

Port Freeport's "FlowInfo": An example of an Integrated Port Navigation and Environmental Data System (IPNEDS)

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Abstract

Texas ports are rapidly expanding their operations because of increased tonnage and security requirements. As a result, they are also expanding their real-time data acquisition and display capabilities for navigational operations and homeland security. Ports such as Port Freeport are collaborating with Texas A&M University-Corpus Christi to develop, install and operate real-time data systems to deliver needed information to the Pilots and operations personnel. The ports need to significantly expand the scale of real-time programs, in terms of both types of observations (i.e., to include chemical and biological sensors in support of environmental and homeland security requirements) and area covered (i.e., both inshore and offshore). They also need, through cyber-infrastructure, to deliver a visualization of the converged data product to its Pilots and other stakeholders, all in a cost effective program. In collaboration with Port Freeport, we are developing the technology required for such an Integrated Port Navigation and Environmental Data System (IPNEDS). It will deliver not only a greatly expanded suite of physical parameters but also new state-of-the-art capabilities to measure precisely, *in situ* and in real-time, standard environmental, chemical and biological parameters. Single-point measurements of currents will be augmented by HF-Radar-measured large spatial grids of coastal surface currents and ADCP-measured, vertical profiles of horizontal current velocity and directional wave parameters (height, period, direction).

Introduction

The Conrad Blucher Institute for Surveying and Science (CBI) at Texas A&M University-Corpus Christi and the Texas Engineering Experiment Station-Corpus Christi (TEES-CC) have a variety of research projects, both ongoing and recently concluded, that are converging to an Integrated Port Navigation and Environmental Data System (IPNEDS) concept. These projects provide the essential building blocks for IPNEDS, leading to the opportunity to significantly expand the scale of real-time programs, in terms of port operations, environmental assessment and homeland security requirements. In order to increase the efficacy and cost effectiveness for IPNEDS, we are converging these monitoring and analysis systems. It is probably cost prohibitive to operate separate environmental assessment, homeland security and coastal navigation monitoring systems. A cost effective approach combines these systems to take advantage of redundant sensor arrays, specialized research infrastructure, and common cyber-infrastructure. The development of stakeholder awareness and appreciation of cost savings and increased efficiency of this concept is an important task. We are currently expanding our sensor array to include chemical and biological sensors in support of environmental assessment and homeland security requirements. Our research will increase the area covered both inshore and offshore, and through improved cyber-infrastructure, deliver enhanced visualization of the converged data products to pilots, stakeholders, and the general public, all in a cost effective product that can be transferred to other port facilities and coastal inlets around the country.

Port Freeport, one of the fastest growing ports on the entire Gulf Coast, ranked as the 16th largest port in the United States in terms of tonnage, is an excellent example of a smaller port that needs to rapidly expand its real-time data acquisition and display capabilities for navigational operations and homeland security. Port Freeport began collaborating in 2000 with CBI to develop, install and operate a real-time data system titled "FlowInfo." It delivers to the Pilots by telephone a set of automated voice observations of current set and drift, wind speed, wind direction and gust, water level, temperature, and salinity for the inshore portion of the Freeport shipping channel. The data are updated every twelve minutes. The Port wants to add similar observations in the offshore approach region, and is interested in the new chemical and biological sensors being integrated into real-time observing systems by CBI for its Environmental Field Facility (EFF) in Corpus Christi Bay.

The IPNEDS Concept and Components

The IPNEDS concept converges a host of real-time physical and environment measuring systems, which CBI is developing under various projects, into a visualization product that would be available on hand-held computers to specific users and the public through various delivery mechanisms. The projects are of specific interest to Port Freeport, which is a collaborator and "beta tester" in an operational mode for the components of IPNEDS being developed at CBI's EFF.

Current velocity information for the region just offshore is one of Port Freeport's immediate interests. HF Radar is now used, mainly by researchers, to

measure ocean surface currents and waves over thousands of square miles (Kelly et al. 2002, Kelly et al. 2003). Results are sometimes provided publicly on the WEB, but not in an industrial format. CBI is developing the dissemination HF-Radar data in real-time in combination with other sensors, i.e., the IPNEDS concept. Figure 1 shows the current and planned HF-Radar coverage in the offshore Galveston/Freeport region. Note the excellent coverage of the shipping channels in the region. Also, CBI has just completed installation of a similar pair of HF Radars that cover the coastal shipping lanes offshore Corpus Christi.

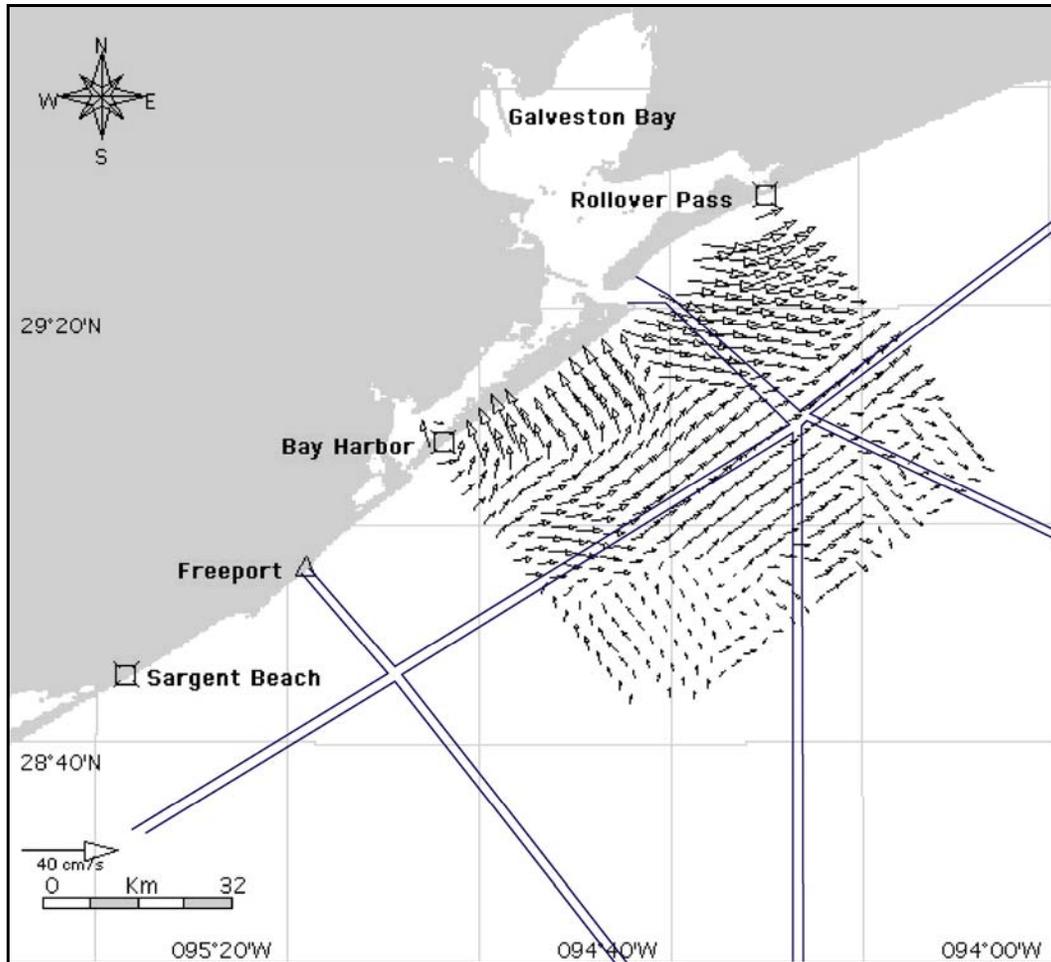


Figure 1. An example of an unedited map of hourly surface-current vectors off Galveston TX (11/30/03 0900 UTC) from the recently installed pair of NSF-funded CODAR HF-Radar systems (at Rollover Pass and Bay Harbor). Weak upcoast flow and an ebb tide from the Bay were in effect at this time. The offshore shipping channels for this region are indicated. A third Radar site will be installed at Sargent Beach in early 2004. When paired with the Bay Harbor site, similar coverage of offshore currents will be provided for the approach to Port Freeport.

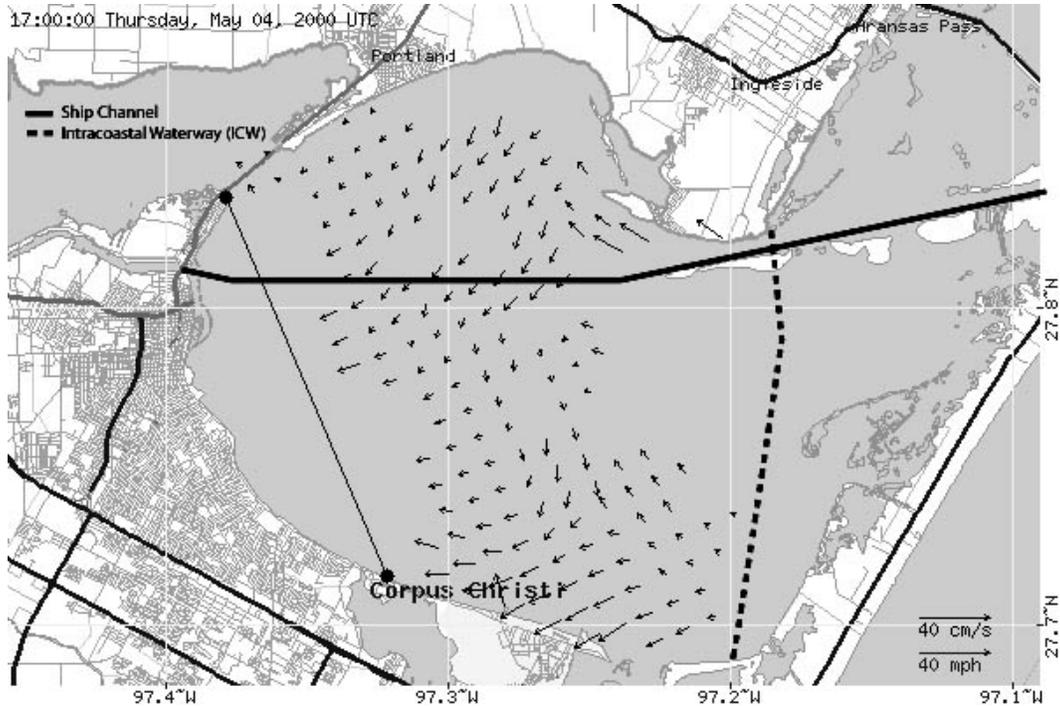


Figure 2. An example of an unedited map of hourly surface current vectors in Corpus Christi Bay (5/4/2000 1700 hrs UTC) from the pair of CODAR HF-Radar systems located at shore sites indicated by the small black circles. The thin line connecting the sites indicates the system baseline, along which only radial components of velocity can be obtained. Elsewhere, total current vectors are produced by the system. The shipping channel from the Gulf to the Port of Corpus Christi and the Intracoastal Waterway are indicated.

Unlike Port Freeport, most Texas ports are located well inside bays. These bays are typically quite shallow, and tides are not the primary factor that determines currents and water level (Cox et al. 2002). To extend the IPNEDS concept to such ports, CBI has pioneered the use of HF-Radar in shallow bays to measure the primarily wind-driven surface current fields. Figure 2 shows an example for Corpus Christi Bay where a pair of HF Radars has been in operation since early 2000. The HF-Radar observations of currents in Corpus Christi Bay are an important part of its EFF. Figure 3 shows an example of observation collected for Matagorda Bay during a two-day experiment. Both bays are home to multiple port facilities.

A current State-sponsored project, “Extension of HF Radar for Water Currents and Direct Observation of Transport Model Coefficients,” and a current NSF Major Research Instrumentation project, “Development of Enhanced Radar Instrumentation for Improved Characterization of Coastal Hydrodynamics”, are increasing the effectiveness of HF-Radar through improved hardware and data processing to yield more complete and accurate observations of surface currents and wave conditions to determining the coefficients for transport and water quality models directly from the radar data (Ojo et al. 2002b).

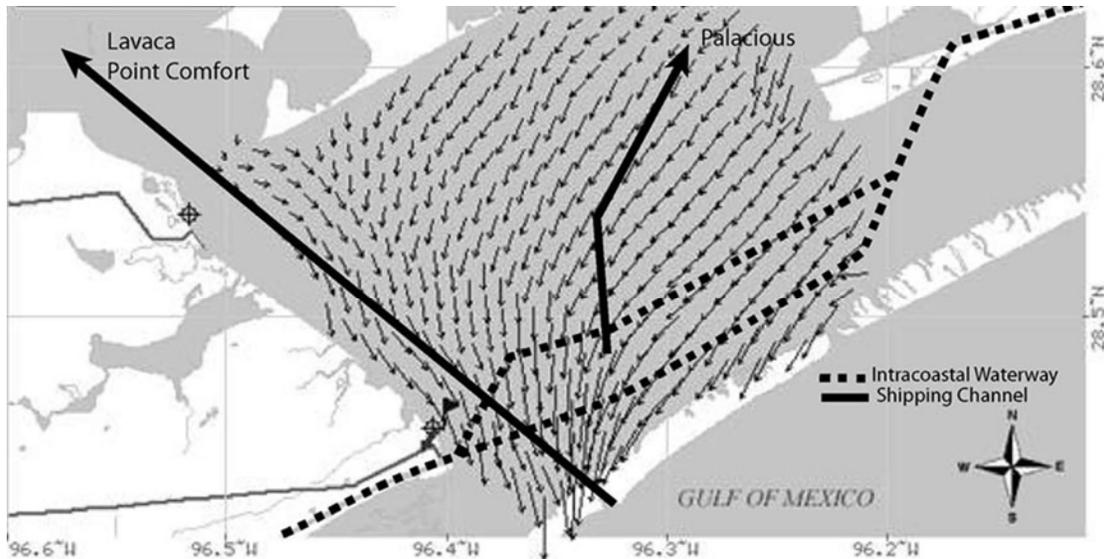


Figure 3. An example of an unedited map of hourly surface-current vectors in Matagorda Bay, Texas 8/24/2000 1600 UTC) from a mobile, 2-day deployment of a pair of CODAR HF-Radar systems. Strong currents flow through the ship channel in the pass to the Gulf of Mexico. The shipping channels in the bay to the ports at Lavaca, Point Comfort and Palacios are indicated.

Port Freeport is also interested in a cost-effective method to obtain vertical profiles of horizontal currents in the region offshore of the jetties of its shipping channel. The instrument of choice for such measurements is the Acoustic Doppler Current Profiler (ADCP), which can be mounted a buoy looking down, or bottom-mounted looking up. The challenge is to get the data to shore in real-time. Traditional approaches are to run a cable to shore or mount the ADCP on a privately operated buoy. Both are costly to install and prone to damage by public and commercial shipping, fishing and trawling. A new approach is to utilize U.S. Coast Guard Navigation buoys. Codiga et al. (in press) have used bottom-mounted ADCPs and acoustic modems to transmit data to USCG buoys, which have radio transmitters to send the data ashore. A second and possibly more cost-effective approach is to mount the ADCP on the side of the USCG buoy in a down-looking configuration. The NOAA PORTS program (Permenter 2003) is investigating this approach (Bosley et al. 2003). Because of the buoy's large ferrous mass, the heading accuracy of the ADCP is marginal even after extensive compensation of its internal compass. CBI is working with equipment manufacturers to test sensitive external heading sensors that can be mounted on the top of the USCG buoy, with the heading data cabled to the ADCP.

Corpus Christi Bay serves as an excellent EFF for development of the IPNEDS concept because it is environmentally very active. A Landsat image (Figure 4), processed in false color to emphasize suspended sediment concentrations in the surface waters, illustrates an example of strong spatial gradients. This image was taken in mid-November 2002 during a significant flood event. The suspended

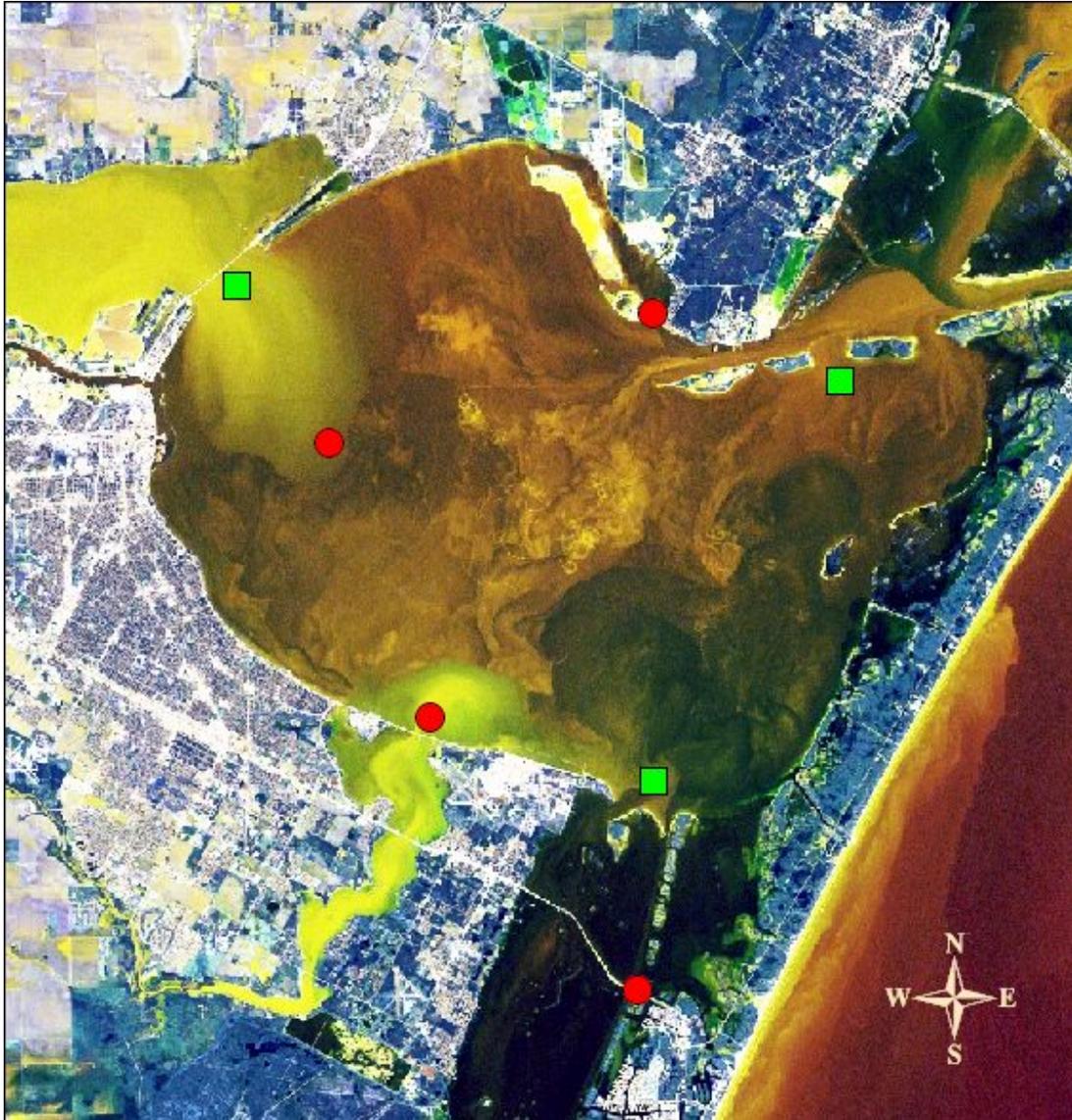


Figure 4. A mid-November 2002 Landsat image of Corpus Christi Bay during a flood period. The false-color image was processed to emphasize the surface suspended sediment concentration. It illustrates the strong spatial gradients present at this time. Red circles are locations of existing monitoring stations; green squares indicate location of stations under construction.

sediment gradients also serve somewhat as a surrogate for gradients of other parameters such as salinity, temperature, eutrophication nutrients and particularly contaminants, which have a strong affinity for particles. To study the dynamics of chemical and biological parameters, CBI is utilizing state-of-the-art sensor suites, reporting in real-time, at fixed sites (Bonner et al. 2002), and in a geo-referenced, rapid-response survey boat (Ojo et al., 2002a; Ojo et al. 2003). The locations of the active real-time sites and those under construction are indicated in Figure 4. Instruments deployed *in-situ* at the fixed sites and those utilized on the survey vessel

include ADCPs, water-quality sensors, oxygen sensors, fluorometers and optical backscatter instruments. Both a chemical nutrient analyser and an *in-situ* flowcytometer are scheduled to be deployed soon. The latter instrument measures optical properties of individual cells, or particles in general, in a flow stream. Since plankton are naturally in suspension, flow cytometry is a good way of studying natural populations of plankton. All these instruments are targeted at more completely characterizing in real-time, episodic events associated with storms, floods, algal blooms, oil and chemical spills, etc. All have potential applications in the IPNEDS concept. The Corpus Christi Bay EFF serves as a developmental test bed for these instruments before integration into the operational needs of a port such as Port Freeport.

Other programs that are contributing to the IPNEDS concept include:

- A Texas Sea Grant Technology Program project, in collaboration with Falmouth Scientific, Inc. has tested various configurations of a new salinity sensor that addresses the need for long-term, stable, accurate salinity measurements in the coastal ocean, where bio-fouling is a major concern (Fougere et al. 2003).
- Projects for the National Weather Service and Texas Coastal Management Program instrumented existing oil/gas platforms at two sites offshore (5 and 17 miles from the Aransas Pass jetties) with real-time meteorological sensors, current velocity profilers, and directional wave sensors.
- Long-term projects operated by CBI and the Division of Nearshore Research (DNR) at TAMU-CC for the Port of Corpus Christi and Port Freeport to provide Real-Time Navigation Systems (RTNS) for navigation and port operations, including current velocity measurements at selected locations in the shipping channels, wind, water level, and salinity measurements, and through computer synthesized voice messages, supply the observations to pilots via dial-up telephone service.
- Operation of the Texas Coastal Ocean Observation Network (TCOON), by DNR to provide real-time water level (to same standards as the NOAA National Water Level Observation Network) and meteorological data at more than forty locations along the Texas coast, including bays, estuaries and ocean facing locations (Michaud et al. 1994).

To make its ongoing, real-time, environmental data systems easy to modify and upgrade by all its researchers, CBI has elected to utilize commercially available operating systems and software. Even CBI's low-power, remote, real-time data collector/loggers use the MS Windows 2000 OS, which is particularly useful since manufacturers of most new "smart" sensors write their sensor interface programs for the Microsoft OS. The IPNEDS project is proceeding through several stages: 1) development of IPNEDS components in the Corpus Christi EFF; 2) development of web-based, converged data visualizations for existing sensor suites, and optimization for Pocket PC or Palm browsers; 3) testing of IPNEDS at Port Freeport; and 4) intensive user feedback for optimization of a useful product.

Summary

The IPNEDS project is focused on bringing our latest technological advances to operational status. The goal is to expand the scale of real-time coastal monitoring and navigational programs to include physical, chemical and biological sensors in support operations, homeland security and environmental requirements. We will also increase the area covered, both inshore and offshore, and, through improvements in our cyber-infrastructure, deliver a more comprehensive human interface that involves visualization of the converged data product to Pilots and other coastal stakeholders, all in a cost effective product.

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