory predictions was especially evident with respect to the real-time wind inputs. During the spill, OR&R worked closely with the National Weather Service to monitor wind conditions and predictions; however, wind fields inside the Bay are complex and difficult to predict. The PORTS meteorological network inside the Bay allowed OR&R personnel to detect discrepancies between forecasted and actual winds and to adjust the trajectory predictions accordingly. In one instance, trajectory model outputs using predicted winds indicated that oil would move in a substantially different direction from model outputs using actual PORTS winds. The more accurate trajectory predictions from PORTS allowed responders to redirect protection and cleanup efforts more effectively.

Coastal Zone Managers. The real-time measurements of physical characteristics in and around waterways and habitats are used to document freshwater inflows and circulation patterns. The information supports the monitoring and assessment of changes to coastal water quality, the transport of contaminants and other coastal dynamics and therefore assists NOAA's efforts to sustain healthy coasts. For example, PORTS water levels and salinity measurements are used to determine adjacent marsh elevations and to monitor the effects of marsh contaminants on salinity. PORTS information is used in San Francisco Bay and other estuaries to adjust the timing and schedule of commercial side scan sonar surveys. Adjustments are necessary when currents push the towed sonar body from its track. Side scan operations are now planned to run parallel with the current in high current velocities and perpendicular to the current in slack water. PORTS is also used as "ground truth" to validate the bay circulation model determining the effects of commercial development on water circulation patterns. Other GIS uses include using PORTS for "ground truth" of remote sensing information such as coastal change analysis and landscape characterization.

The Houston/Galveston PORTS has been used by mosquito control personnel as a tool to determine the optimum time to apply pesticide. PORTS water levels can be used to determine when the breeding grounds are flooded. This application of PORTS technology has been credited with reducing the total amount of pesticide introduced into the environment to control mosquito populations.

Future installations of PORTS in other waterways may expand the application of PORTS to other environmental initiatives. NOS is investigating the implementation of nowcast and forecast models to enhance the navigational information supplied by PORTS real-time observations. The models would predict the oceanographic conditions at many locations within an estuary. Models need observations, and the NWLON and PORTS could provide the backbone of a proposed Coastal Global Ocean Observing System, CGOOS.

Electronic Chart Information Producers and Users. As the PORTS program matures, the CRADA with Lockheed Martin Corporation will assist in bringing oceanographic and meteorological information into shipboard electronic chart systems, using ECDIS standards, significantly enhancing the safety of navigation.

National Weather Service. Real-time tide and current information from PORTS provides critical knowledge enabling coastal flooding and storm surge predictions to be greatly enhanced. A good example of the importance of real-time tides occurred during February 1998 when strong "Northeasters" pounded the Mid-Atlantic Coast. Coastal flooding forecasts in the Virginia Beach area were much more accurate because of the real-time tide observations provided to the National Weather Service from the Chesapeake Bay PORTS Lite. This kind of improved accuracy assists emergency response managers to better identify evacuation areas in the event of major storms or floods. PORTS information also helps NWS forecasters nationwide to more accurately prepare local coastal warnings.

National Hurricane Center. PORTS/NWLON operations include special reporting for hurricane season. With the approach of hurricane season, NOS turns on a "hazards section" in the PORTS web site where water level data are collected from non-PORTS NWLON stations. Non-PORTS NWLON stations are equipped to provide data every 18 minutes as sensors detect a storm surge approaching a waterway or harbor. Normal PORTS NWLON stations still collect data every 6 minutes. With the use of additional NWLON data from more collection points, mariners can piece together a better picture of the effects of an approaching hurricane.

Other Federal and State Agencies. Other public agencies utilize PORTS-type data for a variety of important purposes. City and harbor organizations use PORTS to develop flood control procedures. For example, some of New York's subway ventilation shafts are below the historical maximum tide mark and in the event of a flood must be closed to prevent flooding of the entire subway system. PORTS is used to monitor the water levels in the New York harbor to facilitate early decisions in the closing of the subway ventilation shafts. In providing information to make navigation safer, PORTS reduces the likelihood of a maritime accident, and also provides information necessary to mitigate the damages from both a spill and a flood should one occur. PORTS information also supports the U.S. Geological Survey in running its water level model to understand potential flood areas.

National PORTS database, CORMS, and Contributing Local Environmental System Users. The PORTS information can be augmented by local environmental monitoring systems that supply additional data. The national PORTS database provides environmental information to users, typically for historical analysis of water levels and environmental planning.

General Public. Recreational boaters use of PORTS and particularly PORTS Lite systems is increasing due to the availability of information via voice response system and the Internet allowing them to quickly determine winds, tides and currents for safe movement to and from marinas. Both San Francisco and Houston/Galveston PORTS receive numerous routine queries from the public to gain environmental information for sail boating, wind surfing, and other recreational activities.

Indications of Future Need for PORTS

In the U.S. Coast Guard Authorization Act of 1998, Public Law 105-383, Title III, Congress directed the Secretary of Transportation to establish a task force composed of government and industry members to study the Marine Transportation System (MTS) and make recommendations for future improvements. The Secretary of Transportation is carrying out this mandate through the Maritime Administration, which is primarily concerned with port and shipping economics, and the USCG, which is the principle DOT operating agency responsible for waterways management and navigation safety. NOAA, as a member of the task force, is representing all of the Department of Commerce (DOC). A principle driver behind this MTS initiative is the anticipated increase in port traffic levels. International trade and port throughput is projected to increase

threefold by 2020[37]. Ensuring that inadequate port capacity does not become a brake on the U.S. economy requires that our port infrastructure and navigational services be able to meet the challenges of the 21st century, while also meeting environmental and public needs.

The MTS Task Force released *An Assessment of the U.S. Marine Transportation System: A Report to Congress* in September. The report describes the critical issues affecting the nation's waterway system and recommends specific actions for ensuring the safety, competitiveness and environmental soundness of the MTS. The report specifically states that the "greatest safety concern voiced [by MTS users is] the availability of timely, accurate, and reliable navigation information" and calls for NOAA to work with USCG and other partners to design and install appropriate PORTS technology. A Journal of Commerce editorial also described accurate navigation data, including real-time tide, current and weather information, as the "single greatest concern of professional [38]

In addition, as part of the FY1997 DOT Appropriation Act, Public Law 104-205, Title I, Congress directed USCG to reexamine the way in which it operates VTS and to develop, in cooperation with the marine transportation community, a set of user validated requirements for VTS. In response, USCG convened a National Dialog Group[39] (NDG) to examine VTS in particular and Vessel Traffic Management (VTM) and navigation safety more generally. The NDG made several broad policy recommendations. For example, NDG recommended that local users be involved in the process of identifying risk inducing factors at the port level and that all of the various VTM tools be used in a holistic manner to mitigate identified risks. NDG also recommended broad implementation of a new technology, AIS transponders, as both a collision avoidance device and as a means to distribute real-time information directly to mariners while underway. Additionally, NDG documented the information sets required by the mariner to navigate safely. Included among these requirements is the need for real-time tide, current, bridge clearance, and other environmental information. PORTS was specifically identified by the NDG as a navigation safety tool that may be necessary in a given port, with or without a VTS, to help ensure maritime safety[40]. The need for PORTS in a given port would be driven by local factors such as complex and unpredictable oceanographic conditions.

Finally, the Marine Board of the National Research Council, National Academy of Sciences, chartered a Committee on Maritime Advanced Information Systems to study the issue of information systems in ports and waterways management. The Committee report, *Applying Advanced Information Systems to Ports and Waterways Management*, was released in early 1999. This report endorses the NDG holistic approach to the selection and use of traffic management and navigation safety tools, including PORTS, and the use of AIS as collision avoidance tools and for information distribution.

Future Ports and Waterways Management, and Vessel Traffic Management Information Systems

The paragraphs that follow discuss planned actions and systems that could include or will require tide, current, and other environmental data.

Local Needs Assessments

In response to congressional direction and in keeping with the NDG recommendations, USCG plans to conduct local port safety assessments, focused on vessel traffic management and navigation safety issues. These Ports and Waterways Safety Assessments (PAWSA) will involve local stakeholders, including government, industry and public interest groups, in order to identify risk drivers and then select appropriate mitigation measures. The PAWSA process will look at risk factors such as traffic patterns, channel configuration, traffic mix, the hydrological and geological environment and weather. Current and available navigation safety activities that offset these risks, such as traditional aids to navigation, traffic separation schemes, existing vessel traffic services, and pilotage requirements will also be examined. It is reasonable to assume that many risk factors can be adequately mitigated through traditional methods such as Aids to Navigation (ATON) and traffic separation schemes. Ultimately, the assessment efforts should concentrate

waterway safety improvement efforts on the greatest risks. These assessments will be drivers in determining where VTS will be installed under the Ports And Waterways Safety System (PAWSS) project and will also be instrumental in waterways management decisions by USCG and other entities. One likely decision would be on the need for a PORTS or PORTS Lite installation. The PAWSA process will commence in 1999. For the longer term, it is anticipated that the risk management approach underlying the PAWSA process will become a normal mode of operation for Harbor Safety Committees.

PAWSS/AIS-based VTS

PAWSS is a major USCG acquisition project to build AIS-based VTSs in those ports where a Federally funded VTS is determined to be necessary to meet safety needs. The first PAWSS installation is being built in New Orleans. Figure 9 provides a simplified schematic of an AIS-based VTS showing both the shore-based VTS watchstander (who provides navigation assistance and traffic organization) and some of the kinds of auxiliary information systems and sources which could be incorporated. The number of ports where a VTS will be necessary is expected to be relatively limited.

AIS

A significant recommendation of the NDG and others has been the adoption of the universal AIS. AIS incorporates a number of different technologies including DGPS[41] navigation, digital VHF radio transmission and electronic chart/electronic navigation systems for display. As shown in Figure 9, AIS operates in both a direct ship to ship mode and a ship to shore/shore to ship mode. AIS voicelessly exchanges pertinent information among all AIS equipped vessels and shore stations within radio range. AIS should permit less expensive VTS operations, and the benefits of AIS should be much more widely felt. The direct ship-ship information exchange will provide a broad collision avoidance benefit while AIS provides an ideal path for PORTS information.

Figure 9. AIS Based VTS

Ports and Waterways Safety System

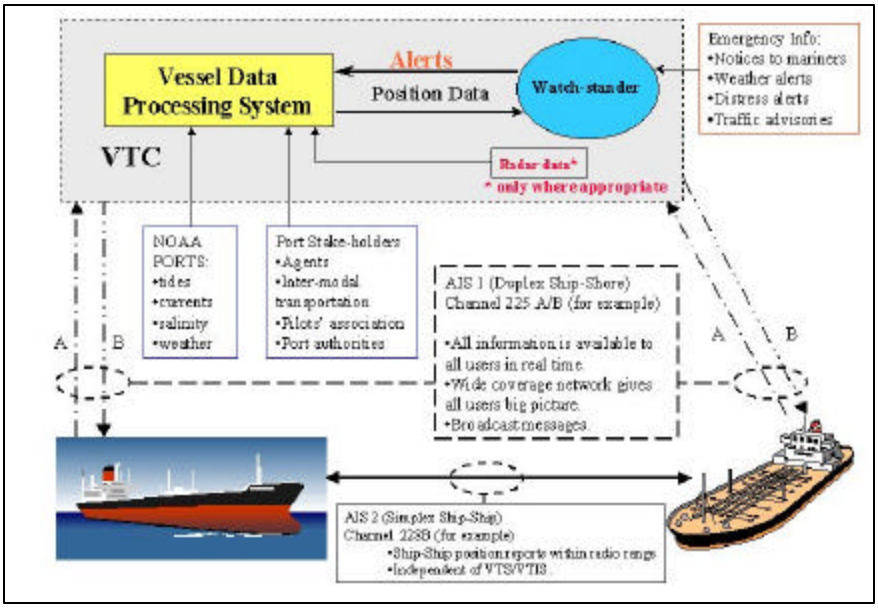


Figure 10 presents a typical AIS navigation and vessel traffic display. Automated shore-based systems could deliver information, such as PORTS data, directly into the wheelhouse. PORTS can provide much of the on-demand environmental information already identified as necessary for safety and efficiency while AIS provides an ideal delivery mechanism for vessels underway.

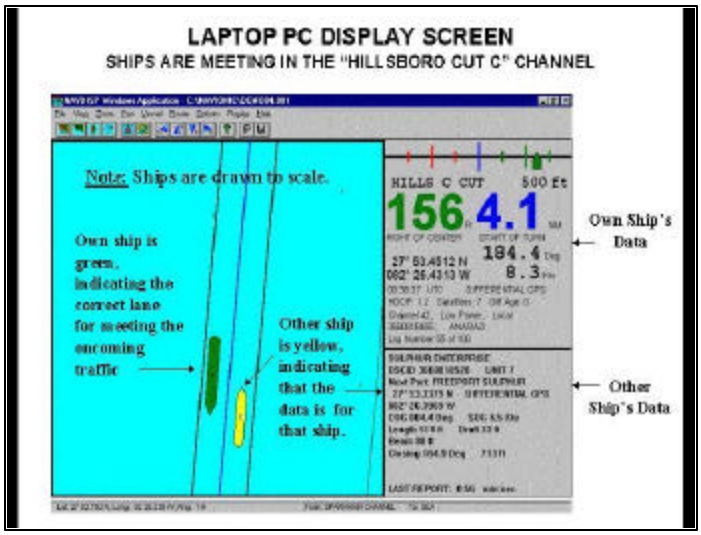
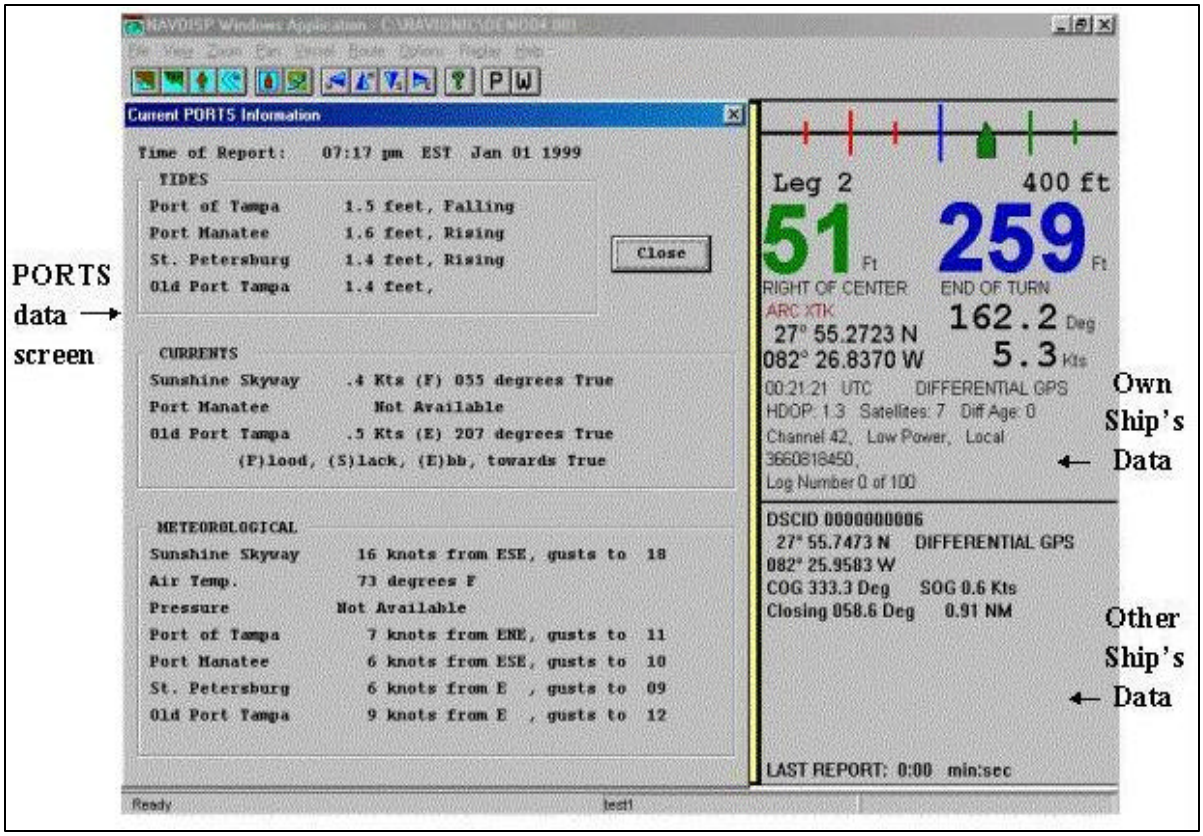


Figure 10. Typical AIS Navigation and Traffic Display

Figure 11 shows PORTS data being delivered via AIS in a prototype installation in Tampa Bay. While some level of shore-based infrastructure would be required to deliver data originated from shore, in non-VTS areas this could be accomplished without incurring the costs of watchstanders or extensive vessel tracking systems. International performance and technical standards for AIS have already been approved. AIS type certification standards and carriage requirements, both international and domestic, are being developed.

Figure 11. PORTS Data Delivered Via AIS in Tampa Bay



POISE

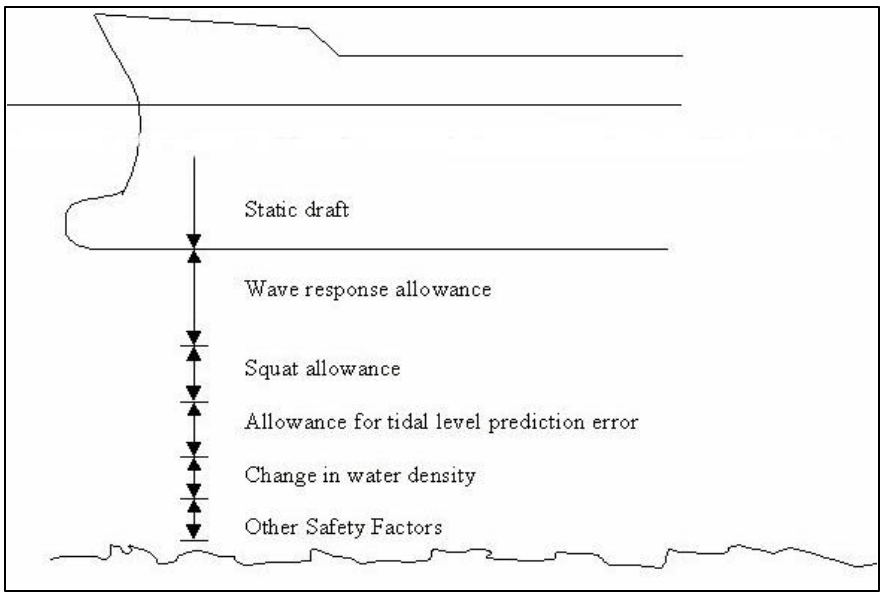
USCG established the Port Operations Information for Safety & Efficiency (POISE) Web site to provide links, sorted by specific ports, to maritime-related Web sites across the Nation. Organized by geographic locations, POISE will provide an easy-to-use, intuitive tool for the mariner. Mariners will only be required to remember one URL address (www.uscg.mil/safeports) to reach all available Web-accessible port and navigation safety information. Notably, POISE links to the NOAA PORTS Web site for each location in the United States. POISE contains pages of links, not data, and is not an expensive undertaking. POISE can link to any appropriate Internet data source and most data sources that are external to the USCG. POISE will be useful to mariners and harbor pilots for obtaining voyage planning and Coast Pilot-like information. While POISE will not replace existing push style dissemination means (e.g., Urgent Broadcast Notice to Mariners), POISE will make it easier for USCG to get important safety information into more hands.

Under Keel Clearance Policies

UKC refers to the distance from the lowest point of a ship, usually the keel, to the bottom at the shallowest point over which the vessel will travel during its transit from deep water to its mooring and back. Adequate UKC is an absolute necessity for a vessel to make a given transit safely. If UKC requirements are too conservative, ships carry less cargo than they could, and the operation is not as economically beneficial as it might be. At the other extreme, inadequate requirements for underkeel margins could jeopardize safety.

Until relatively recently, ensuring adequate UKC has not been a major concern in most U.S. ports. This was because ships were significantly smaller and drew less water. More recently, however, as ships have grown larger and the consequences of groundings have become socially, environmentally and economically intolerable, UKC has taken on increased importance. With the emergence of the newest generation of ships, the lack of available draft threatens to become the limiting factor on U.S. port growth and economic vitality. Dynamic UKC management is now being recognized as a potentially important means of enhancing the health of both the environment and the economy.

Figure 12. Factors Determining Under Keel Clearance[42]



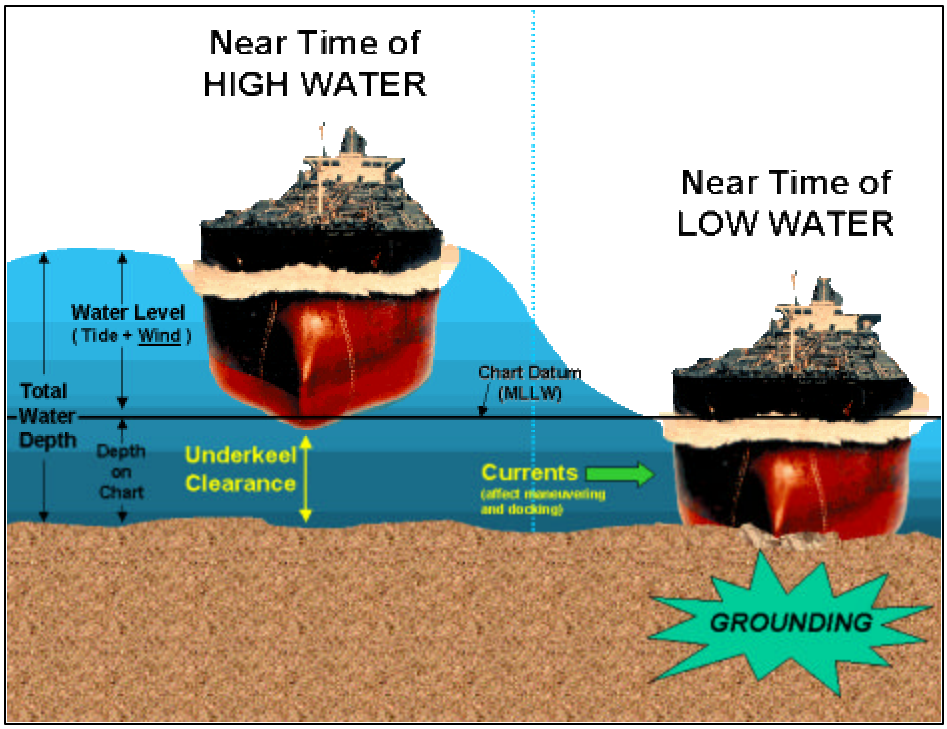
As shown in Figure 12, UKC is determined by a number of specific factors including static draft, wave response allowance, squat allowance for ship speed, allowances for tidal prediction and changes in water density, and a conservative safety factor allowance for variables such as silting and hydrographic survey

tolerances. On some vessels, it may also be necessary to allow for vessel heel during turns. Further, because they are located on the coastline of a continent, the approach channels to most U.S. ports are subject to ocean swells generated by tropical and mid-latitude storms. It is essential that UKC calculations allow for the dynamic motions of vessels of varying size and stability characteristics as they respond to passing swells. Finally, weather influences hydrologic factors such as water depth and current, with consequent impacts on UKC allowances.

Historically, under keel clearances have been calculated using rough estimates for some of these factors, together with a relatively large safety margin intended to account for the unknowns. As ships have grown larger, the residual water depth available to provide an adequate safety margin has grown ever slimmer and, in some ports, has disappeared all together. For these reasons, the traditional empirical approach is no longer acceptable. With all the factors influencing UKC, it is understandable that shipmasters often cannot accurately determine a safe transit window or an appropriate UKC allowance. Figure 13 illustrates the significant effect of environmental factors on transiting vessels and the consequences of inadequate UKC allowances.

A number of real-time variables affect UKC and may determine whether revenues are safely maximized or the vessel ends up grounding. Ready access to reliably accurate real-time environmental information as provided by PORTS, helps take the guesswork out of UKC calculations. Among these real-time variables are water density, weather induced water level changes, and even human induced causes. The port of Charleston, South Carolina has the critical need for UKC information because of human induced factors. Real-time information on water level and current flow is necessary in Charleston because the flow through the Cooper River System is determined by the release of water over the Pinopolis Dam. If a ship captain knows he has six inches more than the predicted tide, he will be able to load his ship that much deeper, adding real commercial and economic value[43].

Figure 13. Environmental Factors Influencing Under Keel Clearance



In response to growing concerns over the UKC issues, USCG issued national UKC planning guidance that allows the Captain of the Port to establish local UKC criteria within broad national parameters[44]. These guidelines, which are somewhat flexible, have been established in most ports. Under these guidelines, shipmasters are responsible for planning their transits, including performing calculations for UKC. The local knowledge of the pilot, port authorities, and the terminal operator (many U.S. port terminals have privately maintained dredged channels) is referenced to get the closest estimate of the anticipated under-keel clearance. After the shipmaster has completed the anticipated UKC calculation, it is reviewed with the pilot. This review includes a discussion between the shipmaster and the pilot concerning any shoaling or weather conditions, with data provided by PORTS where installed. USCG has issued UKC policies for the ports of Anchorage and Nikiski, Alaska requiring vessel operators to calculate UKC utilizing NOAA's PORTS Lite systems. It should be noted, however, that this approach may not always happen in every case and in every port and is little more than a more formal execution of the older empirical approach: addition and subtraction of estimated allowances for numerous factors. However, it remains critically important to use PORTS environmental information to make the calculations as accurate as possible.

The amount of under keel clearance should reflect many considerations including the type of bottom, (forgiving soft mud versus rocky), the criticality of the area as regards ship safety, and environmental conditions. This involves considerations of weather patterns, currents, tides, traffic density, waves/swell (surging) possibilities and general environmental sensitivity[45]. (INTERTANKO)

The objective of one recent research project[46] was to investigate the relationship between various factors, such as UKC, and grounding and collision incidents, and to ultimately focus on solutions to offset the risks. The fact that ship groundings occurred more frequently during high water levels in some ports, such as Tampa, is likely attributable to deep draft vessels making transits during high water, either to maximize UKC or, more likely, to take maximum advantage of the tide to achieve maximum loading. The Tampa findings merit some further discussion. As described earlier, total groundings in Tampa went down significantly after the PORTS was installed. During this same period, the number of groundings in Tampa at high water actually went up. One possible explanation for this phenomenon is that better information made for better planning and decision making generally, while simultaneously encouraging over-exploitation of UKC predictive ability at high water. This is another indication that the old empirical UKC approach is inadequate when trying to take maximum advantage of all available water depth.

An Australian DUKC system introduced in 1993 has achieved increased draft and widened tidal windows at several ports without compromising safety. The Australian computer-based system, now installed at six Australian ports, does not stop at providing real-time hydrologic information. Rather, the DUKC system uses engineering predictive models, tailored to each port's hydrodynamic situation and taking into account the hydrodynamic characteristics of various hull-forms. Running a number of highly instrumented vessels through the waterway with specific loading and speed profiles validates the predictive models. In operation, the system uses real-time tide and wave measurements taken prior to the transit, together with parameters taken from the vessel (length, beam, hull-form type, static drafts fore and aft, and other factors) to determine if a given transit plan can be safely executed. Two ports have achieved significant monetary benefits in increased export earnings of $30,200,000[47] in a short period. In Fremantle, the DUKC system has allowed ships to berth earlier, optimize terminal operations, and clear the berth earlier than would have been possible otherwise. In other ports, cargo loading has been significantly increased with no degradation to safety or the environment. With low start-up and maintenance costs, economic benefits have been achieved without the need for new port infrastructure or the capital costs associated with dredging.

The local maritime community, in cooperation with USCG, is planning to test UKC systems and policies in the Port of New York/New Jersey. In a parallel effort, an ad-hoc committee under the Maritime Association of the Port of New York has developed recommendations for a vessel traffic management information system in the Port of New York/New Jersey. This system would automatically collect, analyze, and disseminate static and real-time information essential to efficient ship operations. Information in this system would include tides and currents, other environmental data available from PORTS, and commercially oriented information.

In the longer term, any major port, as part of its service, could provide DUKC service to its customers to reduce major risks, which have been identified as safety, reputation of the port, damage of natural resources, communications reliability, delays in liner service, and loss of commerce and revenue. The initial start-up costs would be compensated by the port revenue increases, providing a classic win-win relationship. However, just as PORTS information needs quality assurance before it is placed in the hands of users, so too USCG recognizes a need for oversight of DUKC implementation, including minimum DUKC design standards or guidelines and appropriate related operational policies. Access to real-time water level and other environmental information, such as in the successful Australian system and as planned for the Port of New York/New Jersey, is also essential for successful implementation of a DUKC system or for more successful exploitation of available water by calculating UKC using traditional methods.

SECTION V

EXPANSION PLAN AND COST TO IMPLEMENT FUTURE PORTS

The FY2001 budget request of $15.1M includes funds to upgrade CORMS in order to handle the increase in data from additional ports, and to provide for the implementation of OSTEP. Also, funds would be provided to modernize and stabilize the aging NWLON.

Unlike previous demonstration PORTS installations that have been largely carried out by NOS employees utilizing limited contractual services, the estimates provided in the subsections that follow assume limited use of NOS resources and place much of the cost of the development activities on the partnerships. These developmental funding requirements include the costs for architectural and engineering companies to carry out the installation and first year operations and maintenance under NOS oversight. Rough order-of-magnitude estimates have been prepared for potential PORTS installations. These include PORTS that have been requested, or are currently under discussion. There is no prioritized list based on the need for future PORTS installation sites since each PORTS is installed as the partnership obtains local funding. Note that these estimates have not been adjusted for inflation in future year installations or adjusted for the uncertainty in the estimates.

Planned PORTS Implementations

NOS has been working with local user communities to identify priority port areas that desire PORTS technology. The partnership that is developed from local sponsors must agree to provide non-Federal funding for local PORTS costs, with a date set for this to be accomplished. This date establishes a priority for installation and NOS involvement in planning, design, and establishing agreements. Installation priorities thus depend largely upon available funding from the local sponsor and partnerships. PORTS systems that have been requested and are expected to be the next PORTS implemented are shown in Table 2. Estimated implementation costs are displayed. The wide difference in cost between any of the planned installations is due to the size of the area to be covered and the resultant number and complexity of the instrument installations.

Table 2. Estimated Costs (Non-Federal Funds) for Planned PORTS Installations

Location	Estimated Cost[48]
Los Angeles/Long Beach	$400,000-600,000
Philadelphia/Delaware Bay	$1,000,000-1,200,000
Jacksonville, Florida	$1,000,000-1,200,000
Total	**$2,400,000-3,000,000**

Out Year Planned PORTS Implementations

The estimated costs where PORTS systems are under discussion and costs estimates have been completed are shown in Table 3. The costs where inquiries have been made for PORTS, as listed in Table 4, have not yet been estimated, but are under discussion with each local harbor or waterway organization in accordance with the process described earlier.

Table 3. Estimated Costs (Non-Federal Funds) for PORTS That Are Under Discussion

Location	Estimated Cost[48]
Port Hueneme	$300,000 - 500,000
Connecticut	$1,000,000 – 1,500,000
Wilmington, NC	$80,000 - 120,000
New Orleans	$2,000,000-3,000,000

Table 4. Ports From Which Inquiries Have Been Received

Location
Miami
Sabine Pass, Louisiana
Freeport, Texas
Columbia River
Port Everglades
San Diego
Baltimore (upgrade)
Juneau, Alaska
Ketchican, Alaska
Savannah, Georgia
Mobile, Alabama
Boston, Massachusetts
Charleston, South Carolina

PORTS Outlook

Over the past several years NOAA and the USCG have taken advantage of off-the-shelf computing technology, partnerships with the private sector and other Federal agencies, and establishment of new priorities for the commercial marine navigation community to reinvent its marine navigation services. PORTS is a partnership of port organizations, industry, and government with initial installation provided by the local user group with assistance for planning, design, and operations by NOS. The current approach to implement PORTS through partnerships with maritime organizations and industry leverages combined resources that will be able to fund the programmatic growth required to keep pace with the expected increases in maritime commerce.

The Federal role in PORTS is to design, standardize, quality control, test and evaluate PORTS to provide the required consistency and data quality needed to ensure navigation safety. NOS can fulfill this role, contingent upon it receiving the funding levels contained in the FY2001 President's request. A recent study[49] recommended that actions be taken on several matters, such as waterways management, vessel traffic systems, passage planning and pilotage, and UKC. More specifically, hydrographic surveys must be kept up to date, NWLON needs to be modernized into a real-time navigation aid, PORTS partnerships must continue to be strengthened, and an infrastructure coordinating all these elements must be established at each port[50]. PORTS and PORTS Lite installations are crucial parts of vessel traffic management that provide required inputs to the USCG vessel traffic services. They contribute valuable data to support the AIS and future UKC programs. PORTS could begin to leverage a significant increase in U.S. port tonnage, as demonstrated by the successful Australian DUKC system.

Furthermore, NOS is working on the initial stages of a coastal ocean forecasting capability. Higher resolution environmental models are in development to provide a future forecast and warning capability of fog, visibility, dangerous winds and waves, water levels, currents, and thermal structure needed by the commercial shipping industry, the general public, and a host of other coastal users. The PORTS hub will act as a server to provide these new products to mariners. This capability is vitally needed to complement the real-time observational capability of PORTS that was highlighted by President Clinton at the 1998 National Ocean Conference, and reaffirmed in the 1999 report: “Turning to the Sea: America’s Ocean Future”.

Existing PORTS deliver real-time tide and current information to satisfy safety and efficiency needs at U.S. ports. Planned enhancements, including a coastal forecast capability, will extend the reach of PORTS, delivering added value to the commerce, environmental protection, and safety of the maritime community.

REFERENCES AND ENDNOTES

[1] Image provided courtesy of Princess Cruise Lines. Use of this image in no way constitutes an endorsement of Princess Cruise Lines by the Department of Commerce. U.S. Capitol Building and Grand Princess shown same scale.

[2] PORTS is a trademark of NOAA, National Ocean Service.

[3] National Research Council, 1999. *Applying Advanced Information Systems to Ports and Waterways Management*, Washington DC: National Academy Press.

[4] Hydrographic Services Improvement Act of 1998, Section 305(a) of Public law 105-384, Title III.

[5] Kite-Powell, H.L. et al., *1998 Formulation of a Model for Ship Transit Risk: Final Project Report*, Massachusetts Institute of Technology Sea Grant Technical Report 98-6.

[6] Ibid.

[7] Hydrographic Services Improvement Act of 1998, op.cit.

[8] INTERTANKO. 1996. *U.S. Port and Terminal Safety Study: A Discussion Paper*. Oslo, Norway: INTERTANKO, p. 29.

[9] Weikel, D., "Freighters Enter the Age of the Mega Ship", *The Los Angeles Times*, June 15, 1999.

[10] U.S. Department of Transportation, DOT, *An Assessment of The U.S. Marine Transportation System, A Report to Congress*, September 1999, p.26.

[11] NOAA, 2001-2005 Promote Safe Navigation Implementation Plan, (Unpublished Draft) May 14, 1999, p. 3.

[12] National Research Council, op.cit., p. 6.

[13] INTERTANKO, op.cit., p. 1.

[14] For example, during the National Ocean Conference held at Monterey California in June 1998, Richard du Moulin of Marine Transportation Lines pointed out that "Basically, a lousy port environmentally is a lousy port commercially. The two go hand in hand. A port that operates efficiently has good maintenance dredging, has good vessel information, [and] ongoing information on tides and currents to the pilots and masters." The citation is: Du Moulin, R. 1998. Oceans and Commerce Forum, National Ocean Conference Proceedings, June 11-12, 1998, National Oceanic and Atmospheric Administration and the Secretary of the Navy, p. 21.

[15] Woodill, R., *The Needs of the Professional Master Mariner for Improved Weather and Environmental Prediction Services*, address to the American Meteorological Society's Second Conference on Coastal Atmospheric and Oceanic Prediction and Processes, January 12, 1998, Phoenix, Arizona.

[16] DRI/McGraw-Hill and Mercer Management, *World Sea Trade Service Review*, March, 1995, as cited in INTERTANKO. 1996. U.S. Port and Terminal Safety Study: A Discussion Paper. Oslo, Norway: INTERTANKO.

[17] NOAA, 2001-2005 Promote Safe Navigation Implementation Plan, op.cit., p.1.

[18] These systems are described in section IV.

[19] Bookman, C *U.S. Seaports: At the Crossroads of the Global Economy*, Journal of Issues in Science and Technology, Fall, 1996, pg. 71-77.

[20] Adapted from the McGraw-Hill Companies and the U.S. Department of Commerce, 1999 as cited in the DOT,

An Assessment of The U.S. Marine Transportation System, A Report to Congress, op.cit.

[21] As described in section IV.

[22] Greater Tampa Bay Marine Advisory Committee.

[23] Richards, T. Captain NC(ret.), Consultant, NOAA's San Francisco Bay Project, personal conversation, May 7, 1999.

[24] NOAA, *NOAA Strategic Plan, A Vision for 2005*, May 1996, Pg. 89.

[25] U. S. Coast Guard, Marine Casualty Investigation Report, Case #MC93004342.

[26] More detailed process steps are described section III.

[27] Agreement made on October 23, 1997.

[28] such as the ECDIS or USCG VTS

[29] Requested PORTS have been officially requested in writing from the port organization to NOS and negotiations are underway to develop requirements and identify funding.

[30] Terry Hunter, executive director of the Marine exchange of the San Francisco Bay Region, as quoted by Kaser, T., *Computers Prognosticate River Depth*, in "Maritime News and Shipcards," Journal of Commerce Supplement, December 2, 1998 Pg.18.

[31] Ibid.

[32] Ford, S.F. and Bald, R. J., Houston/Galveston *Safe Passage Into the 21st Century* (USCG paper), p.7

[33] INTERTANKO, op. cit., p. 13.

[34] Oceans and Commerce Forum, National Ocean Conference, op.cit.,p.7.

[35] Richards, op cit.

[36] Kite Powell, op. cit., p. 35

[37] Bookman, C., op. cit.

[38] Gray, William O., Journal of Commerce, September 15, 1999, p.6.

[39] National Dialog on Vessel Traffic Services, 1997, Summary of Guidance from the National Dialog on Vessel Traffic Services, Marine Board, National Research Council, 2101 Constitution Avenue, NW, Washington DC 20418. Telephone (202) 334-3119. Available from National Academy Press at web site www.nap.edu, and 888-624-8373 or 202-334-3313.

[40] Ibid.

[41] These DGPS transponders enable the civilian mariner to fix positions very accurately by using data broadcast by USCG to correct signals from the military Global Positioning System (GPS) satellite radio navigation system.

[42] O'Brien Marine Consultant at URL www.tpgi.com.au/users/omc/dukc/paper1.html

[43] "NOAA PORTS Takes First Step Towards Reality", The Standard, The Maritime Association of the Port of Charleston, Vol.6, April 1999, p 3.

[44] Contained in *Navigation and Inspection Circular 2-97*.

[45] INTERTANKO, Sept. 1996

[46] Kite-Powell, op. cit.

[47] In U.S. dollars. From O'Brien Marine Consultant, op.cit.

[48] In FY1999 dollars.

[49] *U.S. Port & Terminal Safety Study* prepared for INTERTANKO by Bill Gray of Gray Maritime in Darien, Connecticut.

[50] Wells, D. "Under-Keel Clearance Navigation: Are We Ready?" *Sea Technology*, April 1997, p.153

July 2000