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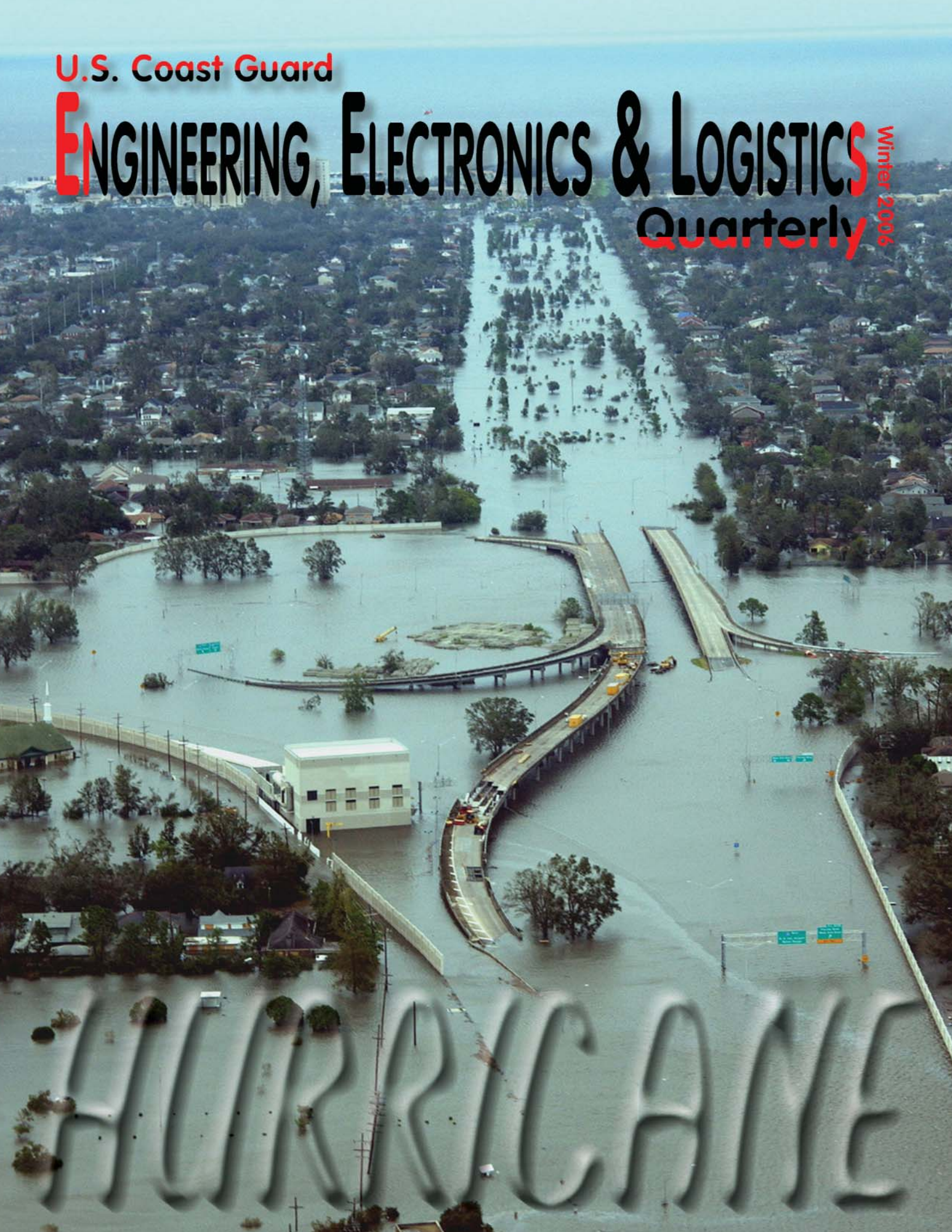
Winter 2006



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Article and Photo Submissions:

Articles should be about 500 words long; however, C4IT, engineering and logistics specific articles can be up to 2,000 words -- all acronyms must be spelled out when first used. To have your article considered for publication, photo(s) must accompany each article. Articles can be submitted by FedEx in hard copy and/or in Microsoft Word on a 3.5 disk, CD, or e-mailed electronically. Please submit original photographs and graphics. All slides, photos, graphics and illustrations should be in color where possible. Please include **by-line** when submitting article Let us know if you want your photos and graphics returned to you. Submit inquiries, letters, articles, and photographs to:

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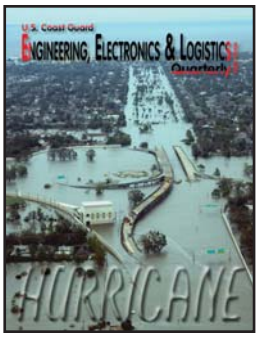
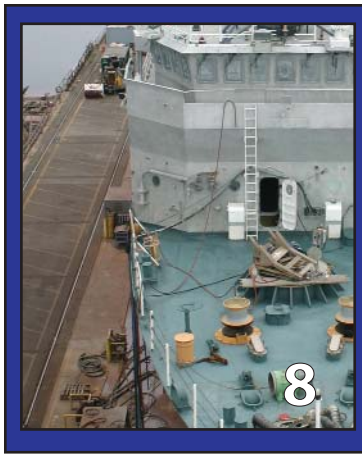


***On the Cover*: NEW ORLEANS (Aug. 29, 2005) - Flooded roadways can be seen as the Coast Guard conducts initial Hurricane Katrina damage assessment overflights here today. U.S. Coast Guard photograph by Petty Officer 2nd Class Kyle Niemi. Read how CEU Miami prepares and responds to hurricanes on page 14.**



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***On the Back*: NEW ORLEANS (Aug. 30, 2005) - Coast Guard Petty Officer 2nd Class Scott D. Rady, 34, of Tampa, Fla., give the signal to hoist a pregnant woman from her apartment here today. In all, the Coast Guard rescued 11 survivors from the apartment building. Rady is a rescue swimmer sent from Clearwater, Fla., to help aid in search and rescue efforts in the wake of Hurricane Katrina. U.S. Coast Guard photograph by Petty Officer 2nd Class NyxoLyno Cangemi.**

From the Assistant Commandant

Greetings,

And welcome to the Winter 2006 issue of the *Engineering, Electronics, and Logistics Quarterly* magazine. In the last quarter we have seen some significant movement in projects that are destined to change the way we plan and perform Coast Guard engineering and logistics. Many of these changes are already being discussed at the field level. Because of that I thought I would take this opportunity to speak with you about how some of the changes may affect the Coast Guard's most important resource - you.

As is true of any changes affecting the Coast Guard in general or the engineering and logistics communities in particular, the changes invite interest, concern and even fear. The changes we are currently considering -- and in some cases already implementing -- such as development of a common logistics business model and integration of Deepwater's logistics system and support concepts, will affect all of our people, both in operational and support lines of business.

The Deepwater logistics system and support concepts promise significant change for the Coast Guard. These systems and concepts offer unprecedented opportunities to leverage technology and industry expertise to ensure operational units maintain the highest levels of readiness and capability. We have already seen new support concepts in action on USCGC HEALY (WAGB-20) and at Aircraft Repair and Supply Center (ARSC) in their power-by-the-hour (PBH) aircraft engine support contracts. Through close partnerships with industry, the Coast Guard has saved both manpower and money while improving cutter and aircraft performance. We have put a lot of faith in our ability to contract out maintenance -- and that faith has not been misplaced. To ensure that these maintenance contracts continue to run smoothly, we have increased Coast Guard oversight and governance. HEALY and the new Great Lakes Icebreaker, USCGC MACKINAW (WLBB 30), are just two examples of how we have increased shore based support systems so that we can manage a wider array of maintenance and support contracts. We have increased the number of Port Engineers for both cutters. But how do we grow people with the needed expertise?

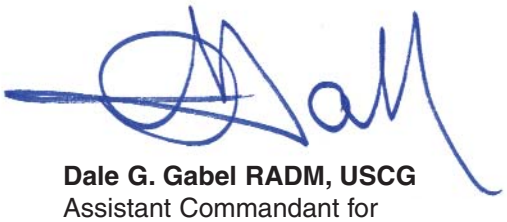
CG-4 has undertaken an extensive study of the competencies needed by our workforce. By now you have already seen the results of that analysis in Direct Access. We have been working on a competency inventory of engineering officers and

enlisted. The workforce managers in CG-481, with your help, have identified those competencies needed by the workforce to continue to provide "superior operational performance through engineering excellence." Each engineering and logistics billet in the Coast Guard will eventually have tied to it a set of competencies (knowledge, skills and abilities) that are required to successfully fulfill the role of that billet. In the near future, commands will have access to the competency definitions and requirements, allowing them to accurately assign these competencies to individuals. Although this system is just beginning to come to life, it will continue to mature and, with your input, help the Coast Guard better manage its workforce. But individual competencies are only a small part of managing the Coast Guard's core logistics capabilities.

Recently, CG-4 has taken a hard look at the Coast Guard's core logistics capability requirements, i.e., what functions and infrastructure are required to ensure the Coast Guard can remain a military, maritime and multi-mission service. Again, we did this with input from programs, depot commands and many field units and we have identified those business activities that are core to the Coast Guard's success in engineering and logistics. The results of this study, which built upon past studies and the work of the Logistics Management Transformation Office (LMTO) and the LOPAT study team, will be used not only by CG-4 but will also help the Deepwater Program Executive Office refine the Integrated Deepwater System integrated logistics system and its support processes. Although focused on identifying the core logistics functions and infrastructure of the Coast Guard, we did not forget our people. With the assistance of CG-1, we completed a detailed analysis of how staffing these core functions affect our workforce. We used the billets associated with the core functions as a starting point and then investigated workforce implications such as sea-to-shore ratios, required organizational flexibility in the face of surge operations, and officer and enlisted pyramids. We then identified those billets that must remain within the Coast Guard to ensure we continue to grow well-rounded engineers and logisticians. The simple answer is that although Coast Guard engineering and logistics are evolving towards a structure that is more integrated with the private sector, we will continue to need superior engineers to ensure our operational commanders have the right capability at the right time, in the right place and at the right cost.

There are some who hint that Coast Guard engineers and logisticians may no longer be as critical to Coast Guard operations as they once were, and that we can procure needed services from the private sector at lower cost. While it's true that you can procure engineering and logistics services from the private sector - and we do so every day - you can't hire Coast Guard engineers, with their core values of honor, respect and devotion to duty, from the private sector for the simple reason that they don't exist in the private sector. They exist in one place only - the Coast Guard. Coast Guard engineers and logisticians will remain critical components of the service as long as there is a Coast Guard. These may seem like truly challenging times, with change looming around every corner, but the engineering and logistics communities will continue to play a vital role in ensuring the Coast Guard is capable of meeting its wide range of missions. Whether analyzing inventories, planning maintenance, managing our workforce, or ensuring operational units meet their commitments, engineers and logisticians will always be an integral part of the portfolio of capabilities. You can expect that before drastic changes are made in our workforce or our logistics systems, the Coast Guard will ensure the changes are in the best interests of the service and its people. I remain supremely confident that together we can master any challenge we face in the future. Through your hard work, dedication and determination, the Coast Guard will remain "Semper Paratus." Thank you for your continued service to the Coast Guard and to our nation. And thank you for being a team of superbly professional engineers and logisticians. As with the Coast Guard of the past, the Coast Guard of the future needs and requires your best efforts.

I would be remiss if I didn't acknowledge the superb performance of the Coast Guard men and women -- active duty, reserve, auxiliary, civilian, contractor -- who either responded to the human needs and property devastation wrought by the year's very active hurricane season, or who supported those responders. The most significant response was, of course, to Hurricane Katrina, and the performance of Team Coast Guard was simply outstanding. Well done to all of those who responded and to all of those who supported the response! -- you make me proud to be wearing the Coast Guard uniform.



Dale G. Gabel RADM, USCG
Assistant Commandant for
Engineering and Logistics

Command Centers (C2CEN)

The Command and Control Engineering Center (C2CEN) will begin deploying new classified tactical computer systems in late 2005 at 19 locations, including Area, District and Sector (San Juan and Guam) Command Centers, CGHQ, National Maritime Intelligence Center (NMIC), Intelligence Coordination Center (ICCs) and Communications Area Master Station (CAMS). This upgrade will provide easy to use Windows™ based computers integrated with the Video Display System (VDS) that will enhance display and briefing capabilities. At the core of the new system are powerful rack mounted Sun servers running the recently approved Common Operating Environment (COE) version 4.0.1 software. These servers will provide a locally controlled tactical picture to Command and Control Personal Computer (C2PC) users via CISCO enclave switches. This project replaces existing equipment that is beyond its service life with faster and more reliable hardware. It will also ensure future interoperability with Department of Defense systems and provides the backbone to support the continuous growth of SIPRNET use. C2CEN will schedule these upgrades with the unit and the installing activities. Schedule and weekly project updates can be found at C2CEN's Intranet web site: http://cgweb.lant.uscg.mil/c2cen. Command Centers POC: LT Baronas (757)-686-4156.

Sensors (C2CEN)

Automatic Identification System (AIS) prototyping is underway at C2CEN. In late August, CGC STATEN ISLAND became the first platform for the Coast Guard's Standard Automatic Identification System (AIS) transponder aboard non-Deepwater cutters 65ft in length and greater. This installation follows a one year procurement and engineering effort by C2CEN. The new ProTec transponder is manufactured by L3 Communications, and provides capabilities unique to Coast Guard cutters, ensuring they have the ability to receive other vessel identities and locations without revealing their own. As of the end of September, C2CEN completed prototype installations aboard seven cutter classes with plans to reach eight more this year. Following successful evaluations and engineering change approvals, contracts will be solicited for completion of installations throughout the cutter classes. Follow-on efforts by C2CEN to integrate AIS aboard its Electronic Charting and Integrated Navigation Systems (ECINS) equipped cutters will increase navigation safety and maritime domain awareness capabilities. C2CEN will coordinate the installation of more than 200 transponders thru operational commanders during cutter maintenance periods in a predetermined order set by Headquarters' Office of Cutter Forces (G-OCU). An introductory primer on how AIS works can be found at Navigation Center's (NAVCEN) we site, http://www.navcen.uscg.gov/enav/ais/default.htm. Sensors POC: LCDR Young (757) 686-2188.

Nationwide/Maritime Differential Global Positioning System (N/DGPS) (C2CEN)

The Nationwide Differential GPS (NDGPS) expansion project continues to increase signal coverage throughout the U.S. Thirty-Four NDGPS sites are now on air supplementing the existing Maritime DGPS sites for a total of 85 transmitting broadcast sites. Eighty seven percent of the country is receiving at least one DGPS signal and fifty five percent of the country is receiving at least two DGPS signals. Recently, U.S. Air Force Ground Wave Emergency Network (GWEN) sites located in Klamath Falls, OR and Topeka, KS were converted to NDGPS operations. The Topeka site replaces the older Kansas City Army Corp of Engineers DGPS site. The upcoming months will show the same steady progress, as additional sites will be brought on-air. These sites include new construction sites in St. Mary's, WV; Dandridge, TN; and Idaho Falls

ID, as well as GWEN conversions in Essex, CA and Mequon, WI. After these efforts are completed, nearly 95% of the continental U.S. will be covered by at least one NDGPS signal. The present NDGPS predicted coverage map is shown in Figure 1 with single coverage areas in gray and double coverage areas in yellow. Figure 2 shows the complete map of proposed NDGPS sites.

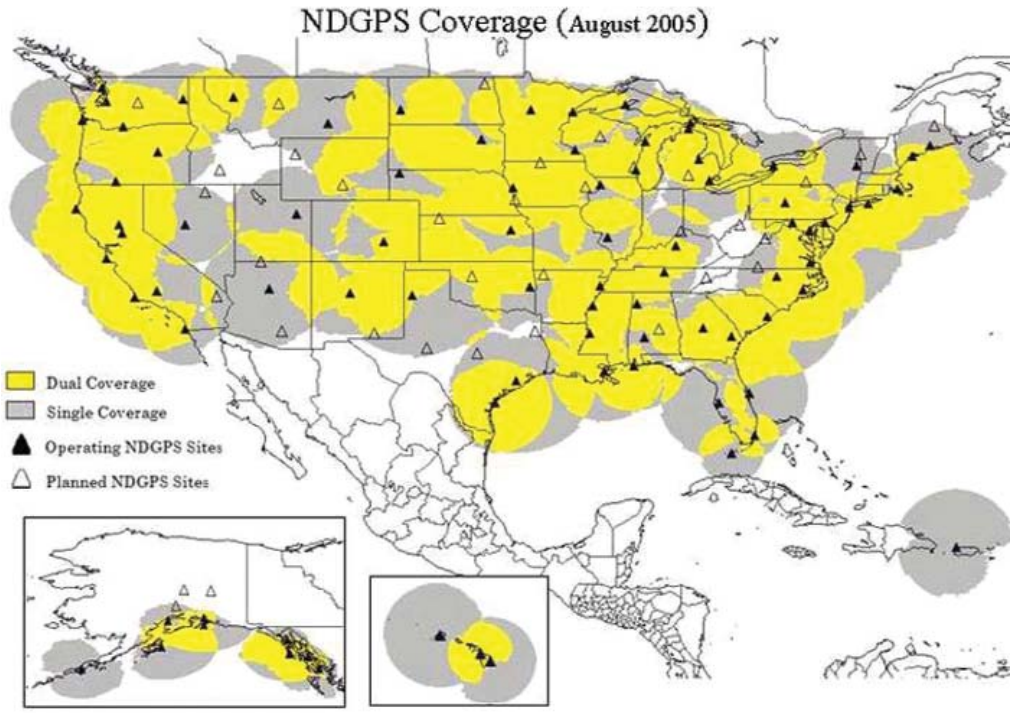
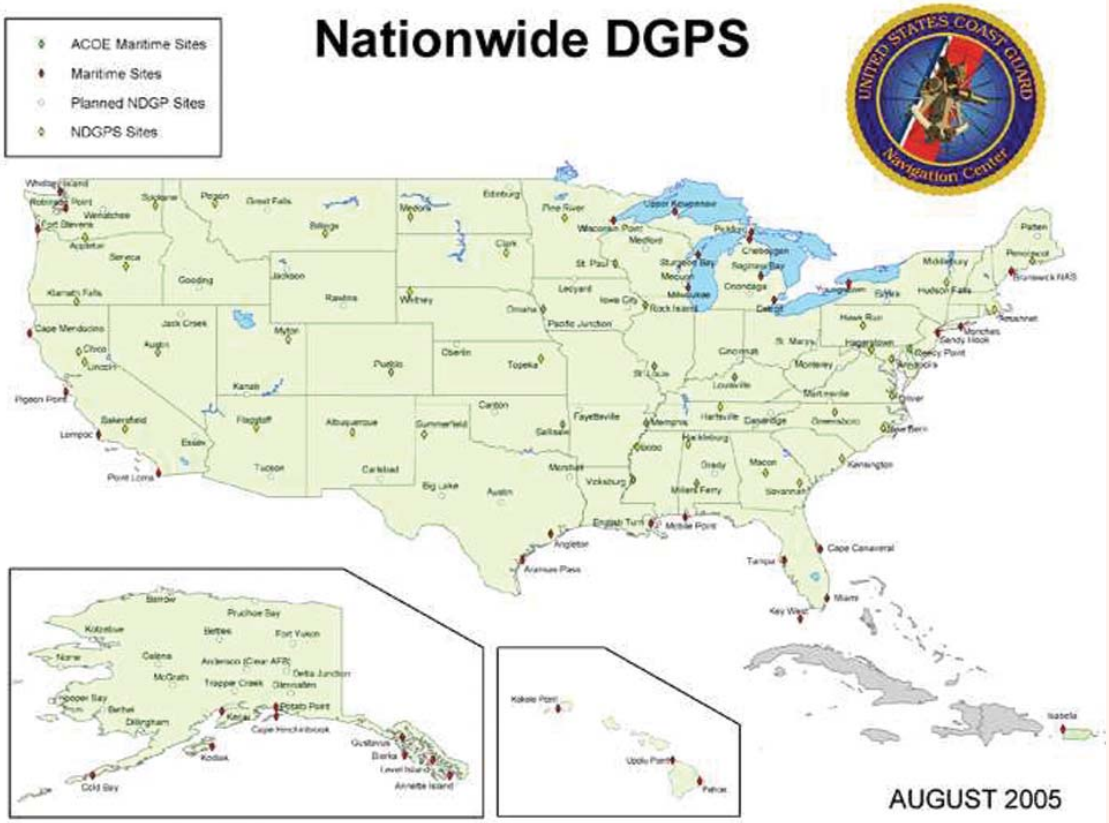


Figure 1. AUGUST 2005 PREDICTED NDGPS COVERAGE (Courtesy USCG NAVCEN).

Figure 2. PLANNED NDGPS SITES (Courtesy USCG NAVCEN).



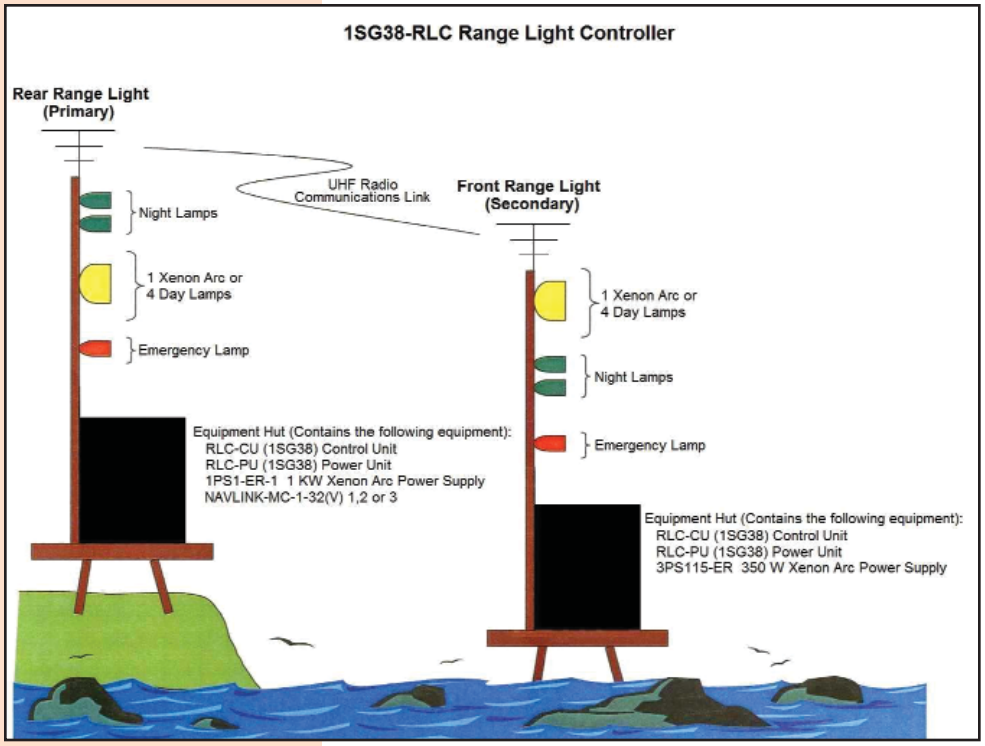
USCG C2CEN (Command and Control Engineering Center) continues to work with equipment manufacturers and field units to implement several recently issued Field/Engineering Changes (FC/EC) designed to improve overall availability and reliability of the N/DGPS service. These changes include EC2, which replaces the Southern Avionics PC1KILO Medium Frequency (MF) automatic tuning units at all maritime DGPS sites and medium power NDGPS sites. Additionally, recommendations have been forwarded to the Maintenance and Logistic Commands (MLC) on both coasts to upgrade maritime DGPS MF antennae to enhance configurations that will improve operability in foul weather.

Several major N/DGPS system engineering changes are in the works at C2CEN including; the replacement of Z-12 DGPS Reference Stations and 4000IM DGPS Integrity monitors with PC based platforms at all N/DGPS sites; reengineering of the Southern Avionics SC-1000 DGPS MF transmitter to improve reliability; replacement of GPS receiver antennae at all sites; grounding improvements to decrease susceptibility to lighting and icing outages; and upgrades to the Nationwide Control Station (NCS).

N/DGPS Point of Contact is Mr. David Wolfe at (757) 686-4015.

Short Range Aids to Navigation (SRAN) (C2CEN)

In the last year, C2CEN prototyped and fielded the 1SG38-RLC Range Light Controller (RLC) system at Elk River, MD. The RLC is a new robust product for the Aids to Navigation (ATON) community which is available for large water ways that require safe navigation via a lighted and monitored range.



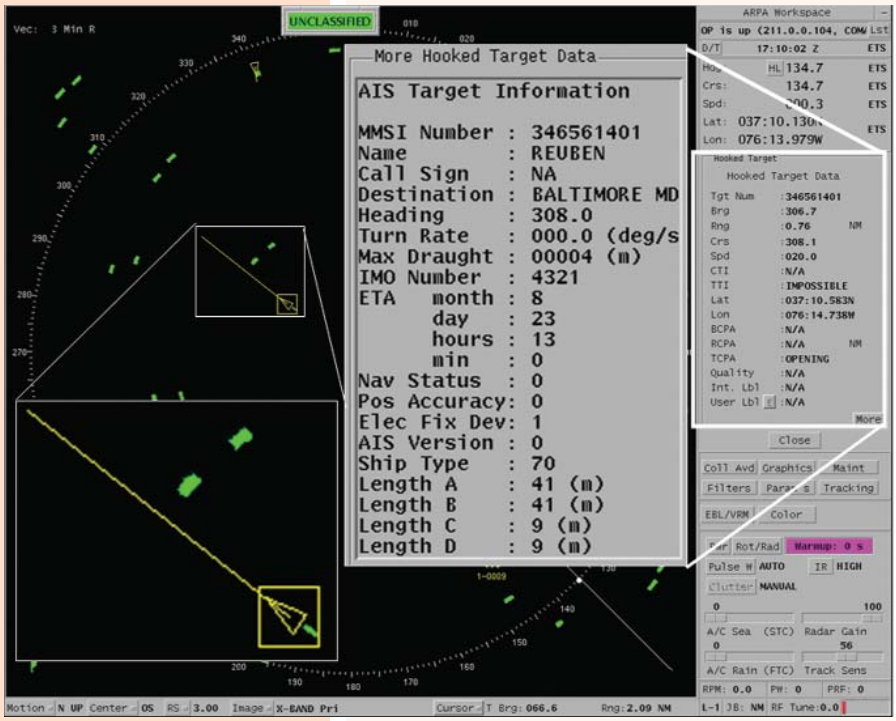
The purpose of the RLC system is to control high intensity optic equipment on Day/Night ranges. The system is designed to control the optic equipment during Day/Night changes and primary power failures and to ensure a balanced intensity to the mariner at dusk and dawn. The Day/Night lamps on each light tower can be configured to include up to four (4) day lights, two (2) night lights and an emergency light, or have the four day lights replaced by one Xenon Arc light. The Day/Night lamps are configured to a set of flash characteristics. These flash characteristics are fixed, normally used with the Xenon Arc and emergency lights, occulting, isophase and flashing. The system consists of a RLC-CU (1SG38) Control Unit (CU) and a RLC-PU (1SG38) Power Unit (PU) installed on one light tower and an identical CU and PU installed on a second light tower. The RLC system requires the equipment on the rear light tower to be configured as the Primary Unit, and the equipment on the front light tower to be configured as the Secondary Unit. The CU, PU and the Xenon Arc Power Supplies,

when utilized, both the Primary and Secondary Units are enclosed in a weather protecting equipment hut. Ultra-High Frequency (UHF) radios with Radio Frequency (RF) modems at each unit provide a communications link between each units CE-SBC-SC400 touch screen Computer Processing Unit (CPU). The data exchanged over this link provides synchronous switching and the lighted optic characteristics of both the Primary and Secondary Units Day/Night lamps. Up to seven lamps, four day, two nights and one emergency, can be installed and controlled on both the Primary and Secondary Units at each range site. The Day/Night operation is protected to ensure that the daytime lamps do not come on at night thereby creating a hazard to navigation. The RLC Primary and Secondary Units operate similarly except for two functions, remote communications and optic synchronization. The RLC Primary Unit directs all remote communications and optic synchronization for the RLC Secondary Unit. The RLC system is fully compatible with the 1SG38-ACMS, Aid Control and Monitor System (ACMS), which allows the system to be monitored and controlled from a remote location. The system can also operate independently as it does in the event of a remote communication link failure. The normal communication link between the RLC Primary Unit and the ACMS Master Unit (MU) is via a Dial-Up Modem. However, if the situation requires, an RF Modem may be used to provide this communications link. The doors to the equipment hut, the CU and PU on each tower are equipped with an intrusion alarm that will notify the ACMS remote station of an entry into the hut and the CU and PU cabinets.

The C2CEN PoC for Short Range Aids to Navigation (SRAN) is Mr. David Wolfe; (757) 686-4015, David.B.Wolfe@uscg.mil.

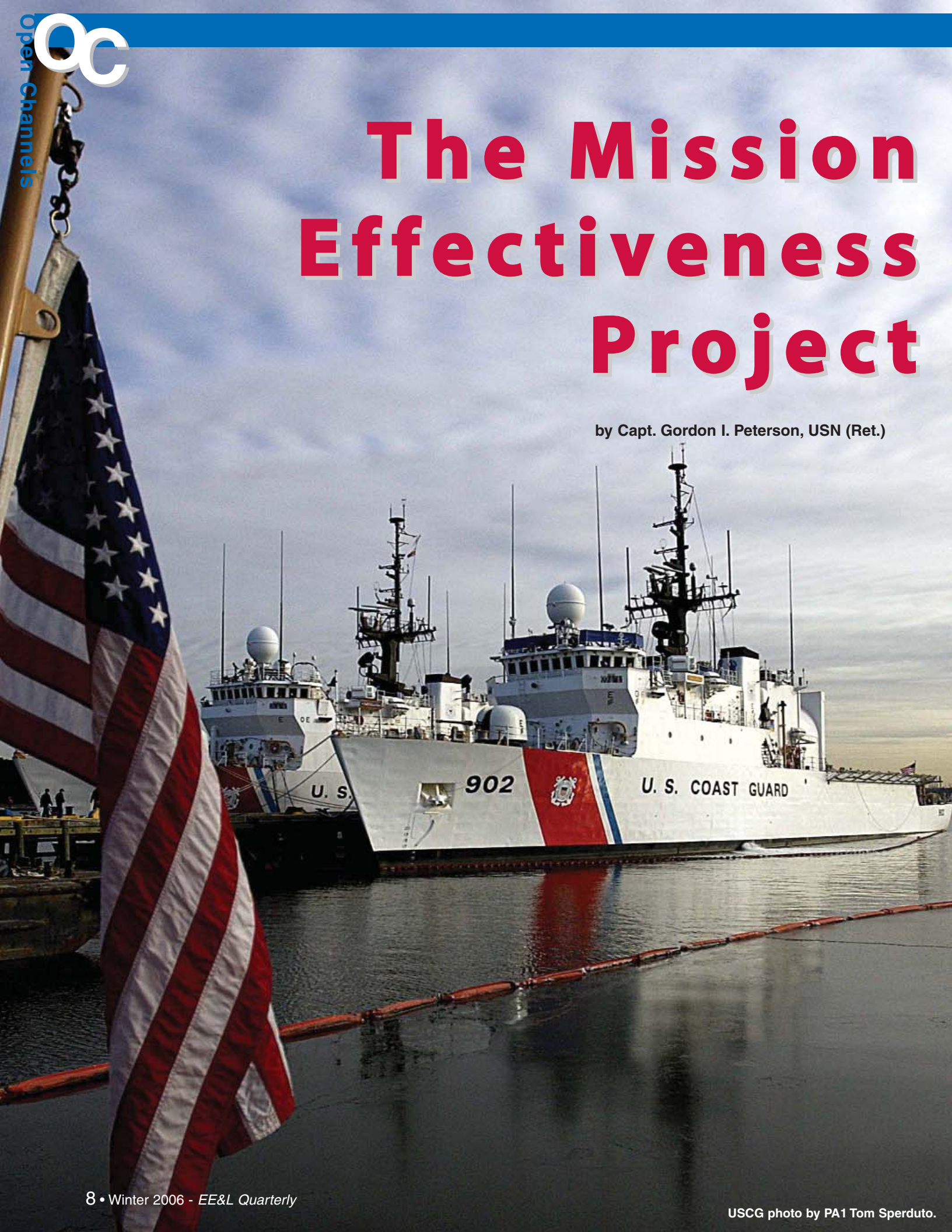
SCCS (C2CEN)

Display of Automatic Identification System (AIS) targets will appear in version 2.2.3 Shipboard Command and Control System (SCCS), delivered to the first cutter in October 2005. Viewing AIS targets in SCCS will provide a display area 50 times larger than what is currently provided by fielded transponders. Initially, AIS targets will be viewed in COMARPA, a software application that displays and controls AN/SPS-73 RADARs. This capability is the first step in a strategy to integrate AIS target data throughout the Coast Guard's navigation and tactical tools. C2CEN's long term plans includes correlating tracked RADAR targets with AIS targets, displaying AIS targets over electronic charts, injection of AIS targets into the AN/SPS-73 system, and transmission of AIS targets to the Coast Guard's Common Operational Picture (COP). SCCS receives a one-way data feed from both ICGS's Saab R4 and C2CEN's L3 ProTec transponders. SCCS is currently fielded on 66 cutters, including WHECs, WMECs, WIX, WPB and WGTB cutter classes. C2CEN announces the release of system changes via C2CEN SMEF advisories, and coordinates upgrades with cutter crews and operational commanders. Additional information, including supporting information about SCCS and how you can reach the Systems Management Engineering Facility (SMEF) help desk, can be found at C2CEN's Intranet web site: http://cgweb.lant.uscg.mil/c2cen. SCCS PoC: LT LaFond (757) 686-2154.



The Mission Effectiveness Project

by Capt. Gordon I. Peterson, USN (Ret.)



USCG photo by PA1 Tom Sperduto.

"Bridging the Gap" for Medium Endurance Cutters

The medium endurance cutter USCGC TAMPA (WMEC 902) now sits high and dry at the Coast Guard Yard in Baltimore, Md. In May, the 25-year-old fleet workhorse became the first 270-ft Coast Guard cutter to enter a nine-month major systems refurbishment as part of the Mission Effectiveness Project (MEP).

"The Mission Effectiveness Project is a key part of the Deepwater strategy," said RADM Dale Gabel, then the Coast Guard's Assistant Commandant for Acquisition, at the Coast Guard's MEP-commencement ceremony held at the Yard in May. "It will allow the Coast Guard to bridge the gap until new, high-tech cutters are delivered over the next 10 to 15 years."

Resting on blocks on the Coast Guard Yard's shiplift -- a modern, land-based ship handling facility -- TAMPA is being refurbished by shipyard workers who have water-blasted several years' accumulation of paint from the cutter's hull, weather deck and superstructure. Access holes have

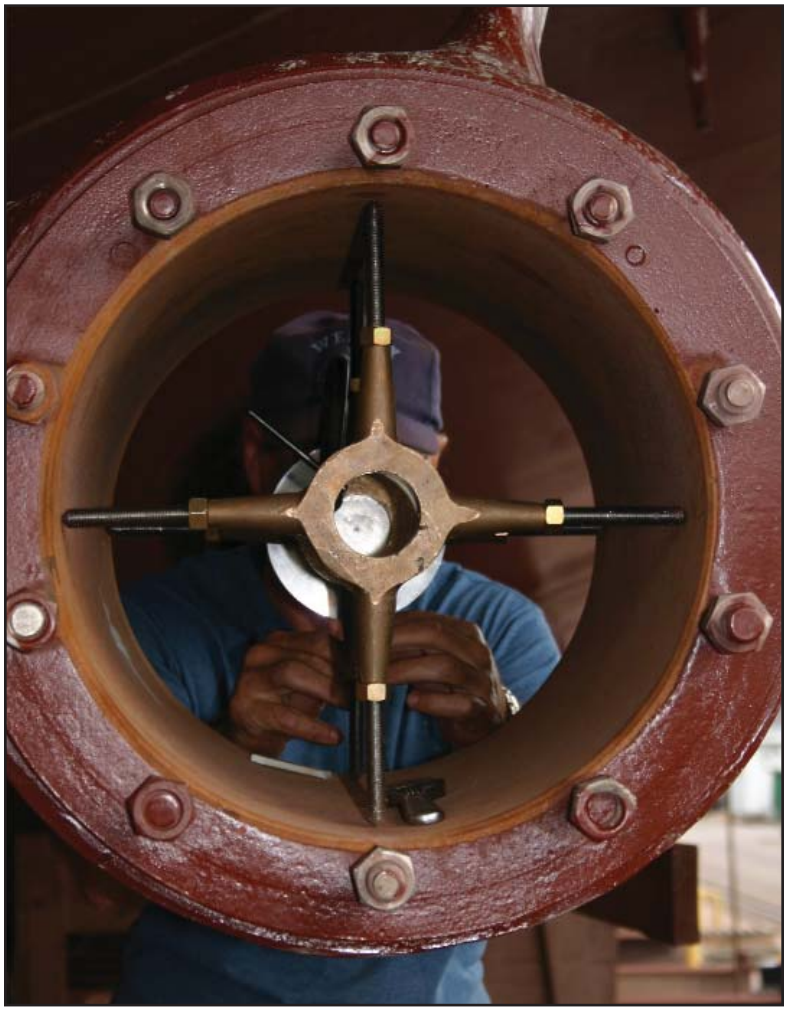
The medium endurance cutter USCGC TAMPA (WMEC 902) sits high and dry at the Coast Guard Yard, Baltimore, Md., during a nine-month major systems refurbishment as part of the Mission Effectiveness Project for 210-ft. and 270-ft medium endurance cutters planned by the Acquisition Directorate at Coast Guard Headquarters and funded by the Deepwater Program. TAMPA entered the Yard in May 2005. USCG Photo by Gordon I Peterson

been cut into the hull's port side to facilitate the removal of large machinery slated for replacement. Former crew members would not recognize selected enlisted berthing, locker, head and lounge compartments now undergoing extensive renovation.

"This multi-year sustainment project for our 210-foot and 270-foot cutters will replace obsolete and increasingly unsupportable systems to improve reliability and reduce future maintenance costs," said CAPT Stephen Duca, commanding officer of the Coast Guard Yard. "The MEP will help to ensure the 210-foot and 270-foot medium endurance cutter fleet can perform all assigned missions until new cutters are delivered under the Deepwater Program."

MEP will eliminate many of the problems associated with the cutter's aging equipment and systems. Some of the new equipment slated for installation on the 270-foot cutter includes the over-the-horizon boat davit, a main diesel engine electronic governor control, an engine room fire-protection system, a reverse osmosis water-making unit and the Mark 39 gyrocompass. Habitability refurbishment will also improve living conditions for the crew.

The MEP is being managed by the Acquisition Directorate at Coast Guard Headquarters, Washington, D.C., and funded annually by the Deepwater Program. The Coast Guard currently anticipates upgrading up to 27 of its 270-foot Bear class cutters and 210-foot Reliance class cutters under MEP. The cutters will be phased into the Yard's workload over the next several years to extend their service lives for an additional 10 to 15 years.



Bob Reed, a machinist at Coast Guard Yard, Curtis Bay, Baltimore, Md, checks tolerances on a propeller stern strut on the medium endurance cutter USCGC TAMPA (WMEC 902). USCG Photo by Gordon I. Peterson

There is also an Operating Expenses (OF) component of the MEP project to cover routine drydocking work being funded and managed by Maintenance and Logistics Command Atlantic.

"Timely delivery is the key goal," said CAPT Duca. Twelve other 270-foot Bear class cutters and up to 14 210-foot Reliance class cutters will follow TAMPA into the yard, beginning with the 37-year-old USCGC DEPENDABLE in September. Each 210-foot MEP is planned for five months; each 270-foot MEP is projected to take nine months.

The 106-year-old Coast Guard shipyard is well-postured to execute the MEP. Co-located with the Engineering Logistics Center (ELC) at Curtis Creek, the Yard has a long history of similar renovation projects to sustain legacy assets. Many of the older cutters slated for refurbishment were either built at the Yard or upgraded there in years past. A full-service shipyard, the Yard delivers a wide variety of products and services encompassing the component design, manufacture and complete overhauls of cutters, boats and weapons systems.

Steady annual funding of approximately $30 million will enable the Coast Guard's Acquisition Directorate and the Yard to plan and execute each cutter's MEP as efficiently as possible.

One unusual aspect of the TAMPA's MEP is that her approximately 100-member crew is no longer stationed aboard the cutter. Crew members have returned to interim assignments with the Coast Guard's Atlantic Area Command to support multi-crewing initiatives and other functions.

Capt. Gordon I. Peterson, USN (Ret.), a senior technical director for the Anteon Corporation's Center for Security Strategies and Operations, supports the Coast Guard's Integrated Deepwater System Program.

In addition to the USCGC TAMPA's refurbishment, the Coast Guard's Engineering Logistics Center is conducting a comprehensive Integrated Logistics Overhaul concurrently to correct the cutter's configuration data and properly align all logistics elements. USCG Photo by Gordon I. Peterson

CAPT Stephen C. Duca (left), commanding officer of Coast Guard Yard, Baltimore, Md, and Bruce Youngbar, a program manager at the Yard, inspect an enlisted berthing compartment undergoing renovation on the medium endurance cutter USCGC TAMPA (WMEC 902). USCG Photo by Gordon I. Peterson

Machinists prepare to align a propeller shaft on the medium endurance cutter USCGC TAMPA (WMEC 902) her refurbishment. USCG Photo by Gordon I Peterson

Integrated Logistics Overhaul

In addition to the cutter TAMPA's refurbishment in the MEP, the Coast Guard's Engineering Logistics Center (ELC) is conducting a comprehensive Integrated Logistics Overhaul (ILO) concurrently to correct the cutter's configuration data and properly align all logistics elements.

"It does not make sense to renovate systems on the cutter if you don't correct logistics shortfalls as well," said CAPT Kevin Jarvis, ELC's commanding officer. "The ILO will improve cutter readiness by providing logistics support that accurately reflects the cutter's true equipment and operating needs."

At present, the ELC plans to perform ILOs on all medium endurance cutters inducted into the MEP.

As part of the ILO, all of the cutter's logistics-support inventory will be off-loaded to a shore-side location for analysis and evaluation. A team of ELC staff, assisted by contractors, will inspect each cutter during the MEP to conduct a "record-to-floor/floor-to-record" audit of nearly all configuration items. At the same time, teams will baseline maintenance procedure cards and technical manuals against the configuration and reconcile any discrepancies. Newly digitized ship maintenance publications and ship drawings will be provided to the crew on CD-ROM discs.

"The stars are perfectly aligned to deliver a system-of-systems answer to sustain our legacy medium endurance cutter fleet," said Jarvis.

The "Yin and Yang" of the Deepwater System

by PAC Jeff Murphy, USCG

On April 16, the crew of the Coast Guard Cutter FORWARD, along with the crew of *USS Doyle*, a Navy guided-missile frigate, with Coast Guard Law Enforcement Detachment 408 embarked, interdicted a go-fast vessel in the southeast Caribbean Sea. The crew detained one suspected Mexican and five suspected Colombian narcotic traffickers. During the boarding, 77 bales of contraband retrieved from the water tested positive for cocaine.

This successful interdiction mission is representative of the close Navy-Coast Guard collaboration in the war on drugs. It also reflects the growing impact the Deepwater Program's progressive sustainment and modernization of legacy assets are having in improving the operational effectiveness of an aging fleet.

According to the cutter FORWARD's patrol summary, "The use of a separate chat room for cutter FORWARD, *USS Doyle*, District Seven Law Enforcement Detached Office and Joint Interagency Task Force (JIATF) South for our go-fast intercept case was valuable to maintain battlespace awareness."

Direct, manned communications in a separate chat room allowed the crew of the cutter FORWARD to request its own "statement of no objection" for warning shots and boarding immediately after the go-fast began to out run the *Doyle* -- even though cutter FORWARD was not in sight of the go-fast. "The time from granting the statement of no objection to rounds out of the barrel was six minutes," cutter FORWARD's commanding officer said. "If the statement of no objection had been 10 minutes later, the go-fast would have eluded us also."

The availability of a secure internet protocol network (SIPRNET), a tool that allows secured communications between operational commands, disseminates information quickly and allows for classified Internet chat. Installed during a Deepwater Program Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) upgrade on the cutter FORWARD, the network played a critical role in this successful interdiction and boarding. "The reason our drug seizure rate set a record last year is because superb intelligence enabled a more effective tactical response. Fewer assets have operated more effectively -- seizing 240,000 pounds of cocaine," said RADM Patrick M. Stillman, Deepwater's program executive officer.

Deepwater's system places emphasis on interoperability between assets -- capitalizing on the synergy generated by multiple units working together to produce results not obtainable individually. Through improved systems for command and control, crewmembers can deter and prevent threats as far from U.S. borders as possible. These same systems also enable quick movement of assets to where they are needed so wider areas may be surveilled with limited numbers of assets. The common link that bonds the system together is C4ISR.

Recently, Senior Chief Petty Officer Eric W. Gallett, an operations system specialist and Deepwater C4ISR team member, visited crews aboard the renovated 123-foot Island-class cutters in Key West, FL, to see firsthand how the new Deepwater communications suite was faring at sea.

"The crews kept telling me, 'This is what we've been waiting for,'" recalled Gallett, who is co-located with one of Deepwater's partners in industry, Lockheed Martin, in Moorestown, NJ. "The patrol boat crews and operators are out there working in concert with one another and able to communicate on chat lines as well as visually through Common Operating Pictures (COP) with the newly installed phase one C4ISR upgrades."

He cited a recent example of cooperative operations enhanced by the upgrades. Coast Guardsmen aboard a new Short Range Prosecutor small boat, working jointly

with an Air Station Clearwater C-130 aircrew and two 123-foot patrol cutters stopped, boarded and seized a suspicious 30-foot vessel and crew near Cay Sal Banks, Bahamas, after discovering narcotics on board the boat. "The suspects were handcuffed before they knew what was coming," said Gallett.

In addition to 123-foot cutters, the legacy 378-foot, 270-foot and 210-foot class cutters and both Communication Area Master Stations (CAMS) Pacific and Atlantic Areas have been upgraded with Deepwater's first phase of C4ISR installations. The core capability for all Deepwater assets is the interoperable communications connectivity (with partners such as Department of Homeland Security and Department of Defense) which enables classified Common Command and Control systems. It also enables development, compilation and sharing of law enforcement case files, and systematic screening of vessels allows analysis of threats, even those well offshore.

"This is Nirvana for operators," said Gallett. "This is the first phase, and it's only going to get better!"

The second phase of Deepwater C4ISR upgrades scheduled from 2008 to 2011, will improve interoperability for joint operations and decision support. The emphasis will be to enhance Sector Command Center integration to improve threat identification and deterrence.

The third phase of Deepwater's C4ISR upgrades, projected for installation from 2010 to 2013, will increase maritime domain awareness, as well as enhance communications capabilities. Common intelligence information will incorporate all-source information (national, internal and non-classified sources of information), enhance Rescue-21 interoperability, and improve the COP for effective blue-force (i.e., "friendly") tracking. Communications upgrades will focus on integrated law enforcement radios, and chemical, biological and radiological nuclear explosive standoff detection and tracking capability for containment and response.

The fourth phase is scheduled from 2012 to 2017. It will complete the system by creating broader communication paths for increased network capability and embedded training to improve operator performance.

Gallett noted training on the new equipment is a concern to the fleet and acknowledged there is room for improvement. "Units are given new tools to complete their mission and provided training, but it is through their resolve that the crew discovers new features with that deliverable."

According to LCDR Paul Baker, Office of Training, Workforce Performance and Development, personnel will discuss the training just provided to the new 123-foot cutter crews with the operators. "This training was provided as a result of significant crew turnover. Upon completion, Sector Key West units will have the opportunity to provide input on the training received. Petaluma is currently being modified to support the national security cutter C4ISR equipment and completed by August 2006 with training to commence in the late August-September 2006 timeframe. We are currently looking at the possibility of installing a 123-foot cutter C4 component out there as well, but that is still in progress."

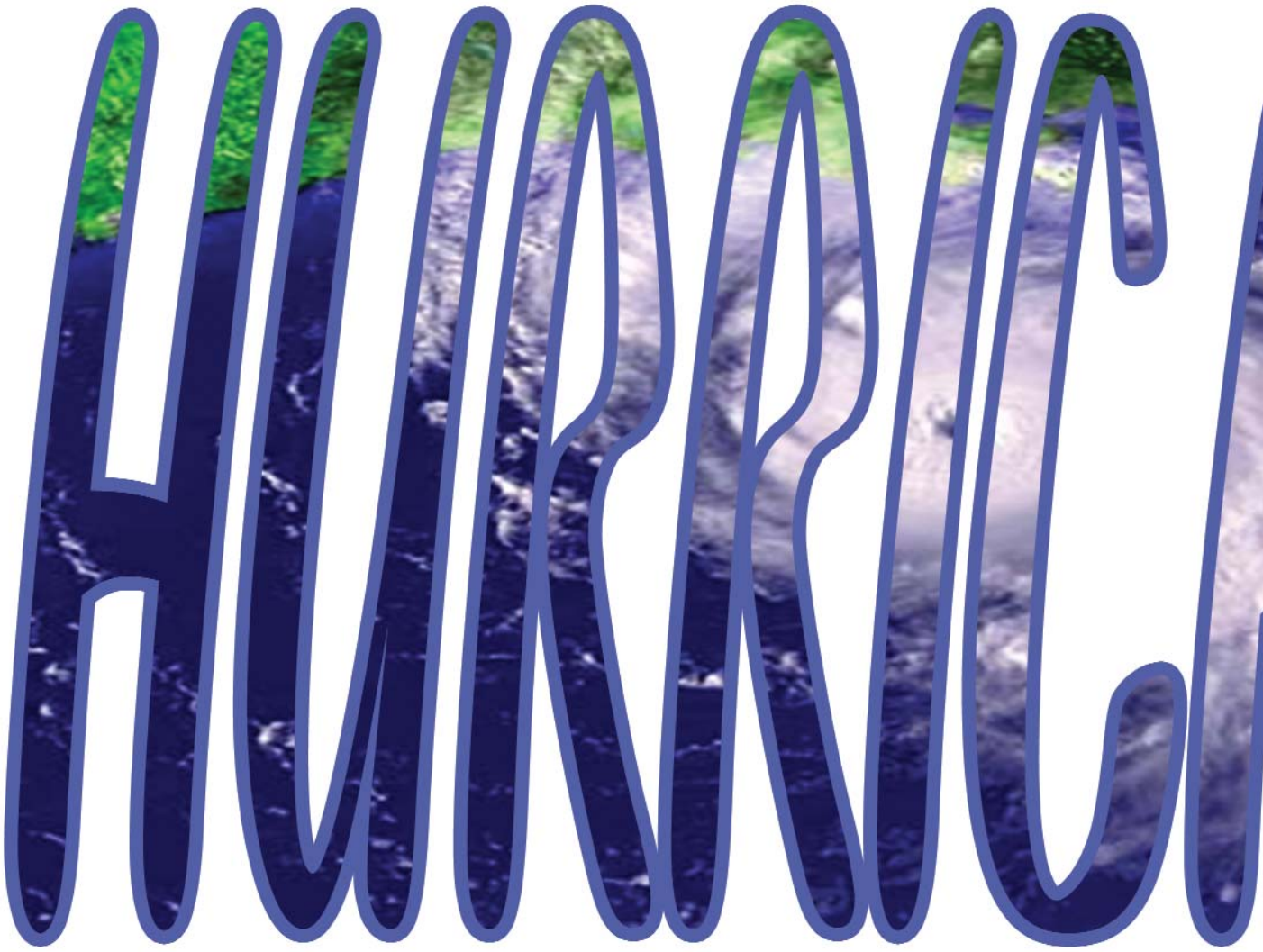
An Integrated Product Team (IPT), located at the Deepwater system integrator's office in Virginia, is finalizing a training plan for each system. "Training will consist of training the trainers at the unit initially," said Gallett. "Eventually, C4ISR will be incorporated into an 'A' School course at Training Center Petaluma, Calif. Train them on capabilities aboard the cutters and you'll see magic. There are so many possibilities vice restrictions when it comes to the new assets. We're getting smarter on how best to use the new equipment."

The Commanding Officer of the 123-foot cutter Matagorda, LT Jose Bolanos, echoed Gallett's enthusiasm for the upgrades his ship received. "The information available on the bridge from the COP, chat, SeaFLIR (a fully marine prepared, gyrostabilized thermal imaging system for maritime and airborne use) and Automatic Identification System (AIS) allows us to more efficiently employ the ship," he noted. "When hull strength issues are corrected, the 123-foot patrol boats will clearly be an improvement over the 110-foot patrol boats."

"The new capabilities have dramatically improved the way we conduct day-to-day operations and the personnel savings with the launch and recovery of the short range prosecutor allows us to focus that energy on sustaining a higher operational tempo," Bolanos asserted.

The new stern ramp on board the 123-foot patrol boats allows the short range prosecutor crew to expedite their transfer safely vice climbing aboard a Jacob's ladder along the side of a vessel. The crew can quickly return to the vessel, transfer passengers and contraband, and get back on patrol in minutes.

Gallett summed up the progress to date this way: "The Yin and Yang of the Deepwater system enhancements are a lot of technological break-through with constant improvements creating more successes," said Gallett, "however, the material conditions of the boats are holding us back. I can't imagine what it will be like when the Offshore Patrol Cutters and National Security Cutters enter the fleet."



Civil Engineering Unit Miami's Hurricane Response

by CEU Miami

U.S. Coast Guard photo.

Editor's Note: *In the wake of Hurricanes Katrina, Rita and Wilma we are presenting this article, prepared in 2003, which describes Civil Engineering Unit Miami's hurricane preparation and response.*

Hurricane Threat

Each year during hurricane season, between the months of June and November, millions of people along the Gulf and Atlantic coasts keep a close eye on the warm waters of the Caribbean Sea for the formation of tropical cyclones. On average, there are ten named Atlantic tropical cyclones that develop each year. A handful of these storms can be expected to develop into major tropical storms or hurricanes that will threaten to make landfall in the United States.

Coast Guard Civil Engineering Unit (CEU) Miami is located in the epicenter of hurricane activity just 10 miles south of the National Hurricane Center in an area devastated by Hurricane Andrew over a decade ago. CEU Miami's area of responsibility stretches from South Carolina to Texas and includes Puerto Rico and the Virgin Islands. The majority of hurricanes that make U.S. landfall do so in CEU Miami's area of responsibility. Each year CEU Miami responds to provide support to Coast Guard shore facilities that have been impacted by these tropical cyclones.

Natural Disaster Support Plans

CEU Miami's preparation for the hurricane season begins in May with a review of the applicable instructions including Maintenance and Logistics Command (MLC) Atlantic's Disaster Support Plan, CEU Miami's Disaster Action Plan, as well as District Seven's and District Eight's Natural Disaster Preparedness plans. Training sessions are held to educate personnel on these documents and basic hurricane preparedness. Recall lists for essential personnel are developed and forwarded to MLC.

Forty Eight to Seventy Two hours before a storm is expected to make landfall MLC designates a CEU that will have primary responsibility to assess storm damage and coordinate repairs. Generally the designated CEU is the one who provides support for the District in which the storm is expected to come ashore. An exception to this practice is when a storm threatens to make land fall in Miami. In this instance CEU Providence or CEU Cleveland would be designated as the primary CEU.

At the same time MLC also designates an Integrated Support Command (ISC) that will deploy an Emergency Response Team (ERT). The ERT is a team of carpenters, electricians and mechanical specialists that will deploy to storm damaged areas to make repairs to the shore facility. The ERT will bring tools and materials (i.e., plywood, drywall and roof shingles) with them to make repairs in the event that local suppliers are unable to provide the necessary building materials.

Homes damaged in Miami from Hurricane Andrew in 1992.

Plywood slices a palm tree during Hurricane Andrew in 1992.

Upon designation, the primary CEU stands up one or more Disaster Assessment Teams (DAT). Depending on the expected severity of the storm, the DAT may range in size from one or two people to a large contingent of engineers and architects. The DAT leader is typically the civil engineering coordinator responsible for the geographic region affected by the storm.

The purpose of the DAT is to be the first Coast Guard support personnel on site at Coast Guard shore facilities after passing of the storm. In order to accomplish this the DAT travels to staging areas just outside the storm's path or at a safe distance inland. After passage of the storm, the DAT makes its way to the Coast Guard facility expected to have sustained the most serious damage. Once on site they assess the damage, make any critical repairs that are within the capability of DAT (i.e., electrical engineer may troubleshoot problems with the electrical distribution system), and reports to the CEU. The DAT reports to the CEU on the extent of the damage and the impact of the damage to Coast Guard operations. The DAT use cell phones, digital cameras and laptop computers to relay images and damage reports back to the CEU. After completing the assessment and making any critical repairs the DAT moves on to the next Coast Guard facility affected by the storm.

Information passed on to CEU from the DAT is collected and compiled by the DAT coordinator. It is the

DAT coordinator's responsibility to interpret the information provided by the DAT and make recommendations to the CEU command and MLC. The DAT coordinator's recommendations focus on what level of resources need to be called in to repair storm damage and which Coast Guard facilities are most in need of these resources. These recommendations are based on the following objectives listed in order of declining priority:

- Protect life and safety
- Protect property
- Restore minimum CG operations
- Restore minimum living conditions
- Restore full CG operations
- Restore full living conditions

In pursuit of these objectives, CEU and MLC will direct the appropriate resources to repair the affected facilities. These resources may include the ERT, local ISC industrial forces and construction contractors. In many instances portable generators and temporary office trailers are brought in for units to maintain operations while repairs to their facilities are being made.

2002 Hurricane Season

During the hurricane season of 2002 seven named tropical cyclones made landfall in CEU Miami's area of responsibility. CEU Miami deployed DATs in advance of two of these storms, Tropical Storm Isidore and Hurricane Lili.

Hurricane Lili 02 October 2002.

Flooding from Tropical Storm Isidore at ISC New Orleans.

Tropical Storm Isidore formed off the coast of South America in mid-September and made landfall at Grand Isle Louisiana on the 26th of September [2002]. Isidore came ashore with sustained winds of 63 mph and a 7-8 ft storm surge. Wind and surge from the storm affected Coast Guard units in Group New Orleans and Group Mobile.

One DAT from CEU Miami was dispatched to catalog Isidore's storm damage. Damage from Isidore included the following:

- ISC New Orleans - Industrial side of ISC flooded.

- Old Station New Orleans - Two above ground fuel tanks were torn from their foundations. Two prefabricated metal storage sheds were destroyed.

- Station Grand Isle - Sewage plant was damaged. Minor damage to siding and roof shingles on Unaccompanied Personnel Housing (UPH) and government homes. The Ground floor on a number of government houses were flooded destroying eleven freezers.

- Station Gulfport - Storm surge damaged shore tie transformer on pier and flooded portions of the station-building ground floor.

- Station Venice - Storm surge flooded portions of the station-building ground floor.

- Station Pensacola - Boathouse roof and siding damaged.

Industrial forces from ISC New Orleans were dispatched to make repairs to Station Gulfport's electrical shore ties and to secure the dislodged fuel tanks at Old Station New Orleans. A contractor was hired to make immediate repairs to the sewage plant at Station Grand Isle. However, additional repairs to the damage caused by Isidore were suspended due to the approach of Hurricane Lili.

Hurricane Lili formed on the 20th of September [2002] and by the 2nd of October (just a week after Isidore came ashore) was threatening to make landfall along the Louisiana coastline just west of where Isidore had come ashore. While over the Gulf of Mexico Lili intensified to a dangerous category four hurricane with wind speeds in excess of 140 mph. With concerns that Lili could be a catastrophic storm CEU Miami dispatched two DATs and MLC dispatched an ERT from ISC St Louis. One DAT was staged out of Mobile, AL and approached damaged areas from the east. A second DAT was staged in Houston, TX and approached damaged areas from the west.

By the time Lili made landfall over Intercoastal City, LA (near CGC PELICAN's moorings) sustained winds had slowed to 74 mph with peak gusts measured at 120 mph. Storm surge was recorded at 11 feet.

Due to high water and downed trees, the DATs were prevented from getting to units such as Aids to Navigation Team (ANT) Dulac and Station Grand Isle

Tropical Storm Isidore damage at Old Station New Orleans.

Flooding at Old Station New Orleans from Isidore.

for up to 48 hours after passage of the storm. Damage from Lili was concentrated on Group New Orleans units. Damaged cataloged by the DATs from Hurricane Lili included the following:

- Station Gulfport - Shingle damage to boathouse.
- Group New Orleans - Erosion around building and waterfront structures.
- Station Venice - Storm surge flooded portions of the Station building, shorting out electrical systems.
- Station Grand Isle - Shingle and siding damage to various buildings. WPB building had windows blown in and roof mounted HVAC unit blown off the roof.
- ANT Dulac - Entire site was covered in 1 to 3 feet of storm surge. Thick layer of mud covered the entire site after recess of storm surge.

Industrial forces from ISC New Orleans were able to make the necessary immediate repairs at Station Grand Isle, Station Venice and ANT Dulac. It was determined that an ERT from ISC St Louis having been mobilized would not be needed and they were directed to return to Missouri before reaching the storm affected areas.

Downed trees block DAT efforts to reach CGC Pelican Moorings after Hurricane Lili.

Hurricane Lili damage to Station Grand Isle gov't housing.

A construction contractor already performing work at Station Grand Isle was hired to make repairs to the housing units and UPH. The WPB building in Grand Isle was scheduled for renovation prior to the storm's damage. As a result, much of the damage was left in place until the renovation contractor mobilized to the site a few months after the storm.

While the damages caused by Isidore and Lili could not be categorized as catastrophic, they ultimately inflicted over $200K of damage to Coast Guard facilities on the Gulf Coast. The diligent pre and post storm efforts of the CEU, MLC and ISCs helped ensure that Group New Orleans and Group Mobile units were able to restore normal operations shortly after the passage of these damaging storms.

2003 Hurricane Season

Forecasters are predicting that the 2003 hurricane season will be very active. Forecasters estimate that there will be twelve named storms with three of these storms developing into major hurricanes. Once again CEU Miami, along with millions of others along the Atlantic and Gulf Coasts, will be closely watching the warm waters of the Caribbean Sea for the development of these devastating storms.

Hurricane Lili damage to STA Grand Isle WPB Building.

Hurricane Lili covers ANT Dulac in mud.

Coast Guard

Our Journey to the Third Generation of Maintenance

by CDR Craig Eller
CG-45

USCG photo by PA2 Sara Raymer.

John Moubray, in his book *Reliability-centered Maintenance II*, tells us there have been three generations of maintenance since the Industrial Revolution. Figure 1 explains the general approach of each generation. The First Generation covered the period up to WWII. The simple approach of fixing what was broke was appropriate given the type of machinery and work processes used at that time. The Second Generation, starting after WWII, takes the approach that equipment failures can be prevented with time-based maintenance. Some industries are still in the Second Generation of maintenance. Others, like the airline industry, have moved onto the third generation.

Figure 1. The growing expectations of maintenance.

First Generation (repairs)	Second Generation (maintenance)	Third Generation (reliability)
- Fix it when it broke	- Time-based maintenance - Measure maintenance activity - Record failures but not consequences	- Track failure modes & consequences, apply appropriate intervention - Performance indicators prove value of reliability program; allow more refined & precise failure/consequence analysis - Maintenance cost reductions allow further investment in RCM tools and system reliability - When appropriate, systems run to failure, with no mission impact

The Third Generation is focused on reliability. It is no longer appropriate to simply "do" maintenance. A successful maintenance department can't claim success just because they complete a prescribed list of maintenance activities. The plant must perform as expected, i.e., it must meet objective, realistic performance standards.

Naval Engineering

The Six Patterns of Failure

Figure 2 shows the traditional view of time vs. failure.[1] The likelihood of failure is relatively constant during the service life of a particular component or system. Then, at the end of the service life the failures increase to a level that is considered unacceptable and the component or system is replaced. Working in the First or Second Generation of maintenance, this is the accepted and expected pattern of failure, and for many components or systems that is indeed an accurate description, but not always. The Third Generation of maintenance recognizes that not one or two, but six patterns actually occur in practice, as shown in Figure 3. With modern complex equipment, there is less and less connection between the operating age of most assets and how likely they are to fail. Age limits and the Second Generation approach to time-based interventions often do little or nothing to improve the reliability of complex items. In fact scheduled overhauls can actually increase overall failure rates into otherwise stable systems.[2]

Modern complex systems generally have fewer, if any, components designed to wear during normal use. Especially when aligned, cleaned, lubricated and installed properly and operated within intended parameters. But even older systems can follow a straight-line wear pattern (patterns D, E or F), depending on how it is maintained and supported. One example is the underground tram that transports elected officials and their staffs from their office buildings to the U.S. Capital. This tram is old. It looks to be roughly 1930's technology with exposed, antiquated electrical switches at the operator's station, but it is reliable and serves its purpose well. Whoever maintains this system has found an adequate supply of spare parts and the old tram system probably costs much less when compared to installing and maintaining a modern tram. It is also probably not a coincidence that congressional staffers escort government officials (like CG personnel) on the tram to and from meetings. This can be an interesting experience, as you ride the antique (but cheap and effective) tram on your way to convince congressional staffers that additional funding is needed to replace an old asset. -- With the tram ride still fresh in everyone's mind, there obviously needs to be more to the story than an asset is old and therefore needs to be replaced, i.e., additional funding is required.

The traditional view of failure

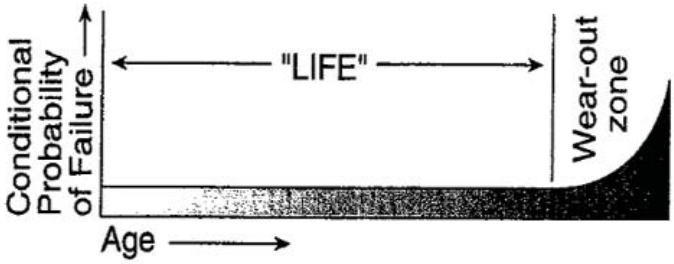


Figure 2.

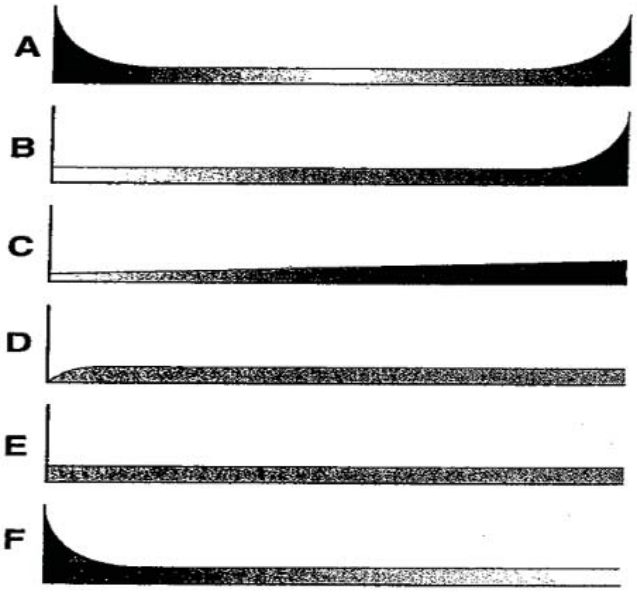


Figure 3. Six Patterns of Failure.

Back to modern systems, a study of the airline industry showed a surprising correlation between the aircraft components and failure patterns. 4% followed pattern A; 2% - pattern B; 5% - pattern C; 7% - pattern D; 14% - pattern E; and 68% - pattern F.[3] Overall that's 89% of aircraft components that do not have a correlation between time in service and failure.

These failure patterns may be interesting but they don't, by themselves, solve the real challenges we have with aging cutter engineering plants. But they do represent a new way of thinking about asset age and failure. Some systems, with an effective, properly funded maintenance program and a robust inventory or source of spares, can move to a straight-line wear pattern. Thinking beyond the traditional wear patterns is one of many

Reliability-Centered Maintenance (RCM) concepts, the foundation of the Third Generation of maintenance.

RCM - Big Opportunities for Operational Effectiveness and Maintenance Efficiency

Reliability - The probability that an item can perform its intended function for a specified interval under stated conditions.[4]

Availability - A measure of degree to which an item is in the operable and committable state at the start of the mission, when the mission is called for at an unknown (random) time.[5]

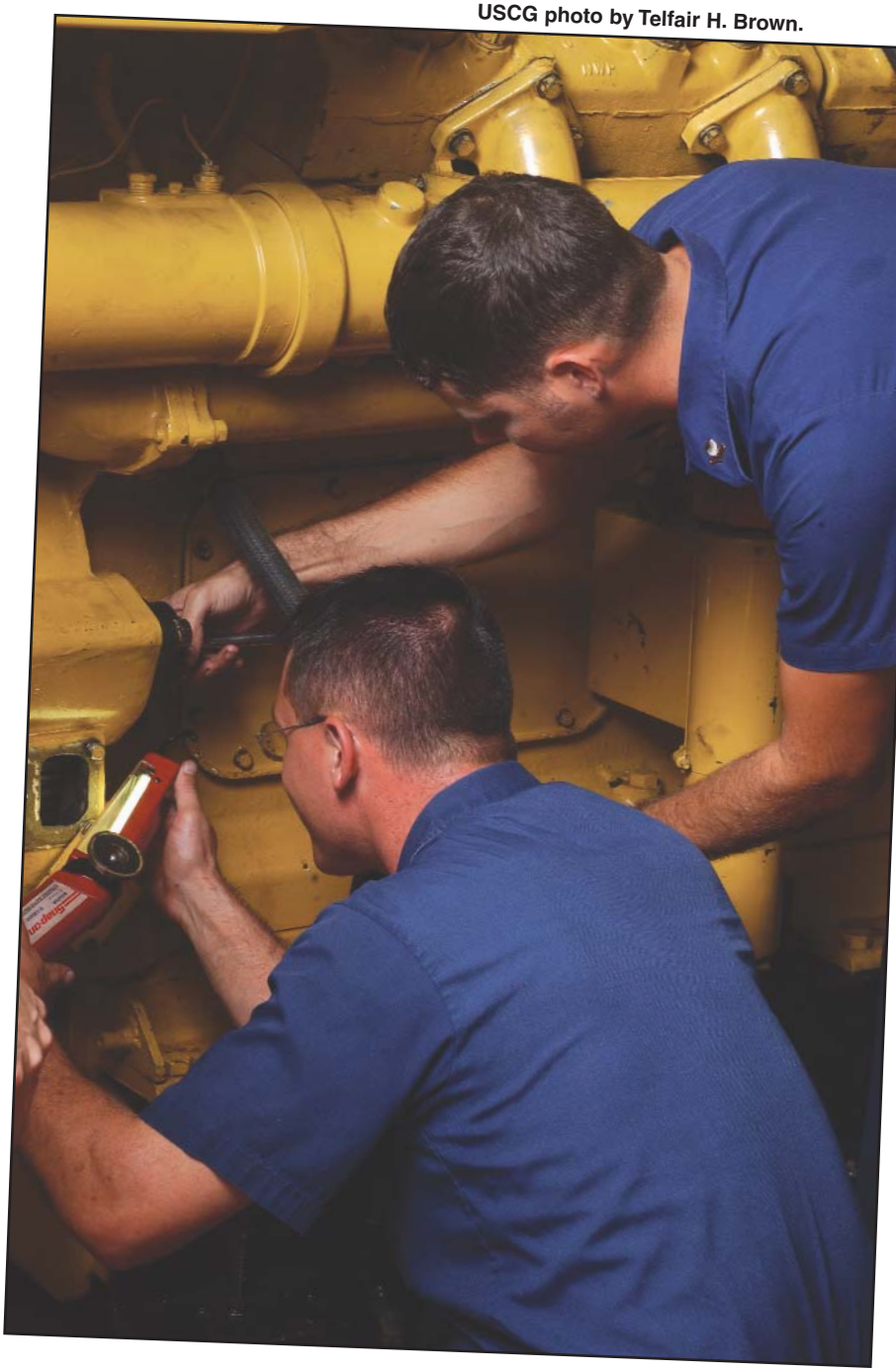
Reliability-Centered Maintenance (RCM) - A process used to determine what must be done to ensure that any physical asset continues to do what its users want it to do in its present operating context.[6]

The RCM Process entails asking seven questions:

- What are the functions and associated performance standards of the asset in its present operating context?
- In what ways does it fail to fulfill its functions?
- What causes each functional failure?
- What happens when each failure occurs?
- In what way does each failure matter?
- What can be done to predict or prevent each failure?
- What should be done if a suitable proactive task cannot be found?[7]

The Coast Guard (CG) Naval Engineering community has embraced the concepts of RCM and we are making big progress in many areas. Captain Paul Roden (USCG) presented a technical paper at ASNE's [American Society of Navel Engineers] 2005 Fleet Maintenance Symposium. The paper *Recent Improvements in Naval Engineering Support for the U.S. Coast Guard Fleet* highlighted many of our ongoing initiatives. For example, we are moving ahead with condition-based drydocking [see Captain Roden's article for the huge potential with this and other promising initiatives at http://cgweb.elcbalt.uscg.mil/branch/branch-page/wow/uscg%20naval%20engineering%20improvements.pdf. Another RCM initiative involves buoy handling systems on the 225 WLB and 175 WLMs, which now receive formal assessments, prior to the cutter's repair availability. Only those components indicating wear, misalignment or other problems will be disassembled -- condition-based maintenance at its best. This initiative was highlighted in two articles in the Summer 2005 *Engineering, Electronics & Logistics* issue. This program will reduce maintenance costs, providing $850K annually for our highest priority deferred maintenance or needed system upgrades.[8]

USCG photo by Telfair H. Brown.



Another initiative with huge potential is bilge preservation preventive maintenance. Designating bilge preservation as formal preventive maintenance is a good example of what RCM can be. Hull failures indicated the need for a better focus on internal preservation. So an appropriate

type of maintenance was developed to reduce or eliminate the identified failure mode (breached hulls). RCM doesn't have to be complicated; it doesn't mean that we must purchase expensive vibration monitoring systems for every piece of rotating equipment and perform extensive condition monitoring. Furthermore, initial RCM implementation does not require you to first start collecting a lot of data, and it does not require mature Mean-Time-Between-Failure (MTBF) or Mean-Time-To-Repair (MTTR) analyses.[9] The point is to know the function of your system components, how and why they fail (time-based or random), and the consequences. The RCM process starts with determining what systems are critical to your operation (or in the CG's case, what systems are mission critical), conducting a Failure Modes and Effects Analysis (FMEA*), considering the consequences, and then using that information to determine the correct maintenance (see the seven steps above). ELC's Maintenance Branch is doing this now with Maintenance Effectiveness Reviews (CG-MER) and Machinery Assessment Programs (CGMAP). You can read more about these great initiatives at ELC's we site: <http://cgweb.elcbalt.uscg.mil/Branch/branchpage/017file/CGMAP/CGMAP.htm>.

*Note: The consequences or criticality are sometimes considered an inherent part of the Failure Analysis, so the acronym FMECA is also commonly used.

Measures Directly Linked to Asset Performance

Another cornerstone of the Third Generation of maintenance is having asset performance indicators that prove your maintenance program is effective, i.e., a wise investment. Our Naval Engineering program has an effort underway to improve our Percent of Time Free (POTF) measurement, which provides data on the percent of time our cutters are free of category three and four casualties. The improvement will link the failure of mission critical systems to the subsequent degradation in operational capability. POTF, broken down into those 15 or 20 mission critical systems for each cutter class, will provide the necessary objective data to support analyses needed to determine the priority for systems to be replaced or modified (modified either by redesign or improved logistics support, to move down to a straight line failure pattern). That data will then provide the justification needed to secure the funding to make it happen.

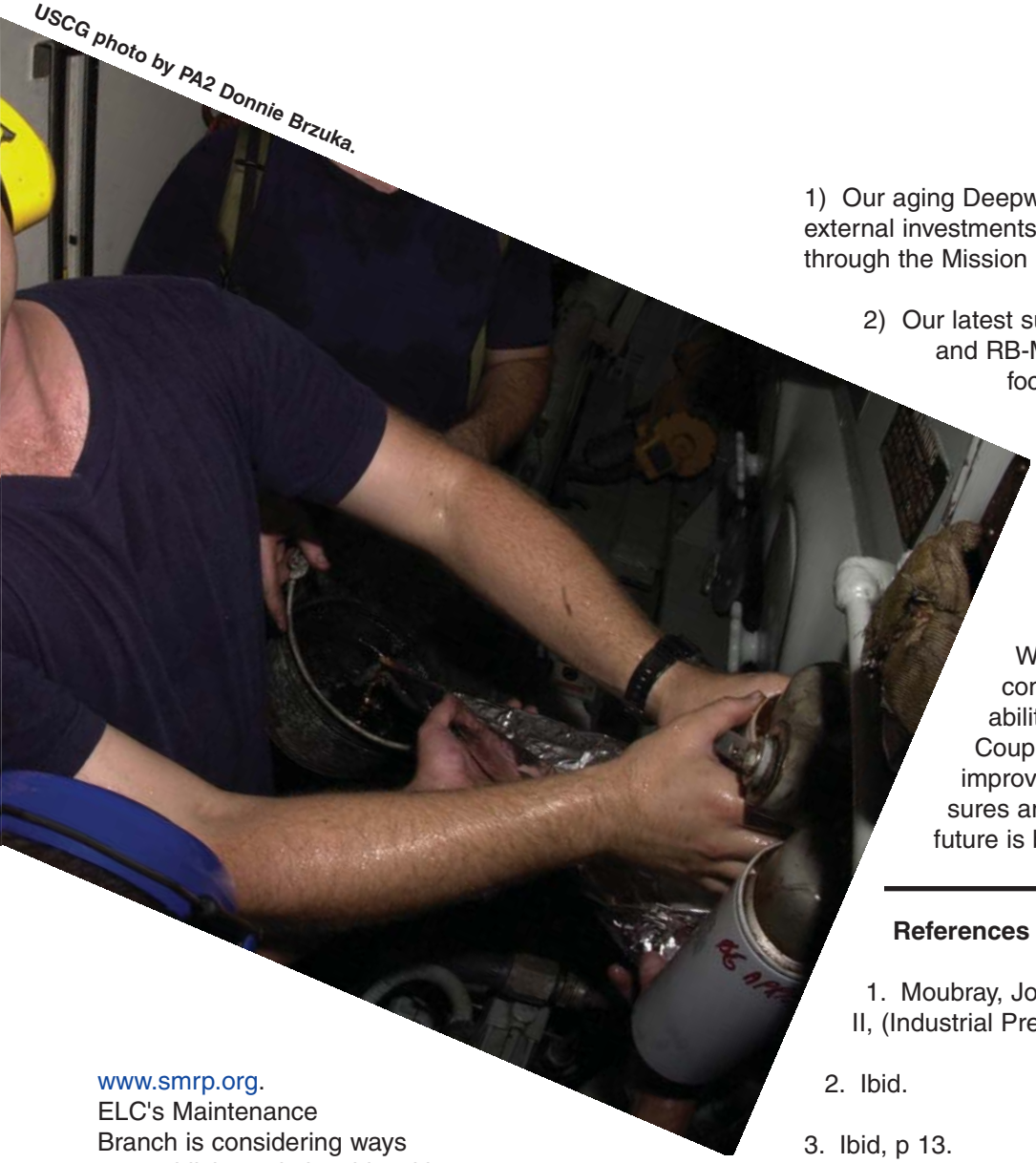
One final note on measures: The difference between Second and Third Generation measures is to move beyond simply measuring maintenance activity. If a maintenance department only measures maintenance activity, they can't really make a case for the value (production or operational value) they are providing to the organization. A maintenance organization, at the macro level, must measure its contribution toward ensuring the assets deliver the intended function, not simply ensuring all the maintenance units complete the activities listed on the chart or displayed on the computer screen.

Make the Business Case for RCM

POTF, broken down by mission critical systems, in addition to highlighting the need for replacements, can also help justify investments in RCM. Interestingly, there are very few endeavors that have a more compelling financial business case than RCM initiatives.[10] But we can't wait for additional funds (beyond our AFC-45 base) to make these RCM investments. Given the current budget climate, it is difficult to make the case that we are going to initiate a program that will improve maintenance efficiency and reduce costs, but only if we receive additional recurring funding to make it happen. Rather, the business case needs to be made to the managers of our AFC-45 account. This is how the assessment costs for the buoy handling condition-based maintenance program will be paid for, through a cut in the WLB and WLM Standard Support Level (SSL). It's an internal investment that will pay big dividends. Furthermore, perhaps we could reinvest the cost reductions from an RCM initiative to obtain more billets in ELC's Maintenance Branch, perhaps those billets could increase the throughput of CG-MERs -- the efficiencies will build on themselves.

Focus on RCM and Performance Indicators

We need to imbed RCM concepts into our culture. The Naval Engineering post-graduate program is considering a focus on reliability engineering, now offered at many engineering schools. We should also send some of our post-graduate school students through a business or management program with a focus on maintenance performance indicators. Several CG members have also attended the U.S. Navy's RCM course and achieved certification. There are also opportunities to join a reliability professional society and gain certification recognized by industry. Check out this web site:



USCG photo by PA2 Donnie Brzuka.

www.smrp.org. ELC's Maintenance Branch is considering ways to establish a relationship with reliability organizations and perhaps proctor a certification exam; with the goal of prompting more of us to pursue certification and learn the latest reliability concepts and explore opportunities within our program. Reliability concepts are also under consideration for senior enlisted advancement course material.

Turning the Corner

New RCM concepts are helping us refine and improve our approach to maintenance. These efforts will make some of our Standard Support Level (SSL) base funding available for recapitalization projects or, if appropriate, provide funding to move some systems down to a straight-line wear pattern (by purchasing a robust rotable pool of spares, etc.). Momentum is building. Along with our RCM initiatives there are promising developments in two other key areas:

1) Our aging Deepwater assets are receiving significant external investments (external to our AFC-45 base) through the Mission Effectiveness Projects (MEP).

2) Our latest surface acquisitions (new MACKINAW and RB-M) include a formal and through focus on SSL development and robust RCM data analyses are provided for the delivered systems (failure predictions & reporting, maintenance interventions, logistics support). We can use these acquisitions to set a new standard.

We are working our way out of the conundrum of an aging fleet, falling reliability, and a static or shrinking budget. Couple the benefits of RCM with an improved correlation between our measures and operational performance, and the future is bright. Opportunities abound!

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8. LT Flannery, James, USCG, "WLB Buoy Handling System Assessment Program," U.S. Coast Guard *Engineering, Electronics & Logistics Quarterly*, Summer 2005, p. 36.

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Civil Engineers Supporting

Vessel Acquisition

by Cadet Shelly Raudenbush, USCGA and FDCCLANT staff

The acquisition of the new Great Lakes Ice Breaker (GLIB) has resulted in a fascinating $4M civil engineering project at Cheboygan, MI. The Coast Guard's Facility Design and Construction Center Atlantic (FDCCLANT) has oversight of the project and I was lucky enough to get involved during my 1st class summer civil engineering intern training program. The construction site is an ideal classroom for a cadet majoring in civil engineering to learn the shore facility impacts of a vessel acquisition. Everything from vessel dimensions and maneuverability to the mission and crew size impacts on the shore facility.

USCG photo.

The new GLIB (WLBB-30) is one of a kind and will replace the 30 year old USCGC MACKINAW (WAGB-83). The new GLIB will also be called USCGC MACKINAW and sail out of Cheboygan. The old MACKINAW will remain in service for one year before decommissioning. For that year both MACKINAWs will be homeported at Cheboygan. Unfortunately, there is only room at the wharf for one MACKINAW! This is one of many shore facility challenges presented by the arrival of the GLIB.

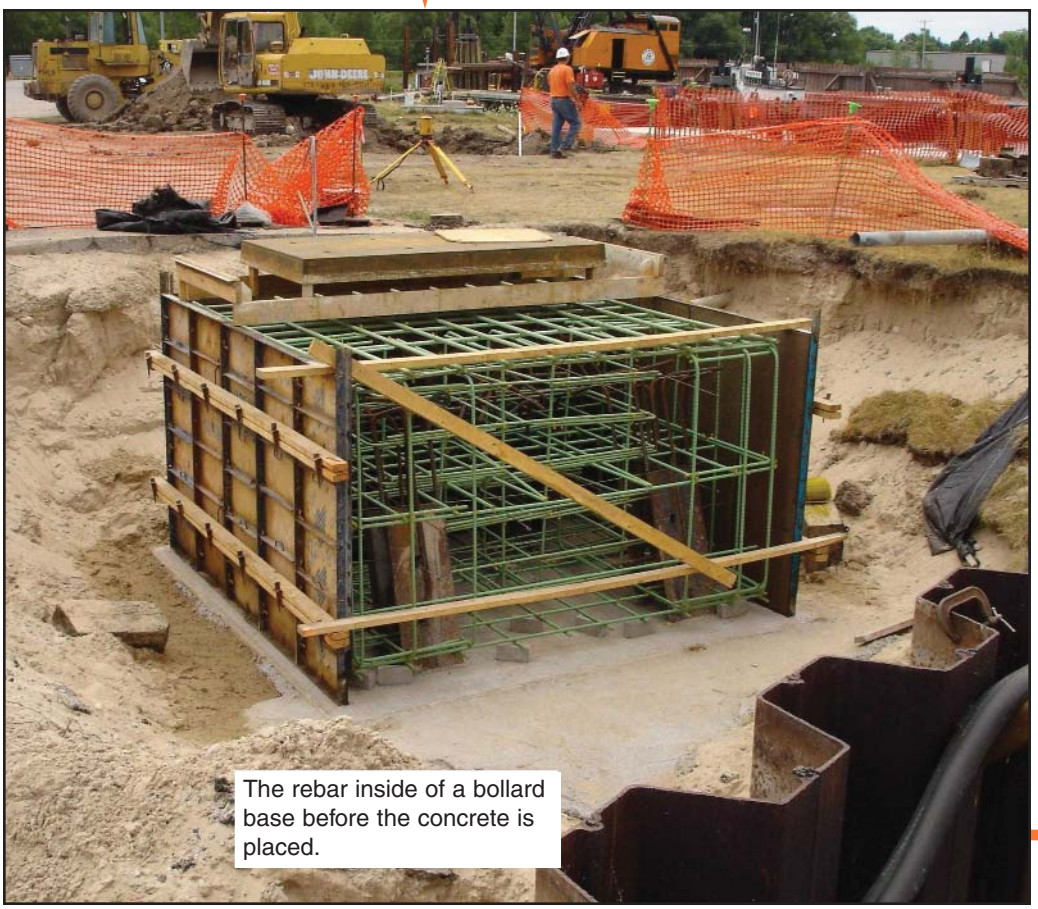
The old and new MACKINAWs are both large cutters with very different hull designs. The moorings at Cheboygan are somewhat confined and shallow, therefore, dredging was a necessary element of the project. Dredging can lead to a less stable bank above and below the water adjacent to the dredged basin. So bank stabilization with rip rap was accomplished above and below the waterline.

The old MACKINAW is 290 ft long and not as maneuverable as the new GLIB. The best place for old Mackinaw to moor is at the concrete wharf where she's always tied up. The GLIB is 240 ft. long and draws 21ft and will be mooring to an existing timber pier (T-pier) on the site. But the GLIB is not only an ice breaker but a buoy tender as well. The dockside facilities in Cheboygan are not equipped to handle buoy tending operations and the T-pier certainly cannot accommodate buoy handling. While the concrete wharf is sturdy enough, the adjacent lot is unpaved, and there is no crane to hoist and move buoys. Grading and paving the lot adjacent to the wharf, buying a crane, and building a garage to house it were necessary elements of this project. All that addition buoy yard paving can lead to flooding during heavy rains, so digging a retention pond is also part of the project. When the buoy yard is completed, the GLIB will be able to on-load and off-load buoys at the concrete wharf. During buoy loading, the old MACKINAW will need to vacate the wharf and move to the T-pier. So, the wharf and the T-pier must be able to accommodate both the old and the new MACKINAW.

USCG photo.

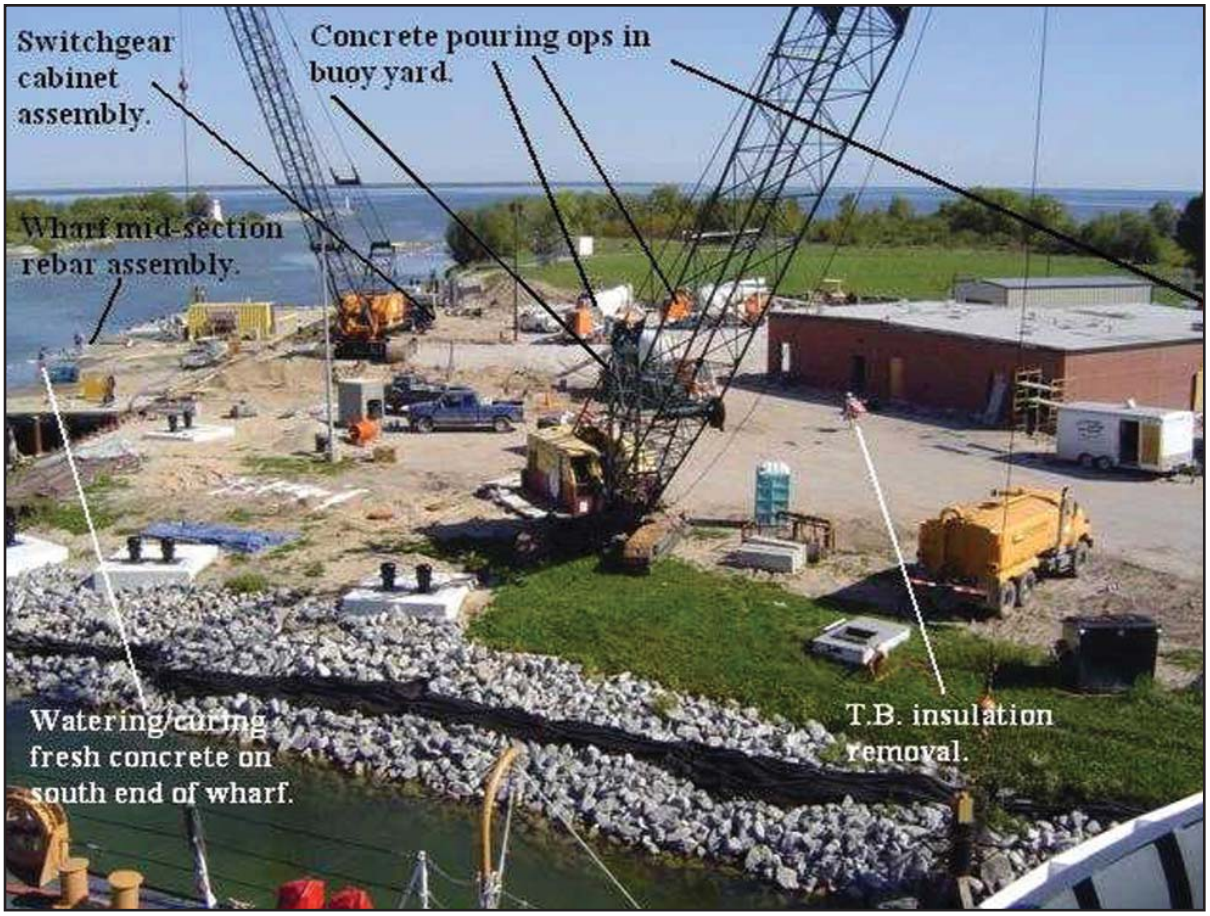
To facilitate mooring at either the wharf or T-pier, old mooring dolphins had to be removed and new dolphins installed. The replacement dolphins are constructed of concrete filled steel pipe center piles surrounded by timber piles. The dolphins had to be large to allow for the flat hull of the old MACKINAW. Coordinating the dolphin construction and wharf extension with old MACKINAW's schedule and the delivery of the new GLIB was tricky. Old MACKINAW got underway for a couple of weeks in July during which wharf demolition began while T-pier dolphin construction was wrapping up. Fortunately, the T-pier dolphins were ready when old MACKINAW returned to Cheboygan on 20 July 2005.

To secure each cutter snugly to their moorings, eight very large mooring bollards were included in the project. The construction of the new bollards was a monumental and very interesting task. During my visit each bollard was in a different stage of construction. I was able to witness H piles being vibrated, spliced and driven into the ground at various angles to support the load of the 50 ton bollards. The H piles were cut to proper size inside the bollard base. Next, a rebar cage was built around the H-pile array to provide tensile strength to the concrete. A wooden form was constructed and concrete was placed. To achieve the required 5000psi (pounds per square inch) compressive strength, a concrete additive was used and after just two weeks of curing the concrete achieved enough strength for use.



The rebar inside of a bollard base before the concrete is placed.

USCG photo.



USCG photo.

The arrival of any new cutter usually requires upgrades to electric shoreties. The requirement for two moorings in Cheboygan meant shore tie upgrade requirements at both the T-pier and wharf. The under and above ground installations had to be coordinated with paving, pile driving and rip rap placement.

USCG photo.

Waterfront construction is a large part of the Cheboygan project, but there is also a lot of construction taking place on shore as well. The existing Training Building was in significant disrepair and did not have the space or equipment necessary for the new MACKINAW's Aids to Navigation (ATON) mission. The original building was poorly insulated and laid out. The old windows and frames were failing and interior drywall was moldy. So, FDCCLANT is renovating the original building and building an addition. The original building is getting new insulation, windows and doors, and will be completely rebricked. Inside, updated kitchenette and bathrooms will replace the 1950's era originals and a projection screen will be installed in the expanded meeting room used by MACKINAW's crew as well as the local community. A new entrance canopy structure and flagpole is included in the building renovation plans. The new support building and two generations of Great Lakes Ice Breakers moored alongside will be a showplace of which the Coast Guard and citizens of Cheboygan should be very proud.

Abbreviated Performance Spec Saves Time and Money in Housing Fire Rehab

by LCDR Scott Fields

Exterior fire damage to CG housing unit on Nantucket. USCG photo.

Interior fire damage to same housing unit, first floor. USCG photo.

Civil Engineering Unit (CEU) Providence used a performance based specification to quickly rehabilitate a fire damaged Coast Guard housing unit located in Nantucket, MA. The damaged unit is a two story, three bedroom, wood framed, strip footing foundation with a two foot crawl space, having approximately 1,200 s/f of living space. It constitutes one side of a duplex unit. What exactly is a performance specification contract? It succinctly describes the required performance of the desired product without specifying in detail the methods to be used in obtaining the end result. The contractor is responsible for delivering the results expected. In this case, service requirements were easily established due to the number of identical housing units on Nantucket and the need for the products to be similar for future maintenance concerns. In this fashion, the cost of construction, as well as time required, were dramatically reduced. Unaffected by the fire, no work on the second half of the duplex unit was included in this contract. The simple intent

of the contract required the contractor to provide all equipment, labor and materials required to duplicate the original condition of the housing unit. The performance criteria used by the government was based upon matching an identical/sample housing unit located on the property. All materials, equipment, floor plans, finishes, casework, etc. were to match the existing sample housing unit. The government provided the contractor copies of manufacturer's data sheets and information on known original material and equipment utilized in the housing unit. The contractor stated that this was one of the best government jobs he had ever worked on. The performance specification created a simpler process for the contractor and allowed him to focus more time on site construction instead of contract administration. This project was completed 21 days early and without any construction changes.

By the way, leaving a hibachi grill unattended on the back porch can be hazardous to your health. Luckily, no one was hurt in this instance.

Exterior after performance contract completed. USCG photo.

Finished kitchen after contract completion. USCG photo.

Logistics Management Transformation Office (LMTO) "Outbrief"

by Jim Sylvester, LMTO & LTPIO

The LMTO The Summer 2005 issue of the *EE&LQ* outlined the Logistics Management Transformation Office (LMTO) initiative in its early days. The LMTO has since completed its work, and this article reports the findings of that effort.

Originally, the LMTO was challenged with three areas of concern; the Department of Homeland Security (DHS) eMERGE2 project, Chief Financial Officer (CFO) Act Audit remediation and the consolidation of Coast Guard (CG) logistics systems for the future. The scope was refocused solely on the Logistics System of the future for several reasons. First, CFO Audit Quality Action Teams (QAT) were already underway to tackle the findings of the audit. Second, the eMerge2 schedule was uncertain at best, and requirements for logistics integration were not forthcoming. Finally, it was concluded, that a consolidated system of the future would actually support long-term resolution of issues for both the CFO Audit and eMerge2 integration.

The objective of the LMTO was to recommend a business model, deliver high level functional requirements and develop a business case for implementation. This would include the following deliverables: Mission Needs Statement (MNS), Cost Benefit Analysis (CBA), Office of Management and Budget (OMB) Exhibit 300 (business case) and a marketing business case. Business Process Re-engineering (BPR) activity was specifically excluded from the LMTO scope of work, and would the subject of follow-on efforts if the business case supported transformation.

The LMTO Approach The team of five took a rigorous project management approach including the development and baseline of a project schedule. They also created risk and quality management plans, as well as project metrics, which included the use of Earned Value Management (EVM). A stakeholder analysis was performed and a communications plan developed. All of the project information, and deliverables, were posted (and still are) on CG-Central in the LMTO micro-site. A limited amount of the same content was also posted to the LMTO Intranet web site (http://cgweb.cetc.uscg.mil/LMTO/) for the convenience of those outside the immediate LMTO activity. The visibility of information and activities was stressed at all stakeholder briefings, and new participants were added after each briefing and meeting.

As the team began the gathering of baseline data on legacy logistics systems, several things began to emerge. First, this was certainly not the first time an effort like this had been attempted. In fact, the team found 20 studies dating back to 1988 which intended to improve or consolidate logistics in one way or another. Second, the importance of a business case could not be clearer. Of the 20 studies reviewed, most of which had the same conclusions, only one succeeded. It was done by the aviation community, and, it was the only one with a business case attached (lesson learned). Third, and most importantly, it became apparent that although all of the logistics communities were performing the same

basic functions (Figure 1), they were doing them with different processes and controls. The potential to use the same system to support a common business model must depend on common processes, even if those processes are performed in diverse locations. This would be a critical prerequisite to consolidating IT systems.

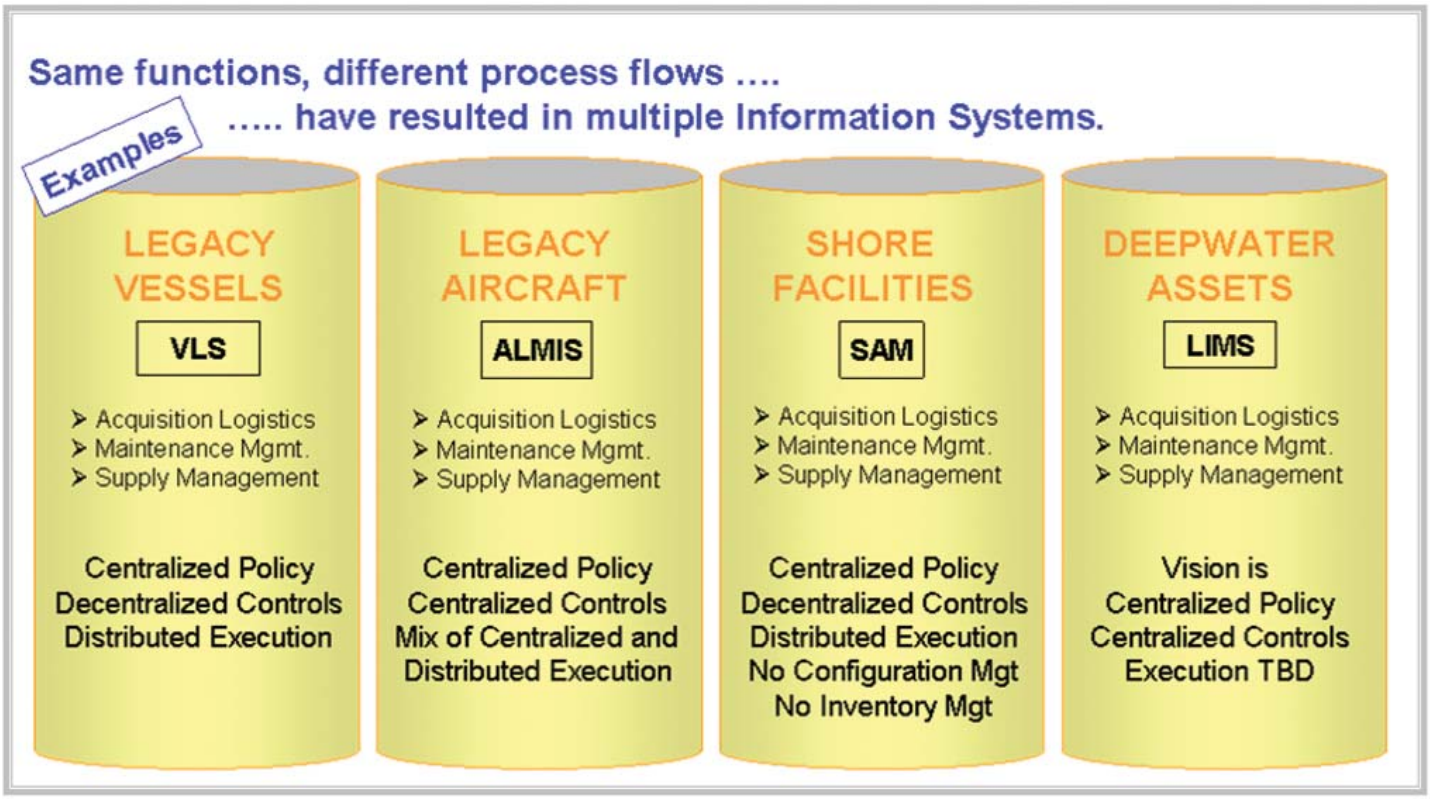


Figure 1. Multiple Logistics Information Systems.

Finally, the effort of collecting information on legacy business processes highlighted the fact that the cost of doing business, and any substantial savings, is not in the world of IT, it is in the business. Now familiar with the needs of a business case, it became apparent that the benefits pool potential was far greater in the cost of doing business, than it was in the IT systems support costs. This revelation would of course be pivotal to the business case, but also informative as to the direction the team needed to go. Suddenly a source for baseline business data, and the ability to build program metrics for transformation, became more achievable.

Defining, Scoping and Bounding The team researched internal and external benchmarks for logistics including the actual definition of "logistics." They found that the Coast Guard definition not only matched the definition used by such organizations as Defense Acquisition University (DAU), Joint Chiefs of Staff (JCS), North Atlantic Treaty Organization (NATO), Department of Defense (DoD) and the Council of Supply Chain Management Professionals, but, it was more succinct. The definition from the Coast Guard Logistics Doctrine COMDTINST 4000.5A reads as follows:

> ***"Logistics is the business activity of the Coast Guard in support of its missions. Logistics encompasses all the activities associated with developing, acquiring, sustaining, and eventually retiring the components of capability: people, information, and systems. Logistics converts appropriated funds into operational capabilities, such as personnel, platforms, and support."***

Yes, that is a very large world! This definition cuts across several organizations and communities in Coast Guard. But again, it is a definition consistent with other federal and non-federal organizations. This definition established the boundary for the legacy baseline costs for Coast Guard logistics.

"It's Not About the IT!" The team first gathered support costs for just the logistics Information Technology (IT) systems, including government Full Time Employee (FTE). This figure represents approximately $30-million annually (2005 dollars). Subsequently, using the above definition as a beginning assumption, the team gathered costs from budgetary documents, budgetary models, encumbered Personnel Allowance Lists (2004), Standard Personnel Cost (SPC) rates, and training documentation to achieve a rough order magnitude of costs in the entire logistics domain (the details of this compilation are avail-

able on the LMTO micro-site of CG Central in the Deliverables-Baseline Activities folder). Needless to say "it was a big number." Literally, the logistics business costs are two orders of magnitude larger (i.e., billions) than the cost of IT support for logistics (millions). The baseline data has been reviewed by CG resource managers, and the average annual cost has not changed significantly. Essentially, under the stated definition, the Coast Guard spends approximate 46% of its annual budget in the area of logistics. This finding was shocking to just about everybody with whom the team communicated. To put it in perspective, the DoD Comptroller admits (on their web site) to spending one third (33%) of the annual DoD budget on logistics, and they believe they have room for improvement. Certainly there may be differences in assumptions about the inclusion of costs for DoD versus the Coast Guard, however, as stated, our definition of logistics are very similar. And of course, DoD has a different mission than the Coast Guard. But as ballparks go, it's a big one, and CG logistics falls within it. Regardless of what the actual number is, the business case is well founded on the cost of doing business, rather than the IT costs to support it.

The LMTO IPT Identification and verification of high level functional requirements would be done using an Integrated Project Team (IPT). The team chartered a cross-functional, cross-community group with the necessary skills and expertise. Members were brought in by charter, or ad hoc, representing electronics, vessels, boats, aviation, shore facilities, National Strike Force, Operations (G-O), Marine Safety & Environmental Protection (G-M), Office Of Financial Policy and Systems (CG-84), Command, Control, Communications, Computers & Information Technology (CG-6), Office of Logistics (CG-44), Deepwater, Maintenance and Logistics Commands (MLCs), Engineering Logistics Center (ELC)/Yard and Aircraft Repair and Supply Center (ARSC). The IPT was chartered with the following objectives:

- Validate Mission Needs Statement
- Validate LMTO Gap Analysis
- Validate High Level To-Be Model Requirements
- Determine Program Risks and Potential
- Validate Definition Of Logistics

The IPT accomplished this, and more. They also provided excellent guidance for future change management as well as an excellent communication channel back to their respective programs. In addition to high level functional requirements, the IPT found that much of the policy in the respective communities was very good, though redundant in some cases. However, the IPT also found that many of the processes documented by the policies had little if any process controls in place. Combined with weak accountability, weak controls often resulted in broken or inconsistent process outcomes. It was also concluded that in the standard business cycle (Fig. 2) of Planning, Execution, Monitor/control and Improvement, the Coast Guard is extremely strong on Execution, fair at Improvement, and generally week in Planning and Monitoring/Control. The IPT also developed specific recommendations for improvements to the:

- Overall Logistics Program;
- Acquisition Logistics Management processes;
- Maintenance Management processes; and
- Supply Management processes.

The group agreed unanimously that with well placed controls, and accountability, a centrally controlled and managed business model (with the potential for distributed execution) would succeed for the entire domain of logistics in the Coast Guard. The caveat here is, of course, that all logistics communities must begin to perform the same functional areas and use the same business processes.

The centrally managed logistics business model recommended by the IPT will bring together the necessary expertise, skills and information to deliver the services needed by logistics' customers. Through a customer-focused and well-coordinated logistics system, improved planning and control will lead to better service delivery to the customer base. The IPT developed the following Service Delivery Framework to describe how the Logistics System of the Future will operate.

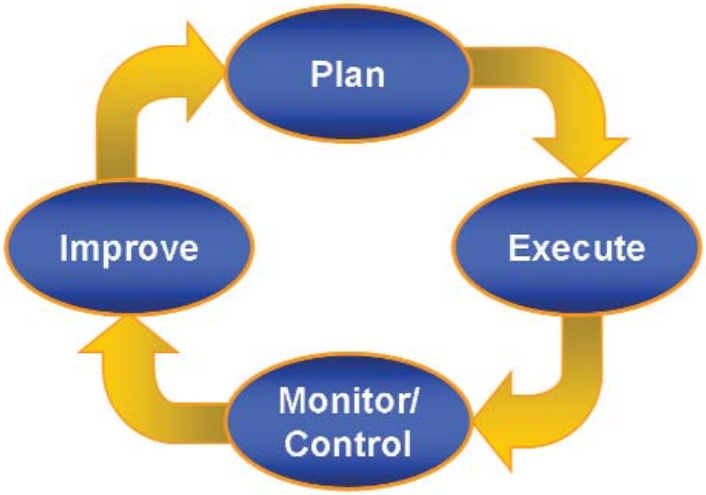
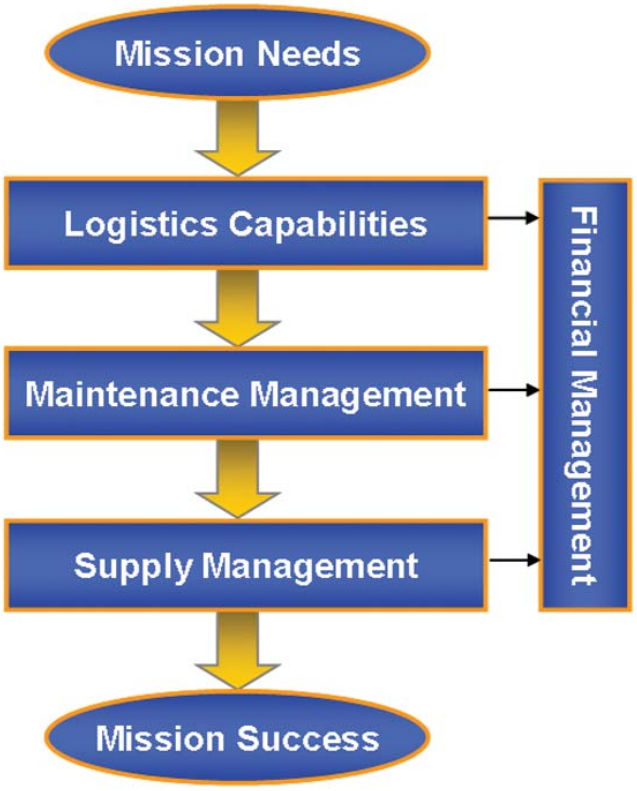


Figure 2. Standard Business Cycle.

Logistics: How It Should Work For logistics, the key customer is operations: supporting mission



Logistics Service Delivery Framework

requirements in the Coast Guard's five operational areas. However, there are important internal customers along the supply chain that require excellent service to ensure that the overall service delivery process works effectively.

Logistics support begins with the acquisition of capabilities required to meet mission needs. It includes not just the physical assets, but all components of capability: people, information and systems. During the acquisition phase, logistics must ensure that the design process for new assets or component system upgrades properly takes into account the Coast Guard's maintenance infrastructure and guarantees that the asset can be effectively and efficiently maintained over its entire life span. In particular, logistics must ensure:

- Accurate and complete configuration information is captured from the outset;
- Effective maintenance procedures are developed and deployed with the asset; and
- Initial provisioning is accurate and properly aligned with how the asset will be maintained during sustainment.

In the sustainment phase of logistics, the goal is to maintain the capabilities required to meet mission needs. Logistics will achieve these goals through tightly integrated Configuration, Maintenance and Supply Management processes.

The internal customers for Maintenance Management services are the Coast Guard's maintainers. Their job is to perform the maintenance work itself. Logistics will centrally plan and ensure the timely delivery of the services that the maintainers need to perform their work, including:

- Accurate maintenance procedures, technical documentation, etc.;
- Appropriate parts and tool lists;
- Accurate schedules; and
- Proper training needed to perform the required work.

After the maintainers perform their work, they need to provide logistics with required information on results and outcomes. Logistics will use this information to analyze performance and proactively improve the Maintenance Management process (e.g., identifying the need for and developing new maintenance procedures to correct breakdowns).

The customers for Supply Management services are the maintainers and operators. Logistics will centrally plan and ensure the timely delivery of the parts required by the maintainers to perform their work and the other supplies required by operations. Logistics will be responsible for the seamless coordination of the end-to-end supply chain needed to meet these requirements: from demand planning based on maintenance and other supply requirements, through inventory management, procurement management, transportation management and warehouse management.

Of course, Configuration Management, including the critical functions of maintaining key technical data about our assets and required capabilities, is the foundational element that enables our maintenance and supply services to be successful.

Finally, information on each key financial event must be captured to ensure that the entire logistics system is managed efficiently and that financial compliance issues are addressed (i.e., CFO Act and DHS requirements). In particular, information on each financial event must be captured:

- At the source (to ensure accuracy and eliminate redundancies in data handling);
- As it occurs (to ensure timeliness and eliminate redundancies in data handling); and
- At the right level of detail for both logistics and financial management needs.

With this Service Delivery Framework in place, the Coast Guard logistics system will be able to deliver improved asset availability at lower cost.

In addition to the quantifiable cost savings, there are benefits from improved logistics capabilities, such as better asset availability which, in turn, translates into fewer assets needed to meet overall mission needs.

Alternative	Description
#1 - Use One Legacy System	Build an integrated set of Coast Guard logistics processes upon on of the current Coast Guard systems.
#2 - LIMS	Build an integrated set of Coast Guard logistics processes around the Deepwater Logistics Information Management System (LIMS).
#3 - COTS/GOTS	Acquire and integrate a suite of Commercial-off-the-Shelf (COTS) and/or Government-off-the-Shelf (GOTS) systems that support the common business model and the derived functional requirements.

Information Technology Alternatives Turning back to the IT aspects of the business case, the following alternatives made the cut going into the CBA from the MNS: For each of the alternatives, the LMTO developed costs for either acquiring and integrating systems or adapting existing systems to meet the needs of the common business model across all the Coast Guard logistics communities. On the benefits side, the LMTO's analysis considered both reduced logistics costs and lower information systems support costs with a consolidated suite of systems. For the logistics cost savings, the LMTO made very conservative estimates of likely savings based on similar logistics transformation efforts. These savings cover the inventory, procurement, personnel and infrastructure components of the "benefits pool" discussed earlier.

The preferred alternative selected is the last of these three. An Enterprise Resource Planning (ERP) system was not considered a viable alternative given the existence of the Coast Guard's Core Accounting System (Oracle Financials), as well as the current budget climate. Also considered non-viable was the possibility of using an existing prepackaged (self-contained) system already in use by another federal agency. This alternative was considered non-viable because none could be found which met all the functional requirements. Each alternative was risk adjusted for cost in each of the functional areas. Of course, the rationale for evaluating these alternatives will be revisited as transformation efforts edge closer to making IT tool selections.

What Next? The work of the LMTO was completed at the end of July 2005 with final deliverables as indicated earlier. Again, these are available on the LMTO micro-site of CG Central. These deliverables, plus change management plan recommendations, have been provided to CG-4 for implementation. The final brief to the Chief of Staff achieved the full support from senior leadership, and was accompanied by the direction to proceed at "best speed" in its implementation. As of the writing of this article a draft charter for a an implementation project staff, the Logistics Transformation Program Integration Office (LTPIO) has been submitted for approval. In anticipation of this effort moving forward, the LTPIO staff has already formed within CG-44 (Logistics Directorate) and is building their action plan. In addition, ALCOAST 477/05 was released by the Commandant and announced his intentions to pursue Logistics Transformation as a critical Stewardship initiative. CG-44 is moving rapidly, not only moving the Coast Guard towards the LMTO vision for logistics, but also tackling short term issues for the CFO Audit compliance, through field unit inventory removal.

Recognition The LMTO project team was Captain Mike Mangan, CDR Dean Bruckner, CDR Dave Hartley, Ms. Michele Fields and Mr. Jim Sylvester. The LMTO effort could not have been successful, nor could it have completed within one year, without the concerted efforts of the LMTO IPT participants. Those members are, in no particular order: CDR Jim Cash (CG-442), Mr. Michael T. Healy (ELC), Ms. Barbara Semiatin (CG-84), CDR Kelly Kachele (MLCP), Mr. Scott Bates (G-MOR), Ms. Gail Marshall (MLCA), CDR Donna Cottrell (ARSC), LT Michael Brown (G-OCC), CDR Dirk Greene (G-M), Russell Smith (G-D), Walt Demmerle (MLCA), Ms. Debora McCarty (ARSC) and Ms. Shelley Diedrich (CG-442).

U.S. Coast Guard photo by Petty Officer 2nd Class NyxoLyno Cangemi.

USCG Photo by PA2 Keith Alholm.

USCG photo by PA3 Louis Hebert.

LOGISTICS TRANSFORMATION PROGRAM INTEGRATION OFFICE (LTPIO)

by LT Jeff Clark, LTPIO

Why Bother to Transform Logistics?

In the naval world the mettle of engineers has often been measured by their ingenuity and ability to improvise. If you went back through the archives of commendations awarded to Coast Guard Naval Engineers you would probably find a common theme among the accolades. The majority would extol the virtues of the innovative snipe who fixed any manner of mechanical casualties with little more than bailing wire, duck tape and bubble gum, and whose efforts brought the vessel and her crew home safely and under their own power. Every naval engineer has heard these stories of resourcefulness that have grown to define the character of naval engineering in the service.

What's wrong with this picture? We should rightly honor those Coasties that can make miracles happen with very little, but should this be the norm? Why do we continuously make things so difficult for ourselves? Is it that we just love the challenge, and being the hero for our CO and shipmates? There may be some truth in that.

Let me paint a picture that is all too common for maintainers in the Coast Guard. (If it's too painful to relive this please proceed to the next paragraph.) Day before a much needed port call, something breaks. Engineering crew spend hours troubleshooting, trying to isolate the problem and figuring how to fix it. An inordinate amount of time is spent scouring technical publications that are decades beyond their useful shelf life and schematic drawings which just do not seem to include the component or system that failed. While engineers are searching cluttered, crowded storerooms which contain everything but the parts they are looking for, the rest of the crew is bouncing down the brow on their way to a night on the town. Next day, engineers go to local marine supply depot to purchase parts, most of which they won't need, but because they have no guidance, they get everything associated with the APL to ensure they get the one part they will need. The rest of the crew in the meantime is enjoying a moral event on the beach. Engineers finally rebuild the system or component just in time to get back underway. Unused parts are shoved into the overcrowded storeroom (or worst case, in someone's rack). Cutter gets underway; engineers get no "libo," but plenty of pats on the back for a job well done. What makes this scenario even more heartbreaking is that we know this failure has happened on other units of the same class, but because the solution was never published we have to re-invent the wheel. And each time we re-invent it, we do it differently. Soon we've lost control of the configuration and any hope of analyzing the true root cause of the failure. So much for reliability centered maintenance!

Obviously a worst case scenario, but every naval engineer in the Coast Guard has lived this to one

varying degree or another. Now, let's visit another scenario, one a little more uplifting. Day before much needed port call, something breaks. Using the diagnostic procedures and tools provided, the engineers quickly isolate the affected system or component. They immediately search their database of maintenance procedures for that system or component and find the procedure to correct the casualty. The procedure includes the Original Equipment Manufacturer's detailed procedures, equipment diagram with component identification; all prepared by the Logistics organization using the latest tech manual required and schematics. More importantly, the procedure clearly identifies the tools required for the job as well as the parts, and delineates exactly how to perform the maintenance step by step. Well before special sea detail, engineers hand a copy of the Maintenance Procedure Card (MPC) to the storekeeper, who looks in the standard location on the MPC to find the part number and cage code to enter into their inventory management system and locate the parts. They find the parts exactly where the system said they would be, in a neatly arranged storeroom, because parts are stocked only for maintenance the ship's crew is expected to perform. Parts are pulled without having to climb through and crawl over a bunch of unnecessary stuff. Parts are expended from system inventory; system automatically reorders. Engineers execute the maintenance action, successfully test the system or component and bounce down the brow with the rest of their shipmates for a night on the town. And because the corrective maintenance action followed the detailed procedures to the letter, the same way it is always done wherever this component is used in the fleet, the system engineer who owns the component can perform an analysis across platforms to determine if it should be upgraded, replaced, recalibrated, etc.

Sound like a pipe dream? Well it's not. With the exception of having a brow to walk down for liberty, the above scenario will sound very familiar to Coast Guard aviation technicians. At one time aviators lived much the same way naval engineers do now, but safety concerns, a failed financial audit of their repair parts and a particular Commandant unhappy with their performance forced them to clean up their act, and clean it up they did. Over the past 10 years they converted their maintenance and supply management programs from an inefficient, undisciplined, parts-hoarding, configuration-management-lacking nightmare to a centrally managed, efficient, controlled logistics business model that thrives on continuous process improvement.

At this point you may be thinking to yourself, "But shouldn't we have identified this problem long ago and done something about it by now?" Well actually, we have. In fact, its been the primary element of the Coast Guard's Engineering and Logistics Concept of Operations, the ECONOP, since 1993. In addition, the idea of the Coast Guard adopting a standard, enterprise approach to logistics management based on a centrally managed business model has been proposed and supported by a series of studies conducted over the last two decades. Each of these studies has demonstrated the benefits of a centrally managed logistics model and consolidated information systems support. But there's no "allure" in logistics and many of the recommendations from those studies were not followed through on, while the ones that were, often did not receive full funding support.

But the cumulative effect of these studies, coupled with the advent of the Deepwater Project and the prospect of another logistics model being thrown into the mix, as well as Chief Financial Officer (CFO) financial audit failures directly related to our material weaknesses in managing Operating Materials and Supply items on board field units, has brought a new sense of urgency to the our logistics organization. The Logistics Management Transformation Office (LMTO) was established in August, 2004 to "identify the desired end-state that clearly defines the vision of a single, unified logistics and finance system for the Coast Guard." The LMTO immediately determined that the only way to achieve this was to first adopt an enterprise wide, standard approach to logistics management based on a centrally managed logistics business model.

The LMTO project team defined the mission need to develop this common logistics business model. An exhaustive business case was developed to demonstrate the need for this overarching transformation and to analyze alternative solutions for implementing a standard suite of information systems to support the new model. The LMTO project team's recommendations to transform Coast Guard logistics were endorsed by the Chief of Staff, VADM Allen and, subsequently, by the Commandant. ADM Collins publicly pronounced his support in his Stewardship ALCOAST 477/05. RADM Gabel, the Assistant Commandant for Engineering and Logistics, was charged with carrying out the Commandant's mandate to transform our Logistics enterprise. The Logistics Directorate, CG-44, was designated as the execution authority for this transformation. The Logistics Transformation Program Integration Office (LTPIO) was created within CG-44 to execute the transition effort. (For more information on the LMTO approach, see LMTO Outbrief on page 32.)

Logistics transformation is a long-term effort, with a current timeline stretching through 2008. So you shouldn't expect to see much for a while, right? Wrong! While most of the early initiatives of the LTPIO involve long term project definition there are short term projects which will have an immediate impact on the Coast Guard. The LTPIO has commissioned a maintenance management

working group to begin the task of aligning maintenance management business processes across our various communities. Detailed maintenance procedures are the foundation of the maintenance driven supply process which will fuel the centralized logistics business model. Please see the insert on the Maintenance Management Working Group (MMWG) for more information on this critical early initiative.

Another project which will have an immediate, far-reaching impact is the Field Unit Inventory Reduction Plan. One of the products of our past logistics failures are that we have lost control of our unit level inventories. The FY2003 Chief Financial Officer's (CFO) audit, conducted by the Department of Homeland Security (DHS), uncovered significant problems with the way we manage our unit level reparable and consumable inventories. The audit results identified policy, procedures, systems, training, inventory execution and management oversight of Operating Materiel and Supplies (OM&S) as material weaknesses.

The CG has been directed to correct the deficiencies that led to the failure of the FY2003 CFO audit. The purpose of this plan is to significantly strengthen our current material weaknesses with the explicit goal of passing the FY2007 audit. The concept is basic: to remove and reposition inventory items that are determined to be excess; in other words, items with no demand history or no tangible link to a system or maintenance procedure. For demand history a 3yr/7yr rule will be applied to consumables and repairables respectively. If there has been no demand for an item within that 3/7 year window the item will be tagged for removal and repositioning. Units will no longer be permitted to restock using short-fall lists based on Allowance Parts Lists (APLs). Only inventory items connected to actual maintenance procedures will be carried on board. The link between this effort and the LTPIO MMWG is the detailed MPC, created for preventative, alterative and corrective maintenance, which will dictate exactly which tools and parts are required to complete a job.

To give an idea of the scope of inventory reduction we are talking about here, consider that inventory data from the WHEC fleet show that fully 58% of the National Item Identification Numbers (NIIN) carried on board have never shown a demand. And we wonder why our storerooms are so cluttered. Applying the 3/7 year rule discussed above the numbers, the percentage of items not being used rises closer to 87%. These criteria will be applied to every unit in the Coast Guard that currently holds OM&S inventory, approximately 640 field units. This equates to approximately $250 million worth of stagnant inventory which will be removed and repositioned. The excess inventory that is removed will be stored in warehouses managed by the Engineering and Logistics Center (ELC) (for repairables) and by the Aviation Repair and Supply Center (ARSC) (for consumables). ELC and ARSC will manage their respective inventories and maintain visibility of the repositioned parts on their web site. If a repositioned part is later needed, it will be shipped at no cost to the unit.

Although this plan presents some obvious risk to the Coast Guard with respect to operational availability, the risk is low due to the lack of recorded demand for the parts being removed. And the risk is mitigated by maintaining visibility of the repositioned parts, and express shipping at no cost, whenever they are needed. The benefits from this reduction of inventory far out-weigh the risks:

At the Field Unit:

- ❑ Fewer parts to track;
- ❑ Easier access to parts that have known demand;
- ❑ Reduced probability of procuring items already on board; and
- ❑ Resource/time savings.

For the Organization:

- ❑ Restored reputation as "best managed" agency;
- ❑ Better accountability and visibility of what we have;
- ❑ Accurate Coast Guard financial statements and audits; and
- ❑ Improved stewardship of taxpayers dollars.

It's important to keep in mind that this inventory reduction plan is merely the treatment of a symptom. The logistics problems that spawned this symptom have spawned others as well, such as a loss of configuration control (aviation excluded) and higher procurement, personnel and infrastructure costs. Falling operational availability numbers are a sign that, even with the superhuman efforts of support personnel at all levels, our execution is beginning to falter. The backs of our people can only hold so much. With an aging fleet of cutters and boats, even with the Deepwater modernization, and an aging infrastructure, it is imperative that the LTPIO execute this logistics transformation as quickly as possible. Change is not easy, but the aviation community has already stepped out and made this transformation. The rest of the Coast Guard needs to follow their lead and take advantage of what they have learned. Ultimately, we want our engineers across the CG to be known for reducing casualties across the organization through maintenance actions that follow detailed, precise procedures, and not just for what they can accomplish with bailing wire, duck tape and bubble gum. And thanks to an efficient supply system driven by maintenance demand and rooted in sound systems engineering practice, we will be able to toast our engineers and storekeepers during those much need port calls on a job well done!

Engineering the All-Weather Antenna Tuning Unit For NDGPS Applications

USCG photo by PA3 Beth Reynolds.

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ABSTRACT
The U. S. Coast Guard is part of the Department of Transportation (DOT) team to expand the maritime Differential Global Positioning System (DGPS) service into a national transportation safety system. The U. S. Coast Guard's role is to implement a Nationwide DGPS (NDGPS) expansion effort to more than double the existing number of broadcast sites. The NDGPS system is designed to meet all surface transportation navigation requirements in the United States and will provide double terrestrial DGPS coverage across the continental United States.

The USCG uses 285-325 kHz (Medium Frequency) to broadcast corrections which provide signal for up to 250 nautical miles. Unfortunately, this frequency range typically requires 340-foot towers for short monopole (tenth of a wavelength) implementation typically discussed in textbooks. Because of the unusually long wavelength, several years of consulting, modeling, and testing were required before fully understanding how to meet system requirements given the severe constraints imposed by practical implementation. The electrically short antennae places increased pressure and complexity for the Antenna Tuning Unit (ATU) to maintain a 50 + 0j Ohm

load for all weather conditions. Legacy equipment lacks the sophistication to maintain a 50 Ohm, low VSWR condition, resulting in transmitter mismatches, amplifier failures, extended off-air periods, excessive technician call outs and exhausted sparing and depot maintenance. An all weather ATU presents itself as a tool to significantly improve system availability.

The desire to develop, build, and field an all weather ATU started with a carefully laid out plan to incorporate the engineering process with the required contracting process to serve as a vehicle to evaluate emerging technology fairly while providing options for design improvement, quality control, and efficient production and fielding. Results are presented from C2CEN baseline testing to prototype evaluation for seven DGPS sites for 5 months. The results show the all weather ATU provides a 50 + 0j Ohm match upon install and an ability to automatically maintain this match through periods of changing weather conditions. Availability through the prototype period increased from 97.52% to 99.26%, a marked improvement toward achieving the system availability of 99.7%.

The successful fielding of the all weather ATU increases system availability and provides timely relief for maintenance and depot commands, with full fielding expected for maritime DGPS application by September 2006 and for nationwide DGPS application by December 2007. The ATU also provides new possibilities to remotely monitor far field coverage in real time via antenna current monitoring as well as a method to improve system bandwidth for rapid fielding of enhanced modulation schemes.

INTRODUCTION

The United States Department of Transportation (DOT) is coordinating the implementation of a network of DGPS broadcast sites across the continental United States, Alaska, Hawaii and Puerto Rico. Several Federal and state agencies, including the Federal Railroad Administration (FRA), Federal Highway Administration (FHWA) and the United States Coast Guard (USCG), are involved in the effort to install the NDGPS Broadcast Network. When completed, the nationwide broadcast network will consist of over 126 broadcast sites and provide a standardized signal for DGPS service throughout the United States.[1]

The USCG was selected as the lead agency in implementing NDGPS based on its success in building its existing network of USCG maintained maritime broadcast sites. The USCG's role in the project is to implement the expansion of new sites and provide maintenance and support for each transmitting facility. Although the NDGPS system uses identical reference station and integrity monitoring equipment as the maritime DGPS sites, the NDGPS sites have several differences. These include larger transmitters, larger, more efficient broadcast towers, and various back-up power systems. The NDGPS System is the integration of smaller networks, including the U.S. Air Force (USAF) Ground Wave Emergency Network (GWEN) conversion sites, Army Corps of Engineer sites, and the Maritime USCG sites.

At the same time the NDGPS project was assigned to the USCG, the USAF was in the process of decommissioning its GWEN sites. Although the GWEN sites were designed for a different purpose, the layout of each site and transmit antenna was well suited for DGPS broadcasts. The USAF transferred ownership of many of the GWEN sites, as well as assets that were staged to build additional GWEN sites. The USCG is in the process of converting the GWEN sites to NDGPS sites and has observed excellent coverage and availability of the signal.

The U.S. Army Corps of Engineers (ACoE) also had built several DGPS sites near the inland river system. The USCG partnered with the ACoE in standardizing the transmitters, couplers, and message format, as well as agreeing to work together for preventative and corrective maintenance issues. However, each ACoE site has a unique antenna system, using a variety of inefficient wire antenna designs. Although the sites provide adequate coverage, the availability of the signal is troublesome as the sites are easily influenced by weather.

The USCG maritime DGPS sites also have a variety of antenna heights and configurations. The USCG has studied the past performance of each of various designs and is making continuous improvements in design as more is learned about successful antenna configurations. Site performance varies widely regarding coverage and availability.

The Federal Communications Commission has allocated 285-325 kHz for DGPS use. Each station uses 1 kHz of bandwidth and currently supports 100 or 200-bit per second (bps) Multi-Shift Keying (MSK) modulation scheme. Stations frequencies are allocated to prevent interference and allow users to receive multiple stations at the same time. The information contains corrections for GPS satellite pseudo ranges, applicable to the coverage area. The accuracy of the correction is best at the reference station and degrades with range. Typically, the corrections are considered useful for a range of up to 250 nautical miles.[2,3]

The USCG maritime sites have been declared Fully Operationally Capable (FOC) with a requirement to provide coverage 99.7% of the time. For single coverage areas, this means the site is only allowed 2 hours of maintenance per month. Dual coverage is common to allow scheduled maintenance for tower and transmitter inspection. NDGPS will ultimately achieve dual terrestrial coverage in the continental United States with a signal availability of 99.9%.[1]

The USCG Command and Control Engineering Center (C2CEN) is the System Management and Engineering Facility (SMEF) and has overall system engineering responsibility for DGPS systems. To meet these high standards, C2CEN established the Radio Frequency Working Group (RFWG) to pool corporate knowledge and to ensure system wide success. The working group is comprised of USCG electrical engineers, civil engineers, technical experts, installation experts, navigation experts, and USCG Academy professors. The mission of the RFWG is to design an antenna system and ATU requiring minimal training for operation and maintenance as well as meeting coverage and availability requirements. The Enhanced Series N/DGPS antennas will provide more efficient and wider bandwidth antennas, but will take several years to upgrade all sites. While field units upgrade antennae, C2CEN focused on engineering an all-weather ATU as a second major improvement for system availability.

Commercially available ATUs all featured the same basic design, with primary differences in implementation. All ATUs are able to account and tune for changes in antenna capacitance, which is essential for antennae one-tenth of a wavelength or less. All ATUs also feature an autotransformer, which multiplies the antenna's real resistance to achieve a near 50 Ohm match. Some ATUs featured up to 11 matching positions, but all provided a finite number of matches, which typically provided some reflected power upon installation. Having observed weather patterns, changes in antenna resistance and transmitter failures, we deduced that the antenna resistance changed seasonally, which legacy ATUs cannot adjust for. The result is a match which can stray from 50 Ohms to as low as 30 Ohms, causing an overcurrent situation in the transmitter, along with amplifier failures and loss of broadcasting signal. Although DGPS uses two reference stations and two amplifiers, unless the ATU mismatch is corrected, the second amplifier will also fail, rendering the site off-air and requiring maintenance personnel to correct the ATU match. Therefore, it became obvious that if the ATU provided a 50 Ohm match regardless of changes in antenna resistance, transmitter failures will decrease significantly.

The purpose of this paper is to propose new concepts and is not intended to reflect USCG direction or policy. Use of company names, trademarks, or copywrited material is not an endorsement of any product or service.

REQUIREMENTS DEVELOPMENT

The goal of this study was to engineer a commercially available all-weather ATU for N/DGPS application. Engineers worked closely with contracting officers and contractors to allow the engineering process to be completed while providing options to fix any problems encountered in the design and to move seamlessly into production level effort. The result appealed to industry, contracting officers, supporting units, and the USCG Navigation Center. The engineering team evaluated COTS [Commercial-Off-The-Shelf] ATUs (none were all-weather), developed a requirement, released a request for proposals, evaluated proposals, awarded a contract, installed prototype units, held a critical design review, and purchased equipment for all maritime DGPS sites.

The evaluation of existing COTS ATUs was [a] key factor [to] the success of this project. Although none of the ATUs were capable of tuning the resistive component of the antenna in real time, the different technical approaches identified areas to evaluate and test each new ATU. Ninety-one (91) areas were identified for testing and evaluation, covering all areas from bandwidth observed via network analyzer; to placement and shielding of tuning cards; to recommended RF feed; to the antenna. Core requirements were ATU efficiency and system bandwidth observed via network analyzer.

Recall the circuit equivalent of the RF Datalink is:

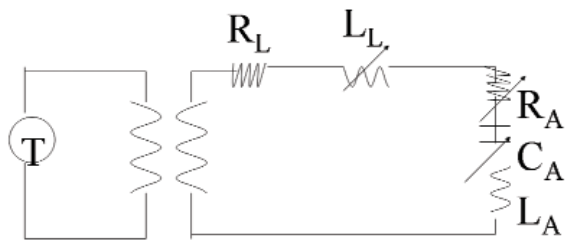

Figure 1. Norton-Thevenin Equivalent Circuit for DGPS Datalink.

Where R (var), C (var), and L represent the antenna and the remaining components represent an existing COTS ATU which is unable to automatically compensate for changes in antenna resistance. Recall that antenna resistance can be broken down into:

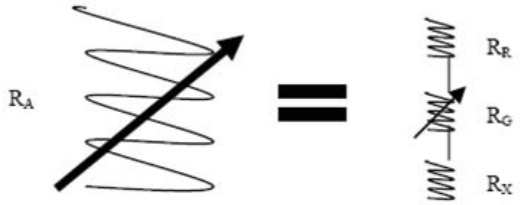

Figure 2. Breakdown of Antenna Resistance.

Where RR is radiation resistance, RG is ground resistance and RX is connections throughout the RF path. Note that as the antenna ground plane becomes moist,

dry, or changes conductivity as the seasons change, the overall antenna changes. C2CEN has concluded that rain, snow, fog, and ice have changed RG and that an ATU capable of compensating in real time for this change would (a) ensure a 50 + 0j Ohm match at time of install and (b) this match would be maintained, allowing the system to operate in adverse weather, improving system availability.[4]

An important distinction of this project is that C2CEN did not require higher efficiency or more bandwidth via the ATU. Changing RL has a dramatic effect on both efficiency and bandwidth; however, in replacing the ATU, improvements in efficiency necessarily mean decreasing bandwidth and vice versa. To ensure the equipment maintained present coverage, all designs were baselined from the far field using C2CEN's 90' Rohn antenna with the existing equipment to ensure coverage would not be degraded. Decreases would not be tolerated; meeting the same level or slightly improving coverage would be ideal; dramatic increases would lead to poor evaluation.

MEASUREMENTS

Bandwidth was measured directly via network analyzer on C2CEN's 90' Rohn antenna. Bandwidth is defined as the difference between two frequencies at a consistent level or mark. For the purposes of our test, we used 1.7:1 VSWR and 1.1:1 VSWR as defining points in measuring bandwidth. To illustrate ideal configuration, here is a typical network analyzer plot showing bandwidth is shown below for a 150' Rohn antenna with the new all-weather ATU:

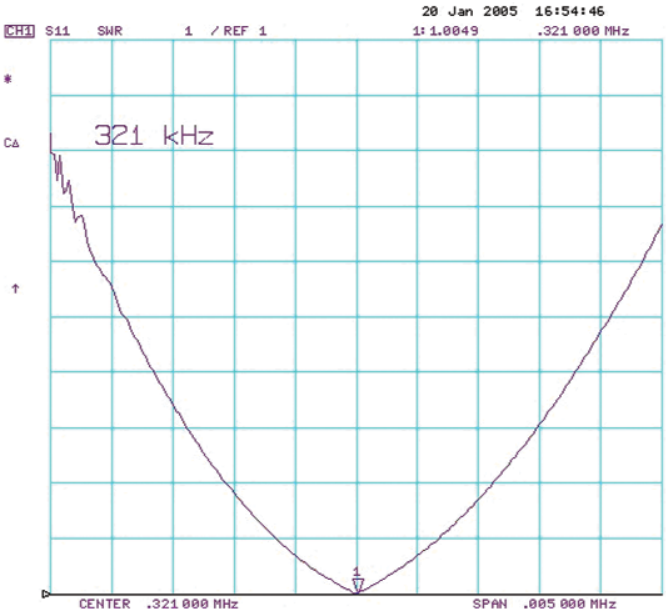

Figure 3. All Weather ATU VSWR Bandwith.

Note that the plot nearly touches at the bottom of the screen, nearing 1.00 VSWR. The minimum VSWR is observed from this screen and bandwidth can be measured by scrolling the cursor to the respective 1.7 and 1.1 areas, recording frequencies, and performing the arithmetic to measure the span of frequencies available for broadcast use. The next figure shows the same 150' Rohn antenna with the legacy equipment:

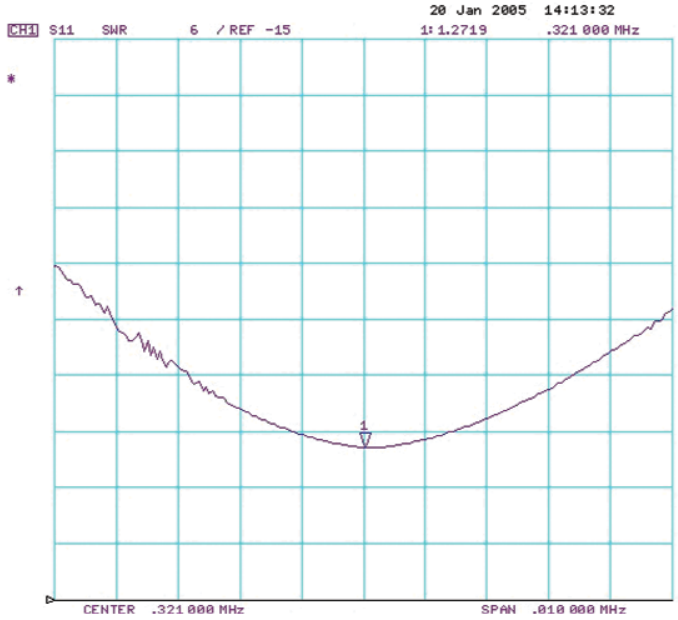

Figure 4. Legacy ATU VSWR Bandwith.

In this case, the antenna is considered tuned as the capacitive part of the antenna has been equalized by the ATU loading coil. However, the ATU is not matched to a 50 Ohm load or the VSWR would near the bottom of the graph. Thus, the ATU starts with a higher than required minimum VSWR at 1.27:1. The bandwidth observed at 1.1 VSWR is non-existant since our minimum VSWR is above that threshold. Note that the 1.7:1 VSWR bandwidth is distorted as the measurement will be taken across two broad points here, rather than in two more narrowly defined points above. The overall power distribution is optimized when the VSWR at the carrier frequency is nearly 1.00 when referring to narrowband broadcasts (<1 kHz) such as DGPS.

The Smith chart is also a very useful tool when determining the quality of a tuned antenna. The VSWR chart represents a 2D representation of the map where it is clear whether the antenna capacitance is balanced by the loading coil, but it is not clear which direction or what value the resistive match is made to. The Smith chart most accurately describes the match using a vector from the center of the chart (50 + 0j Ohms) which indicates how close the match is to minimize VSWR.

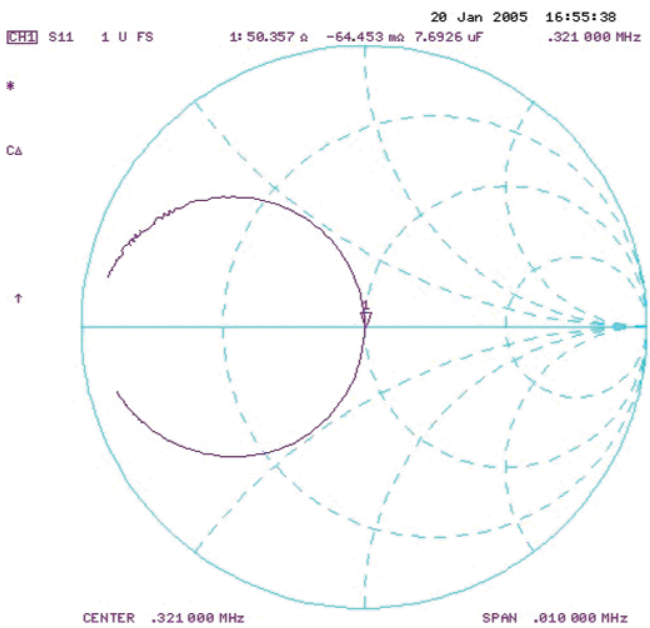

Figure 5. All Weather ATU Smith Chart.

Figure 5 shows the same 150' Rohn antenna with the all weather ATU. Note that the cursor is at carrier frequency and shows a match of 50.3 + 0.06 j Ohms. This is very near an ideal match. The all-weather ATU operates on a RF feedback loop to keep the ATU at the point whenever RF is present. However, using the network analyzer, the components were manipulated manually to achieve this match; in reality, the match obtained would be even closer than what is observed here.

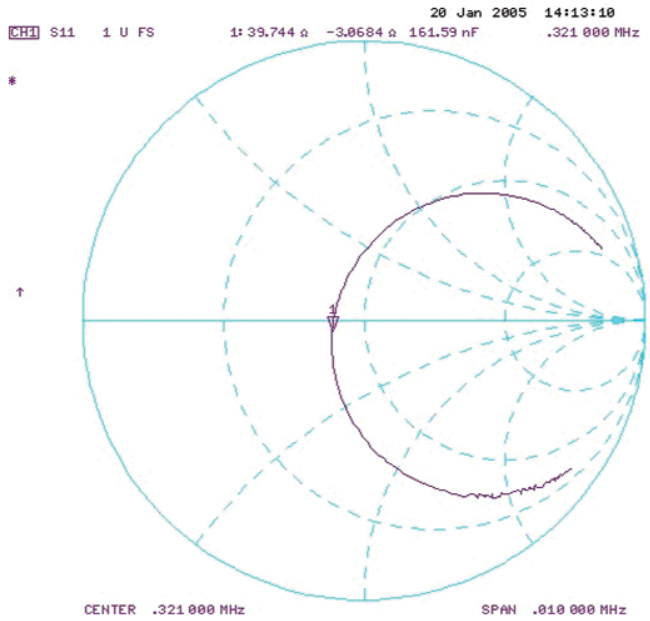

Figure 6. Legacy ATU Smith Chart.

Figure 6 shows the same 150' Rohn antenna with the legacy equipment. The match is far from ideal and was found at 39.7 - 3 j Ohms. Although the legacy equipment does tune for changes in antenna capacitance, the motor operating the variable loading coil is not smooth and changes are erratic. More disturbing is the distance from the 50 Ohm match. The legacy equipment cannot automatically adjust for changes in resistance and thus, even a small change in resistance is multiplied by the impedance matcher. Note that this change will force transmitter currents to surge and pull, often causing an overcurrent state of the match drops too low. It is also worth pointing out that there is a 180 degree difference in phase between the legacy equipment and the all weather ATU. The legacy equipment uses a very simple circuit; the all weather ATU uses a more sophisticated circuit which actually inverts the phase through their patented matcher.

The network analyzer is invaluable to gather an objective description of the antenna match and to provide basic guidelines for required bandwidth. All prospective entries submitted products to demonstrate the functionality of their match and ensure the match could be recreated, predicted, and repeated for future installs.

The requirement measured bandwidth at the 1.1:1 mark and at the 1.7:1 mark. The present equipment generally meets the 1.7:1 ratio, which coincides with the transmitter folding back into a protected, reduced power output. However, the present equipment is not guaranteed to meet a 1.1:1 match as the equipment has a discrete number of impedance taps which attempt to match the total system resistance to 50 Ohms. The result is almost assured reflected power during static weather conditions, with variations sure to increase or decrease the 50 Ohm match, which has been linked to transmitter failures, high call out rates, depleted spare kits, and low system availability.

Two sets of bandwidth were taken using the VSWR function on the network analyzer to show improved bandwidth at 1.1:1 by simply providing a better 50 Ohm match and to compare bandwidth at 1.7:1 as a check for far field measurements. These measurements would be repeated in the field for each antenna type to determine suitability for increased bandwidth requirements for future DGPS correction modulation schemes.

ALL WEATHER ATU EVALUATION

The requirement was released with great interest from industry, especially since the requirement did not require the vendor to use a particular technology. Several L-L, R-L, and L-C designs were possible, but to maximize the number of vendors and explore the technologies togeth-

er, C2CEN specifically abstained from requiring any circuit, motor, or component combinations. The evaluation would be based off efficiency, bandwidth, and the remaining quality assurance items to ensure the equipment was hearty and technician friendly. Unfortunately, several potential vendors were unable to meet the timeline as contracting and legal review times were underestimated. Two vendors used two different technologies to submit technical proposals via paper and on-site demonstration at C2CEN. Both proposals were evaluated per the posted 91 requirements and C2CEN submitted the results with a technical recommendation. The contracting office considered the recommendation and cost to achieve the best value to the government. The contract was awarded to Nautel Maine for its submission of the "ATU-HP" in September 2004.

Seven sites representing each major antenna type were selected for prototype installation, which started in December 2004 and ended in January 2005. During the installs, the ATU efficiency and bandwidth was measured during the System Operation and Validation Tests. The sites were remotely monitored for approximately 5-months to observe seasonal changes in the ground plane, antenna icing, and general response to DGPS system requirements.

NAUTEL ATU-HP

The Nautel ATU-HP, an all-weather ATU, functions much differently than the legacy ATU and is important to understand the basic operation to fully appreciate how it meets the USCG requirement. It has the same fundamental design as the legacy ATU in that it uses a loading coil to cancel the antenna capacitance and uses an autotransformer to match the antenna resistance close to a 50-Ohm load. The new design inserts a balanced tank circuit which is appropriately named the matcher.

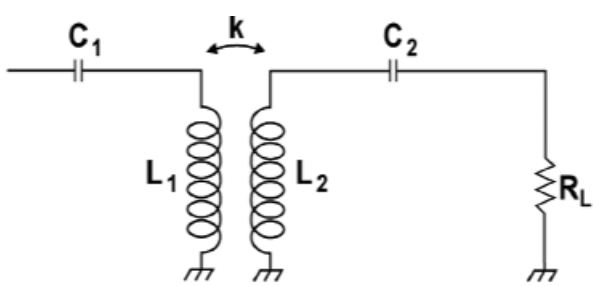

Figure 7. Nautel Matcher.

The design maximizes the capacitance by selecting a low value for the coils. For DGPS applications, L1 and L2 are 46 uH. C2 is a fixed capacitance at 7000 pF and C1 is nearly 7000, but varies slightly depending on the carrier frequency. Rather than use a large vacuum variable capacitor for C1, Nautel uses a binary series of capacitors in parallel to choose the correct frequency. The circuit provides a DC path to ground, which prevents the capacitors from failure if the antenna collects a DC charge from the wind flowing through the antenna. Note that since the design uses a large variable loading coil, C2 is technically optional, although the design has not been implemented without it. RL represents the antenna, loading coils, and resultant match from an autotransformer. Since the antenna reactance will be equalized by the loading coils, the antenna will appear as a resistive match which the tank circuit will tune.

The function of the matcher is to provide a smooth 50 Ohm match for the transmitter. This is possible since L1 and L2 are mutually coupled with an air gap between them. The inner coil is 80% of the diameter of the larger and is slightly longer to maintain the 46 uH and remain resonance. The inner coil is placed on a screw type drive to slowly move the coils in and out of each other. The movement of the coils does not change their inductance, but rather changes their coupling factor (k). For example, if the coils were directly on inside each other, the coupling factor would be very high; if the coils were barely overlapping, the coupling factor would be very low.[5]

$$k = \frac{m}{L}$$

Equation 1. Coupling factor.

In equation 1, k is the coupling factor, m is the inductance shared by the coils, and L is the inductance of each coil (46 uH for our application). Ergo, if a change in RL is observed, k must change, which means the mutual coupling between the coils must change, and a screw drive serves to automatically find the new point of resonance and keeps the transmitter input impedance at 50 + 0j Ohms.[5]

$$Z_{in} = \frac{k^2 X_L^2}{R_L}$$

Equation 2. Transmitter Input Impedance.

The changing of this coupling factor is what is needed to account for changes in antenna resistance. The requirement was to provide a + and - 50% change from the original antenna resistance, a significant change, but since radiation resistance, ground resistance, and loss to connections is low, any slight variation is magnified. From a centered 50 Ohm position, we have observed the capability to artificially match as low as 3 Ohms and as high as 194 Ohms on C2CEN's 90' Rohn antenna, with each

major motor increment equating to 0.1 Ohms, resulting in a smooth transition as real antenna resistance changes. For short antennas, the change in the coupling factor is observed to be almost purely related to the resistive term; the all-weather ATU controls reactance and resistance with two different vectors.

The goal during installation is to center the coils so they are approximately 50% coupled to allow tuning conditions for both dryer and wetter grounding conditions. The coupling factor also provides transmitter protection in the event an open or shorted condition occurs, either through fracturing the RF feed, icing over guy insulators or icing over the base insulators. This ATU is in fact, an all-weather ATU in that it will protect the transmitter from a variety of changing extreme conditions.

The Nautel ATU-HP also features an optional resistor bank, which is mounted on top of the ATU and is protected from the elements via a solar shield. Although not part of the requirement, this feature allows the installer to add 0 to 5.6 Ohms in approximately 0.8 Ohm increments. The benefit of this equipment is that for very short antennas, where bandwidth is very narrow, additional bandwidth may be inserted by adding series resistance. This is not the preferred method to increase bandwidth as it sacrifices signal efficiency, but the Nautel ATU-HP has a Q-factor on the order of 1000; the legacy equipment's Q-factor is near 700 when optimally loaded, but for shorter antennas, the Q-factor degrades to 500. Thus, there is a noticeable difference in bandwidth and efficiency for the shorter antennas. This feature ensures the customer may maintain, increase, or decrease bandwidth as desired. C2CEN has elected to maintain bandwidth for DGPS applications. However, if lower output power conditions became acceptable, series resistance could be added to provide wider bandwidth for emerging modulation schemes.

Nautel provided another feature which was not part of the original requirement -- the ability to measure and report ATU information digitally. The Nautel ATU-HP has a serial port which uses RS-485 protocol to communicate up to 5000 feet. Previous communication between the transmitter and ATU were unthinkable as the ground planes for most antennae extend at least 100 feet, if not 1000 feet at some sites. The ability to communicate locally over large distances in RF saturated environments brings new possibilities. The ATU-HP samples and reports output power, reflected power, ATU current and ATU temperature via the RS-485 port. The output power and reflected power provide easy reference for spotting line loss and also provide instant feedback whether the ATU is tuned and if enough RF is present to warrant hazardous conditions. The ATU current is provided as it is the most reliable and stable source of information to indicate signal propagation. Legacy practices calibrate near field antenna probes to the appropriate level as fringe antenna measurements are taken. The antenna probes are susceptible to decay over time, along with degraded signal as lightning protection wear, and cable loss. The ATU current sampling is performed via iron core torroid, which is very stable and is wound to 1% precision. If sampled in real time, the ATU current can provide real time coverage information with fairly straightforward calculations. This technology could provide the NAVCEN [Navigation Center] the ability to monitor coverage in real time and accurately predict tertiary, dual, and single coverage. The ATU CPU monitors ATU temperature and controls two cooling fans, which simply circulate air from the bottom of the unit to the top of the unit. The Nautel ATU-HP uniquely met all of our requirements and also laid the foundation for significant improvement in DGPS RF engineering by considering many elements of the future and incorporating them in to the present design.

RESULTS

The seven sites were selected for the prototype represent each of the major antenna types-Sloping-T, Longwire, 90' Rohn, 120' Rohn, 150' Rohn, 150e, and 295' GWEN. The 90e and 120e antennas were not selected as they were still prototypes and had not performed through the winter; the USCG also uses 70' Valcom whip antennas at 4 sites, which are gradually being phased out. The site locations were selected to include a variety of weather, including ice and lightning. Site output power was also a factor -- all sites used a minimum of 750 Watts output power to test the durability of the RF components. Previous site availability was also a factor, especially where cases of poor all-weather performance was documented. The final list of prototype sites and locations are listed in the table below.

Antenna Type	Site Location
Sloping-T	Omaha, NE
Longwire	St. Louis, MO
90' Rohn	Brunswick, ME
120' Rohn	Tampa, FL
150' Rohn	Lompoc, CA
150e	Angleton, TX
295' GWEN	Driver, VA

Table 1. Prototype Site Locations.

The contract required the contractor to provide and install the ATU; USCG engineers and technicians were on site

for all installs to check the configuration of the ATU. C2CEN engineers made the determination on site to finalize the amount of series resistance to achieve approximately the same coverage and bandwidth as observed with the previous equipment. Antenna reactance and antenna resistances were carefully measured to develop a table so that all future antenna orders with the exception of the Sloping-T and Longwire antennas could be factory configured, ready for installation. Future installs will not require a network analyzer and will save approximately 2-3 hours from an evolution that could easily take 8 hours. Additionally, every setting, including meter ranges and power options on the ATU can be factory set, thus saving additional off-air and on-site time.

The first measurement considered was the minimum VSWR. Sites with the lowest VSWR coincided with sites which were most recently visited and adjusted prior to C2CEN arrival. In real time, conditions vary so an array of measurements coincides with expected VSWR values, which varied greatly with the existing equipment, from 1.01 to 1.21, with a standard deviation of 0.074. The all weather ATU consistently attained values lower than 1.02 with a standard deviation of 0.007. Actual VSWR and reflected power was lower than the hand tuned values recorded below.

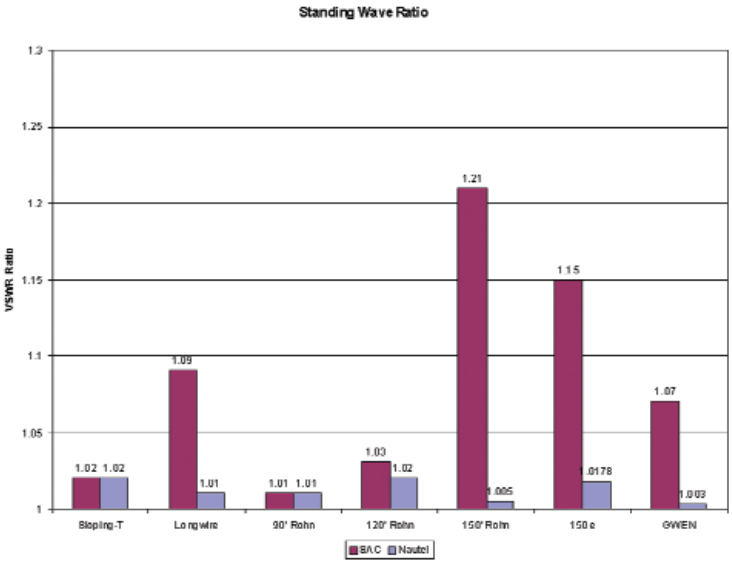

Figure 8. Minimum VSWR.

The data indicates the resistive match and reactive match worked constantly for all antenna types, as observed at the C2CEN berm when manually tuning. The tuning motors moved with great precision, allowing an analog match to achieve nearly 1.00 VSWR manually with less than 2 watts reflected. A much lower VSWR indicates the transmitter is nearly perfectly aligned, reducing stress and prolonging the expected life of the transmitter.

The 1.7 to 1 VSWR bandwidth indicates series resistance was successfully manipulated to neither gain bandwidth nor improve efficiency, preserving the envelope. This is key to the study as it would have been very easy to insert too much bandwidth to provide a larger tuning buffer for the ATU and increase availability; unfortunately, this would come at the expense of our coverage area. This is also a useful baseline for the maximum data channel available for future modulation schemes.

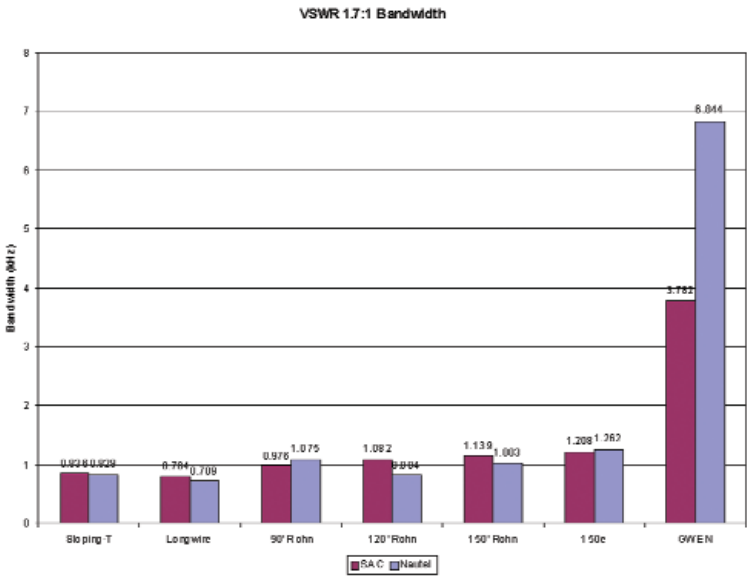

Figure 9. 1.7:1 VSWR Bandwidth.

Note the GWEN antenna has a much larger bandwidth than the other antennae; this is largely due to the significant size difference and its' near resonant frequency. The GWEN antenna uses very little inductance and with the Nautel ATU-HP, the loading coils are actually configured in parallel to maximize efficiency, so we would normally expect a lower value. Referring back to Figure 4, recall that the GWEN antenna was not very well matched; the new ATU provided a better match and also provided wider bandwidth in the process.

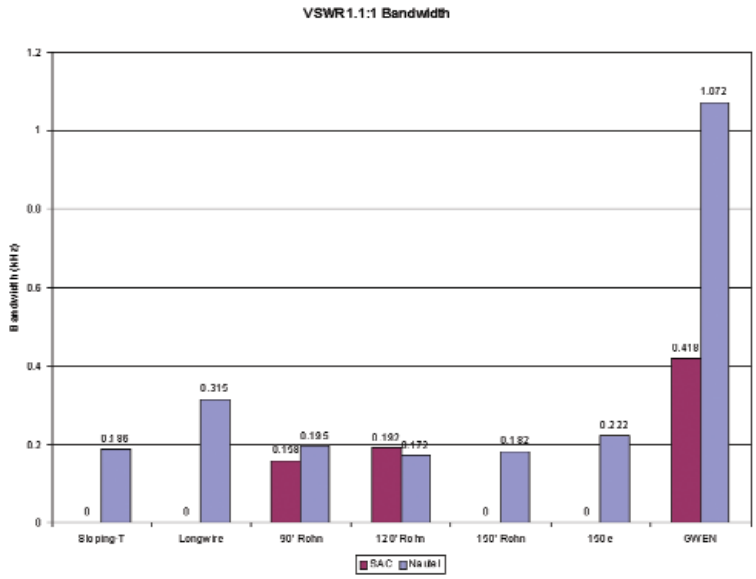

Figure 10. 1.1:1 VSWR Bandwidth.

The 1.1:1 VSWR bandwidth indicates the reduction in stress the transmitter is expected to have for each particular antenna type. Note that in many cases, the minimum VSWR was greater than 1.1:1 and had no measurable bandwidth. It is important to note that with the new ATU, this measurement is always possible as the minimum VSWR is always less than 1.02:1.

It should not be surprising that the GWEN, again, has plethora bandwidth, which increased as we improved the initial match with the new ATU.

After the bandwidth measurements were completed, C2CEN measured signal coverage and ensured all systems were working correctly. Upon completing the System Operation and Validation Tests (SOVT), C2CEN turned the site over to the watch stander located either at Navigation Center West (Petaluma, CA) or Navigation Center East (Alexandria, VA) for 24/7 monitoring and data collection.

Transmitter output power, transmitter reflected power, and Integrity Monitor Near Field Probes A and B were remotely monitored and archived. The data was collected from time of install to May 6, 2005 and compared with the same dates last year to simulate similar weather conditions with the old equipment. Actual humidity and temperatures were found and correlated via NOAA's database. Figure 11 shows a comparison for the 90' Rohn antenna in Brunswick, ME for Feb. 2004 and Feb. 2005:

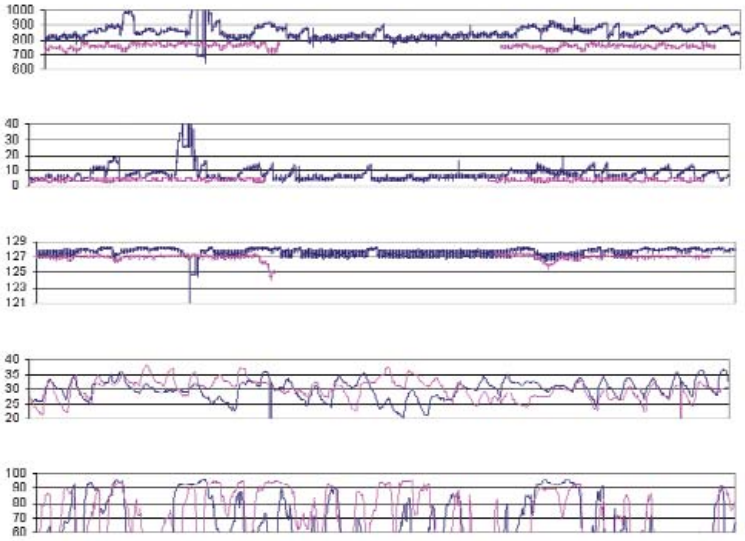

Figure 11. 90' Rohn in February 2004/2005.

Note that approximately 1/3 into the month in the blue, 2004 data, humidity rises and temperature drops, indicating either snow or ice. Reflected power increases and output power decreases, indicating that an antenna mismatch is made and the transmitter is in a protected, folded back state. Since the transmitter is not operating under normal power, it is not able to cover the full range of the coverage area and this time is considered off-air time due to low beacon signal strength. Some of the 2005 data is not available due to communications outage, so another example will be used to illustrate the new ATU maintaining a match during ice storms.

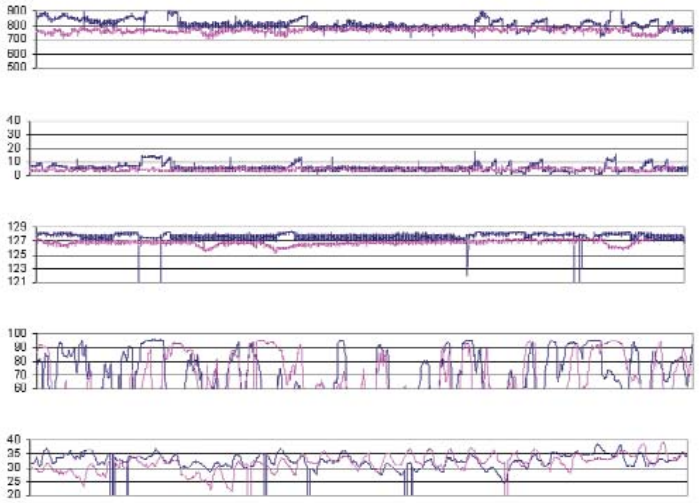

Figure 12. 90' Rohn in March 2004/2005.

Several extended humps in the humidity for March 2005 with low temperatures indicate freezing conditions. Reflected power remains low during this period and only a slight loss of signal strength is observed, but within alarm tolerance. Thus, the site remained on-air with the transmitter at full power. The small decrease in signal strength is likely since the antenna ground plane resistance was changing and thus, the efficiency of the antenna was changing as well. A more thorough study of the issue is now available since the Nautel ATU-HP can report output power, reflected power, ATU current and ATU temperature via a RS-485 communications link. Although this link is not being used, monitoring ATU current will provide a more objective method for studying and understanding far field conditions based on measurements available in the near field.

In addition to remotely monitoring transmitter and near field sensors, C2CEN also monitored overall on-air time from December 2003-May 2004 (old equipment) and December 2004-May 2005 (new equipment). The report was formed based on the weekly on-air reports from the USCG Navigation Center and removed off-air time attributed to other equipment failures. The 90' Rohn (Brunswick) data is as follows:

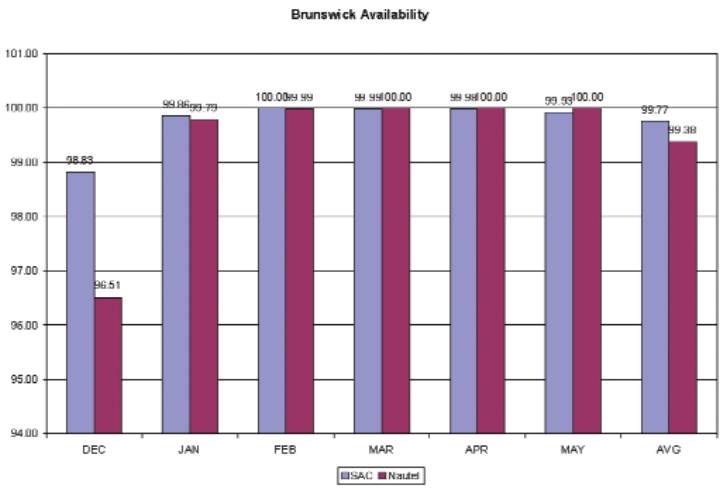

Figure 13: 90' Rohn Availability.

Although the data reports were submitted weekly, the nature of the December 2004 data is misleading in that the site was off-air experiencing a casualty at the time of install. Thus, some of the December 2004 data actually is the old ATU.

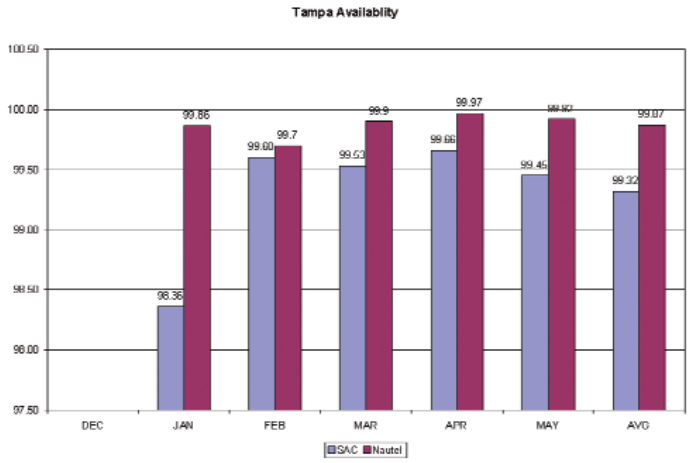

Figure 14. 120' Rohn Availability.

For the 120' Rohn, although 100% availability is not achieved, it is an improvement from previous equipment.

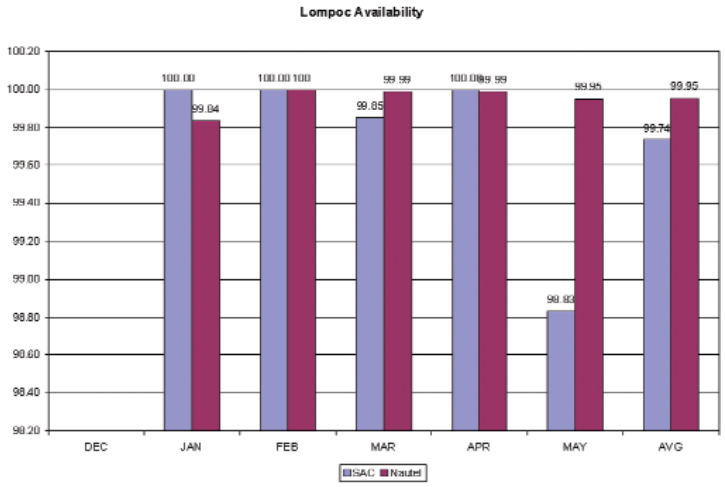

Figure 15. 150' Rohn Availability.

The 150' Rohn shows issues with previous year's data; this year's data meets the availability goal of 99.7%.

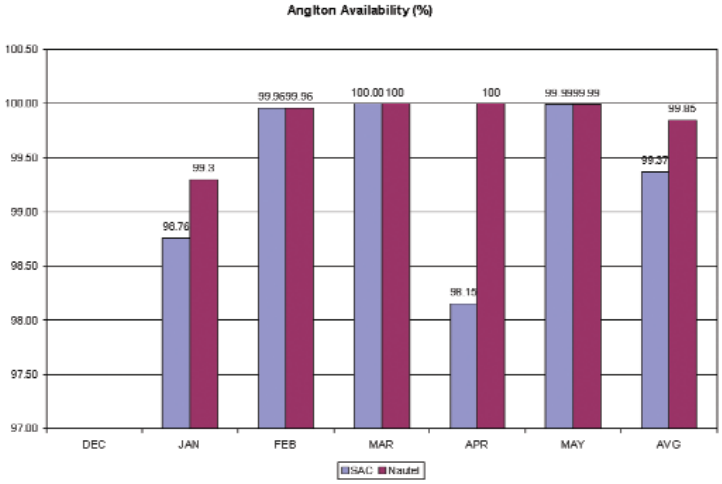

Figure 16. 150e Availability.

The 150e also shows consistent improvement. The low value for April 2004 is likely due to a communications outage rather than an RF outage. Specific details for previous years data was unavailable.

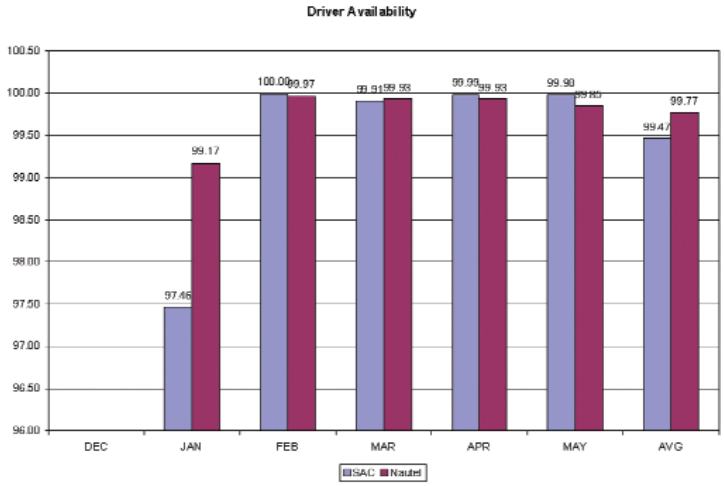

Figure 17. 295' GWEN Availability.

The 295' GWEN antennae have normally been high performing antennas, although they are susceptible to icing as they lack ribbed insulators. In general, the ATU improved performance at this site.

The Sloping-T antennas, particularly Omaha, NE, are poor performing sites. The unstable wire is often carried by the wind, which requires continual tuning of the loading coil. Notice that although this site is not meeting the 99.7% goal consistently, there are more cases for it meeting the requirement with the new ATU than with the old ATU. Additional antenna work is required to stabilize the antenna to achieve 99.7% availability.

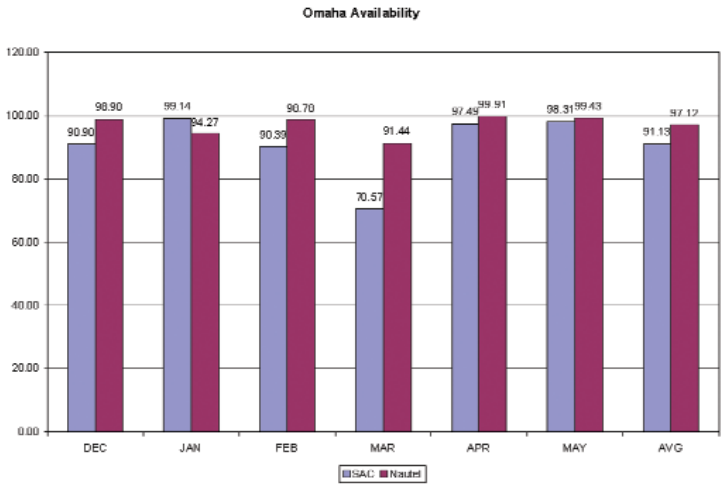

Figure 18. Sloping-T Availability.

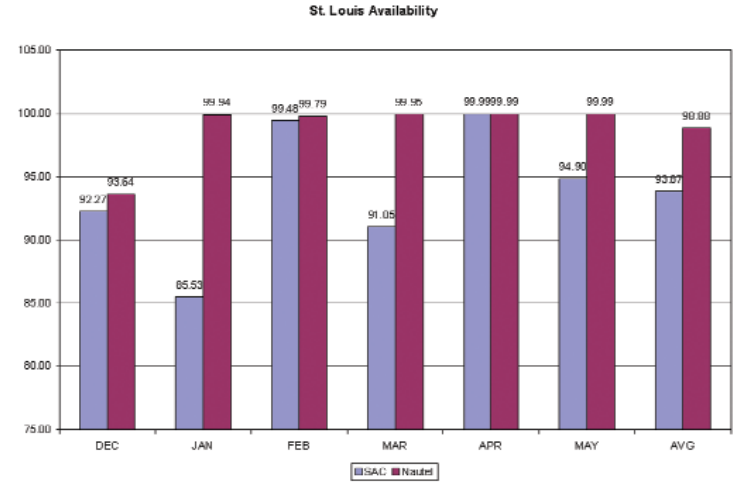

Figure 19. Longwire Availability.

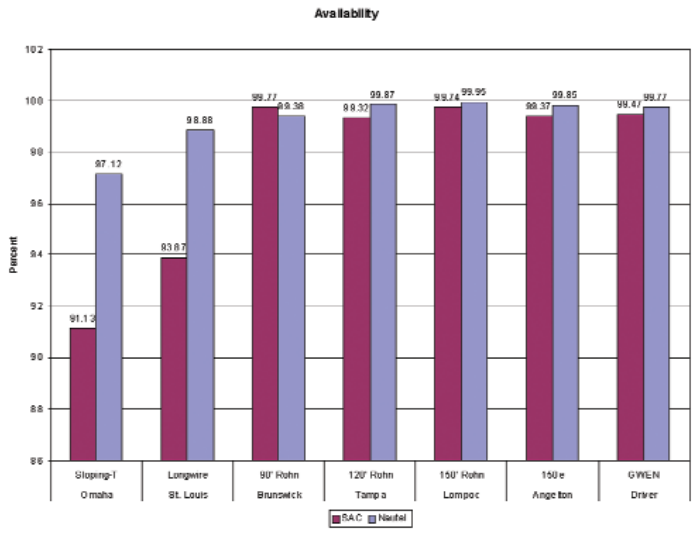

Figure 20. Availability Summary.

This longwire antenna has experienced a dramatic improvement in performance. The site typically shut down due to ice and weather but since the install of the new ATU, the site consistently exceeds availability of 99.7%.

To summarize the results of availability, before and after availabilities were summed and each antenna type was placed on the same chart to show the difference in performance between the antenna types.

The Nautel ATU-HP has improved system availability for the sites prototyped on average from 97.52% to 99.26%. The impact is most noticeable on the weaker sites, bringing them from the 90-95% range to the 95-97% range -- a significant stride forward toward meeting our overall goal of 99.7% system availability.

CONCLUSION

The install of the all-weather ATU has improved DGPS system performance by (a) ensuring the install achieves a 50 Ohm match with VSWR of less than 1.02 and (b) maintaining a 50 Ohm match automatically, keeping the DGPS site on-air when experiencing changes in weather.

While the upgrade of the antennas are still necessary to improve antenna efficiency and bandwidth to harden the site, the all weather ATU provides immediate relief for transmitter amplifier issues and a cost savings in technician call out, travel costs, equipment repair, and the logistics strain for seasonal failures of transmitter amplifiers.

The all weather ATU opens the door to many future capabilities. For example, the ability to add system resistance and bandwidth at all sites may prove invaluable if enhanced modulation schemes require additional bandwidth and all sites have not received antenna upgrades. Operators can weigh the benefit of the added modulation scheme with adjacent site coverage to closely manage the fielding and roll out of the new signal.

The all-weather ATU introduces antenna current monitoring and reporting as a possible tool for remote site monitoring. Present datalink performance monitoring is accomplished using near field probes which are calibrated using far field measurements. Antenna current will provide a much more intuitive metric for determining signal coverage -- one that will readily account for changes in antenna efficiencies and near field instability. By monitoring antenna current in real time, it is possible to predict coverage real time, showing areas of single, double, and no coverage. If transmitter output power is remotely controlled, the coverage could be held constant, or even increased if adjacent sites were off-air for maintenance.

ACKNOWLEDGEMENTS
We would like to recognize Dr. Michael McKaughan, Professor at the U.S. Coast Guard Academy, for sharing his passion and knowledge in working with antennas, particularly in finding systemic flaws in the ATU and providing suggested solutions.

We also recognize John Pinks, Chief Engineer Emeritus of Nautel for the design of the ATU and his engineering expertise.

The purpose of this paper is to present initiatives and propose new ideas for exploration. It is not intended to reflect USCG direction or policy. Use of company names, trademarks, or copywrited material is not an endorsement of any product or service.

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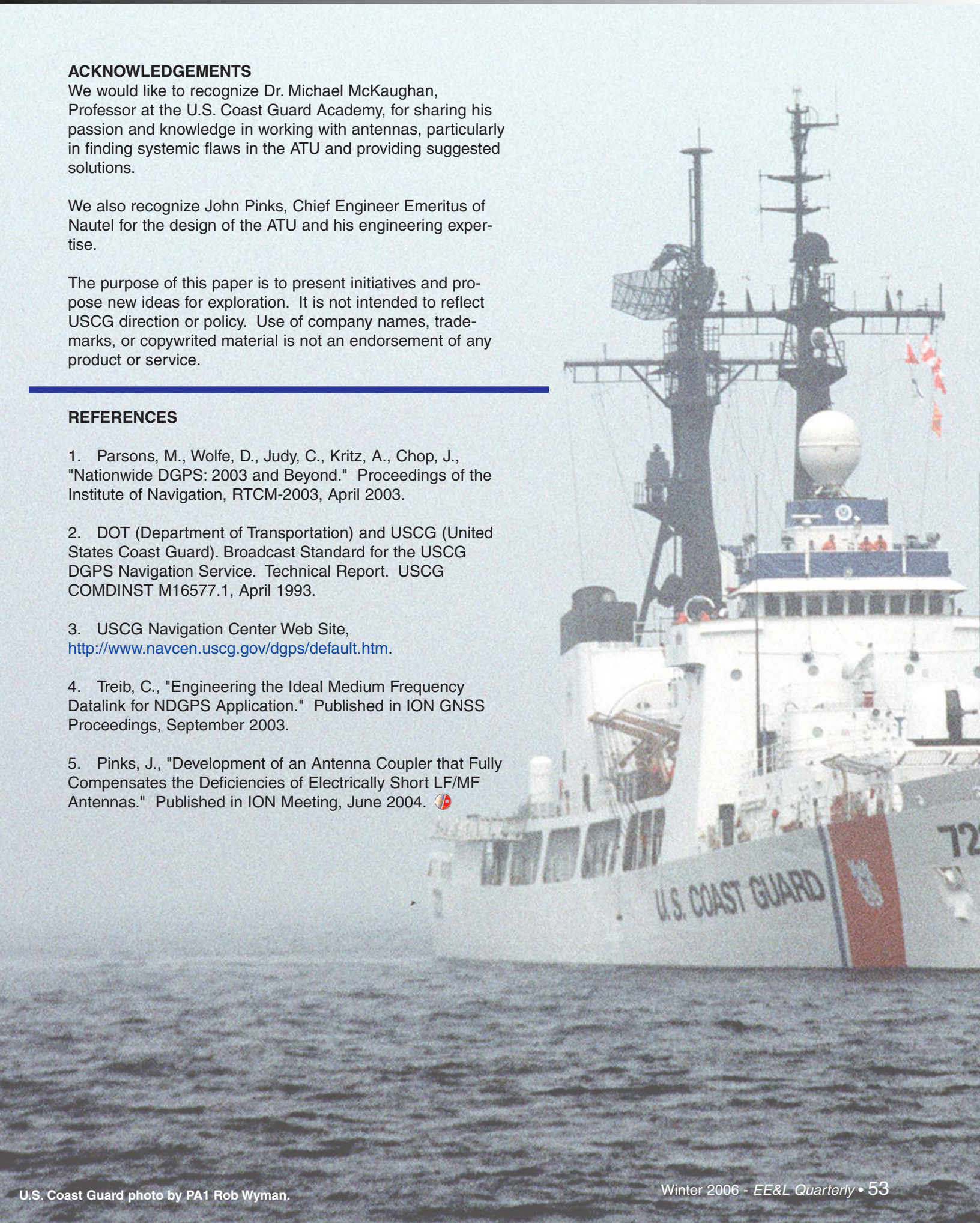
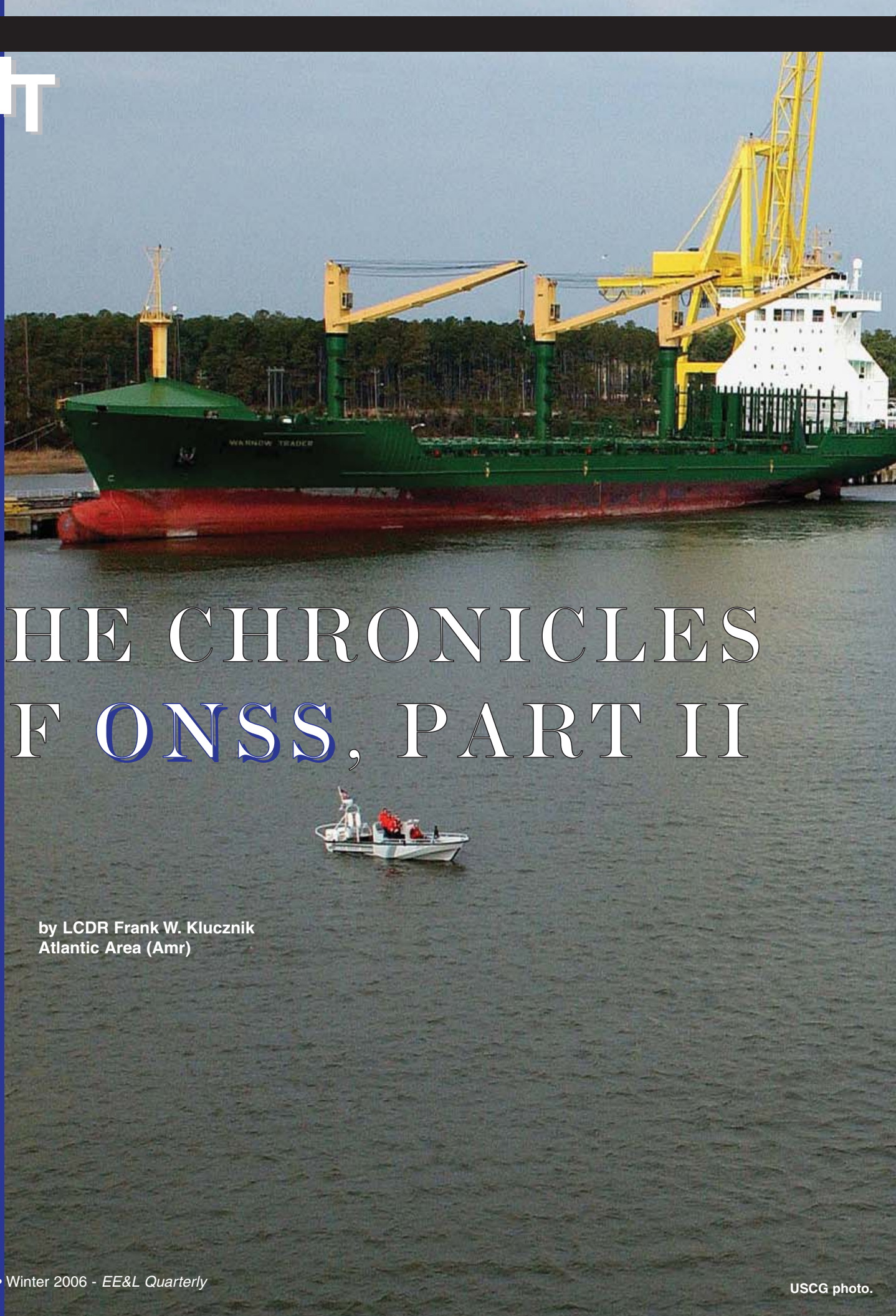


U.S. Coast Guard photo by PA1 Rob Wyman.

PART II

THE CHRONICLES OF ONSS, PART II

by LCDR Frank W. Klucznik
Atlantic Area (Amr)



USCG photo.

This is part two of a multi part series chronicling an IT [Information Technology] pilot project from conception to disposition. The pilot was dubbed ONSS, pronounced "onus," and involves a reporting process in support of Operation Neptune Shield (ONS). Part one was presented in the Fall 2005 edition of the *Engineering, Electronics & Logistics Quarterly* and describes in detail the report process and conception of the project through its first year. Part II of the series discusses the System Development Life Cycle (SDLC), its impact on project development, and the latest chronicles of ONSS. Nothing in this article is intended to criticize, malign, or embarrass any individual or organizational entity. This series is designed as an informative journal describing events as they unfold and explaining some of the processes involved in system development.

ONSS OVERVIEW

During the first year, the concept of a web-based ONS Scorecard (ONSS) was developed through an evolutionary progression of Excel spreadsheets, which were used to report field level operational activities. This application of Excel presented a variety of complex problems for ONS managers because the captured data was classified, the methods used to collect and collate data across the Coast Guard varied, not all field units had adequate secure communications, and there was no central data repository to store information for future analysis.

The idea of a web-based scorecard was first presented to Headquarters in October 2004, where a group of program managers agreed the ONS Scorecard process ultimately belonged in an existing enterprise system. Unfortunately, enterprise system managers were not willing to implement the project because requirements were frequently changing since the ONS program was relatively new. This problem was exacerbated by the fact ONS represented a merger of "O" and "M" activities, and given that most data collection systems were already stove-piped within their own sponsoring programs, ONSS was not a good fit for any of the existing systems. In spite of these challenges, the Headquarters group agreed there was a valid need for an IT system that would: (1) provide consistency to the data collection process, (2) reduce the administrative time required to analyze, validate, and process reports, and (3) establish a central repository to store the data for future analysis. In addition, the project could be used to create a system requirements document for marketing the process to existing enterprise system managers at a later date. A web-based solution was selected because it offered quick development with organic resources and low-cost maintenance through existing support contracts without any funding increases. A web solution also provided the flexibility to change quickly, without requiring a large engineering effort, in response to the evolving ONS program. Figure 1 contains a historical log of the project to date (see next page).

SDLC OVERVIEW

The preamble to the SDLC states the document was created to make sure Command, Control, Communications, Computers and Information Technology (C4&IT) are managed more effectively. The process was designed to ensure end-state solutions meet user requirements, and support Coast Guard and Department of Homeland Security (DHS) strategic goals and objectives. Although these statements are true, they only provide a partial description of the SDLC. The missing part includes: The SDLC was also developed as a detailed guide to help Program Managers with ALL aspects of IT system development, regardless of the system size and scope. The SDLC contains a comprehensive checklist of the rules and regulations governing IT systems, and is the Coast Guard's way to ensure system developers comply with all applicable Government regulations, because the consequences of not doing so are high and wide ranging. This is especially true in the post 9/11 environment where larger amounts of information are considered sensitive in nature, and are shared among our international, federal, state, and local partners.

The SDLC went into effect in January 2005, and established seven progressive steps or activities Coast Guard IT systems' development must follow. These activities include: conceptual planning, planning and requirements definition, design, development and testing, implementation, operations and maintenance, and disposition. Figure 2 (see page 57) depicts the SDLC phases and the documents that define the life-cycle of a typical C4&IT system. These phases begin with the identification of a need, and span all facets of a C4&IT initiative, including development, deployment, operation, and final disposition or retirement of an asset.

The seven step process contains a procedural checklist and the systematic progression required to evolve an IT system from conception to disposition. CG-6 [Command, Control, Communications, Computers & Information Technology Directorate] created a quick reference guide and document templates to guide users

Figure 1. Operation Neptune Shield Scorecard (ONSS) Historical Timeline.

MMM/Year	Event
Dec/2003	- Operation Neptune Shield OPOrder released and scorecard reporting began with daily reports from field units
Jan/2004	- Daily scorecard reports extended to weekly reports
Aug/2004	- Idea of web-based scorecard conceived
Sep/2004	- Prototype scorecard reports developed and field tested
Oct/2004	- Idea of web-based solution presented to HQ program managers and given the go ahead
Nov/2004	- Web-based scorecard concept presented to PWCS/ONS stakeholders and approved - Established development team for project (e.g. G-MPP, Amr, Pmr)
Dec/2004	- Organic resources began development on web-based application using requirements derived from original scorecard and prototypes - LANTAREA entered into an informal maintenance and support agreement with MLCA(t) for ONSS
Jan/2005	- SDLC process goes into effect
Mar/2005	- Informally established G-MP and G-OP as joint HQ sponsors for ONSS pilot project - Beta test of ONSS by six field units and five district offices
Apr/2005	- Submitted Business Case, Project Management Plan, and Funding Plan to HQ for review /approval - Revised ONS OPOrder released from HQ
May/2005	- First training for ONS and ONSS CG wide. Trained reps from all MSO and Sector Commands, Districts, Areas, and HQ elements on ONSS and Operation Neptune Shield - Weekly scorecard reporting extended to monthly cycle
Jun/2005	- Completed development on ONSS V 1.0.0 - Completed testing of ONSS V 1.0.0
Jul/2005	- ONSS received official system designation letter from CG-6 and entered the SLDC at the Conceptual Planning Phase - Expanded testing of ONSS to all LANTAREA units on a voluntary basis - LANTAREA requested approval to operate system on a limited basis to support elevated MAR-SEC levels - LANTAREA entered into a formal maintenance and support agreement with MLCA(t) for ONSS
Aug/2005	- LANTAREA received conditional approval from CG-6 for limited deployment of ONSS in support of elevated MARSEC levels - CG-6 designated Program Managers, Asset Manager, System Development Agent, System Support Agent, and System Sponsor Representatives for ONSS - D9 began using ONSS
Sep/2005	- ONSS met all conditions outlined by CG-6 for limited deployment of ONSS in support of second period of elevated MARSEC levels. 16 units began using system to report ONS activities - D1 began using ONSS - Documents drafted and routed by Sponsor Representatives to move project from Conceptual Phase to Planning and Requirements Phase
Oct/2005	- Formal contract for web developer went into effect - Completed requirements capture for ONSS V 1.2.0 - Completed formal requirements capture for ONSS - D5 began using ONSS

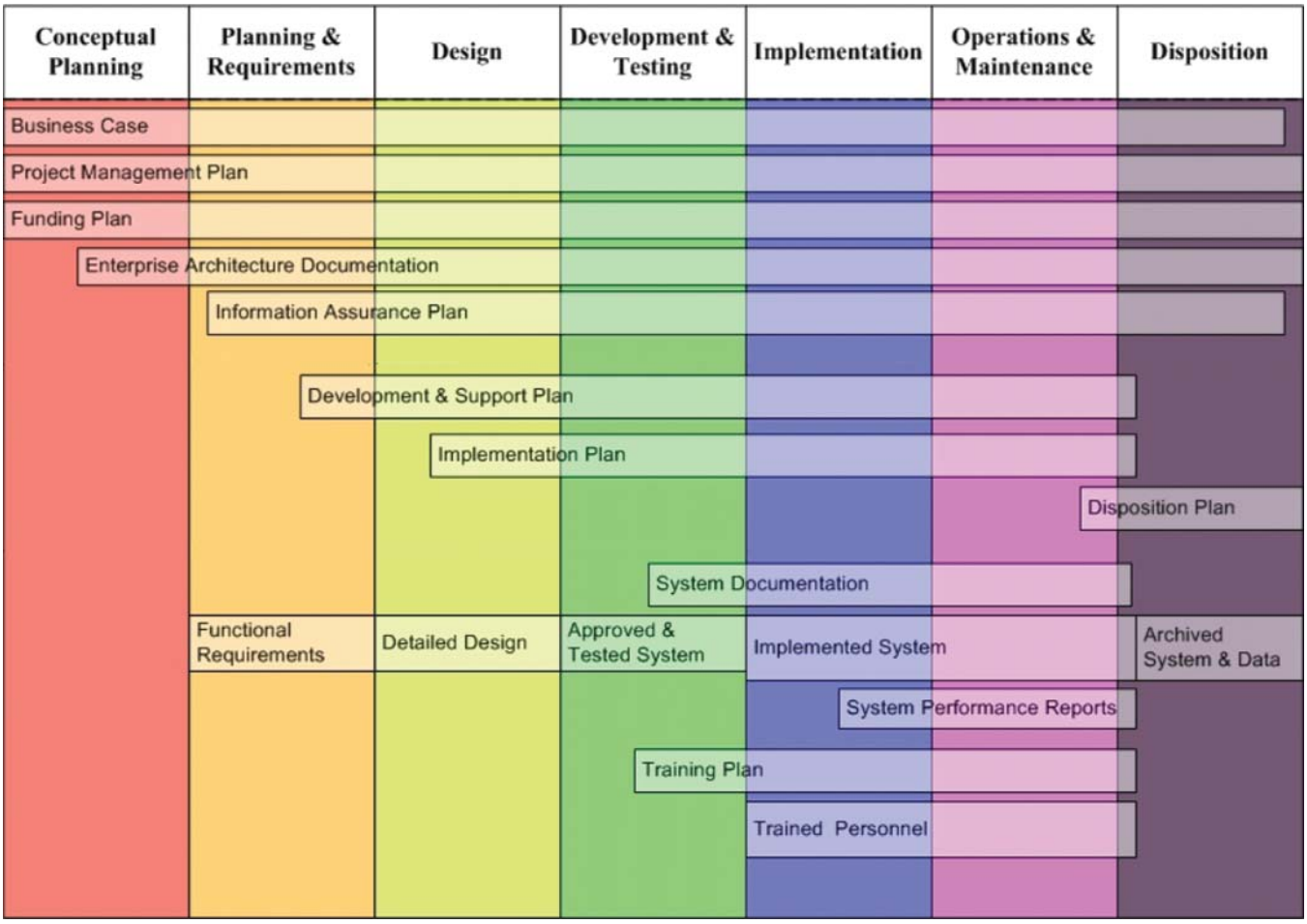


Figure 2. The seven phases of Coast Guard SDLC.

through the system development process, and although the 110-page document is daunting, it provides a set of step-by-step instructions for system developers to follow. The following descriptions were excerpted directly from "System Development Life Cycle (SDLC) Quick Reference Guide and Product Templates" dated 11 Feb 2005, and briefly explain each of the seven phases of the Coast Guard's SDLC:

✔ Conceptual Planning. This phase is the first step of any system's life cycle. It is during this phase that a need to acquire or significantly enhance a system is identified, its feasibility and costs are assessed, and the risks and various project-planning approaches are defined. Roles and responsibilities for the Asset Manager, Sponsor's Representative, System Development Agent (SDA), System Support Agent (SSA), and other parties in SDLC policy are designated during this stage and updated throughout the system's life cycle.

✔ Planning and Requirements Definition. This phase begins after the project has been defined and appropriate resources have been committed. The first portion of this phase involves collecting, defining and validating functional, support, and training requirements. The second part is developing initial life cycle management plans, including project planning, project management, Configuration Management (CM), support, operations, and training management.

✔ Design. During this phase, functional, support and training requirements are translated into preliminary and detailed designs. Decisions are made to address how the system will meet functional requirements. A preliminary (general) system design, emphasizing the functional features of the system, is produced as a high-level guide. Then a final (detailed) system design is produced that expands the design by specifying all the technical detail needed to develop the system.

✔ Development and Testing. During this phase, systems are developed or acquired based on detailed design specifications. The system is validated through a sequence of unit, integration, performance, system, and acceptance testing. The objective is to ensure that the system functions as expected and that sponsor's requirements are satisfied. All system components, communications, applications, proce-

dures, and associated documentation are developed/acquired, tested, and integrated. This phase requires strong user participation in order to verify thorough testing of all requirements and to meet all business needs.

- ✔ Implementation. During this phase, the new or enhanced system is installed in the production environment, users are trained, data is converted (as needed), the system is turned over to the sponsor, and business processes are evaluated. This phase includes efforts required to implement, resolve system problems identified during the implementation process, and plan for sustainment.

- ✔ Operations and Maintenance. The system becomes operational during this phase. The emphasis during this phase is to ensure that sponsor needs continue to be met and that the system continues to perform according to specifications. Routine hardware and software maintenance and upgrades are performed to ensure effective system operations. User training continues during this phase, as needed, to acquaint new users to the system or to introduce new features to current users. Additional user support is provided, as an ongoing activity, to help resolve reported problems.

- ✔ Disposition. This phase represents the end of the system's life cycle. It provides for the systematic termination of a system to ensure that vital information is preserved for potential future access and/or reactivation. The system, when placed in the Disposition Phase, has been declared surplus and/or obsolete and has been scheduled for shutdown. The emphasis of this phase is to ensure that the system (e.g., equipment, parts, software, data, procedures, and documentation) is packaged and disposed of in accordance with appropriate regulations and requirements.

A project or concept must establish a Headquarters level sponsor, and be presented in the form of a business case for review and acceptance into the SDLC process. Once accepted, the documents and products from the current phase must be completed, reviewed, and accepted by an approving authority in order for the project to proceed from one phase to the next. The SDLC Quick Reference Guide and Templates contains several multi-page matrices indicating what documents must be completed or updated by the end of each phase, and who the approving authority is for each document. The process requires Asset Managers, Sponsor's Representatives, System Development Agents (SDA), System Support Agents (SSA), and other involved parties all work together in order to (1) scope each document and product to determine the amount of information required and complexity of each document; (2) complete these products and documents; and (3) get appropriate products and documents approved. Working together these individuals make up a team responsible to ensure the proper completion of C4&IT products in order to deliver a mission and business-effective C4&IT system.

IMPACT OF SDLC ON ONSS

The title of this section is somewhat of a misnomer because the SDLC process did not directly impact the ONS pilot. Rather, it was a rapid increase in regulations governing IT systems between 2001 and 2004 that hampered the deployment of ONSS by placing a large administrative burden on system development. If the volume of regulations and policies governing IT development in government were represented by a pair of size 15 shoes, then the ONSS project would be a pair of size three feet. Every time ONSS attempted to take a step, its feet keep slipping out of the shoes. This size mismatch is primarily caused by two factors: (1) ONSS is extremely small when compared with other government data collection systems, and (2) the regulations governing the project were designed to manage much larger IT systems and do not make allowances for system size or scope.

In basic terms, ONSS is a relational database populated by two web forms (e.g., a daily activity report and a periodic report). Data stored in the repository is viewed through one of three output forms, including a GIS Map, scorecard report, and static periodic report. Since the application directly impacts 47+ shore side field units, 30+ Sector commands, 9 Districts, both Areas, and several Headquarters divisions, it falls within the bounds of government regulation and is clearly obligated to follow the SDLC process. Although the breadth of documentation required to develop and implement ONSS is considerably smaller than what is required for a larger system, the scope of the documentation is identical.

In the end, 25% of the delays in deployment were caused by an increase in regulatory compliance. An additional 25% were introduced by project creep as a result of the application's beta test in March 2005, release of the revised ONS OPORDER in April 2005, and sector implementation. All three of these events required major changes to the system prior to deployment. The remaining 50% was introduced by the documentation review and approval process. A small IT system enjoying joint sponsorship from two Headquarters divisions is not necessarily the panacea one might expect. Smaller IT systems don't garner the same attention a larger more expensive system might, and having two sponsors actu-

ally doubles the number of individuals involved in the review and approval process. Without strong support from Headquarters sponsors, the process of developing and deploying a new IT system is a long up-hill battle.

THE CHRONICLES OF ONSS

It has been said: "Timing is everything in life."; the same is true for IT projects. The development on the ONSS pilot began six months before the SDLC went into effect. Consequently when the project adopted the SDLC process, development on the first version of its web application was nearly 50% complete. This meant the project had literally progressed through the Conceptual Planning Phase, Planning & Requirements Phase, and Design Phase, and was operating within the Developing & Testing Phase. Experienced IT people, following the Coast Guard's spiral software development model informally accomplished these efforts with minimal documentation. Regardless of how much documentation was generated, the team already developed a detailed business case and cost benefit analysis, project management and funding plan, requirements documentation, information assurance plan, and established a maintenance and support agreement with MLCA. Unfortunately without the SDLC as a guide to follow, the team had no way to accurately estimate the amount of documentation necessary for deploying an enterprise system, or the proper format required for certification and accreditation. Consequently, the team had to start at the beginning and formally document all they made using the templates in the SDLC guide.

The project team first learned about the SDLC guide in late February 2005, and began earnestly documenting the pilot in accordance with the SDLC templates in March. The project's first SDLC submission was sent to Headquarters in early April, and contained a proper business case, project management plan, and funding plan, all of which spanned nearly 50 typed pages. The team expected their submission to expeditiously advance the project through the SDLC process in a matter of a month or two, and had high hopes of getting the system approved for operation by July 2005, August at the latest.

In preparation for a summer delivery, the team acquired funding from G-MPP [Office of Port Security Planning & Readiness] to organize a training seminar for the ONS program and web-based scorecard in Oklahoma City, OK in May 2005. The primary goal of this training was to provide a forum for training and discussing the ONS program with mid-level managers from all levels of the organization. The event was an overwhelming success, and attracted 80+ individuals, including representatives from every MSO [Marine Safety Office] and Sector Command in the Coast Guard, all nine Districts, both Area Staffs, and four Headquarters divisions. This represented the largest and most diverse group brought together to discuss the ONS program to date, and resulted in a productive dialogue both up and down the chain of command. The field unit representatives left with an improved understanding of what was required of them, while the Area and Headquarters Program Managers came away with a clearer picture of the impact ONS operations had on field units.

June 2005 represented one of the first milestones of the project as the first version of the web application was completed, tested, and uploaded onto a full production server at Maintenance and Logistics Command Atlantic (MLCA). At this point, more than 125 users and administrators were trained, a complete set of system documentation was in place and available to all users, and the development team was confident ONSS was ready to begin operation. The only missing component was an approval from CG-6.

The first official response from CG-6 came in the form of a designation letter in early July. The letter confirmed the ONSS project fell under the Coast Guard's SDLC policy, and formally placed the project in the Conceptual Planning Phase (e.g., Phase 1 of 7). The letter further stated the project would remain there until authorized to move on to the next phase. This notice came as a surprise to everyone on the development team, because they felt the project was further ahead than the SDLC process was willing to acknowledge. Repeated discussions with various Headquarters entities revealed that no one was willing to commit to a specific timeline for bringing the system on-line, and the SDLC did not specify a minimum timeframe for documentation review and approval. As a result, the reality of how long it might take to develop and deploy an enterprise system began to sink in. Even though ONSS represented an IT solution to an existing manual reporting process, there were no short cuts or workarounds to the SDLC process. Program Managers and approving authorities were not willing to consider size or scope of the pilot project because experience had proven the risks associated with circumventing the SDLC process were not worth the gains. In light of this new information, the project team re-evaluated the need for the web-based scorecard. In the end, they decided it was worth the effort to bring ONSS to fruition, and rededicated themselves to completing the administrative paperwork as quickly as possible.

A portion of July 2005 was spent formalizing maintenance and support agreements with MLCA(t) [the Electronic Systems Division], who agreed to host the application on one their web servers, and support the system with organic resources under an existing maintenance contract with LANTAREA. MLCA came through as previously promised, and signed a formal agreement for

the project on 21 July. At the same time, G-MPP supplied the funding necessary to hire a fulltime web-developer for FY-06 [Fiscal Year 2006]. Previous application development was completed by a contractor working on an "as available" basis. However, the individual was scheduled to demobilize at the end of FY-05. The unexpected monetary windfall provided another year's worth of system development, and added the help-desk support necessary to maintain the system while the SDLC process progressed.

Another significant milestone achieved in July was the development and approval of security training for the ONSS system. Security training was one of the key elements facilitating the Scorecard's transition from the classified SIPRNET to the unclassified Intranet. The transition was made possible through a series of checks and balances designed to reducing risk through training and multiple levels of pre-validation review. The first reduction in security was accomplished by removing the classified standards from the scorecard report. The second was effectively managing the Commander's Assessment portion of the periodic reports generated in ONSS. The Commander's Assessment is free-form text area and possessed the greatest risk to security because users could discuss operational activities and write concerns in an unrestrained environment. With the help of (At) and Headquarters personnel, the development team was able to create a simple set of rules to guide users in generating and reviewing periodic reports. These rules were presented to system users through a simple but affective Power Point training program available on the system's homepage. In addition to the training, multiple levels of review work sequentially as a series of safeguards to prevent classified information from being entered into the system. Information entered into the system by field units is reviewed by senior members at the unit and validated. Validated field unit reports are forwarded to Districts for additional review and validation before a final review and validation by Area Commands. Current plans are to include Sector Commands in a future release of ONSS, thus adding a fourth layer of review. The final combination of security training and four levels of pre-validation review are expected to provide the safeguards necessary to prevent introduction of classified information on the unclassified Intranet.

The summer of 2005 also ushered in an unprecedented level of elevated security activity for Coast Guard units in response to terrorist activity abroad and a series of domestic natural disasters. This elevation, or surge, in operational activity resulted in an increase in reporting requirements (e.g., ONS Scorecard periodic reports) at all organizational levels. In an attempt to alleviate some of the administrative burden created by the increased activity, the Atlantic Area Commander requested authorization from CG-6 to operate ONSS in the areas impacted by surge operations. Two weeks after receiving LANTAREA's request, CG-6 responded with a conditional approval for limited deployment of the web-based reporting system in the areas impacted by surge operations. Conditions for deployment included deployment in only 16 LANTAREA ports for a time limit, not to exceed 90 days, and prior to deployment the system had to comply with any security requirements specified by CG-65 [Office of Information Assurance]. When contacted about the security requirements, CG-65 asked that MLC servers hosting the application pass a vulnerability scan conducted by TISCOM [Telecommunications and Information Systems Command], and comply with the October 2004, Defense Information Systems Agency (DISA) Web Server Security Technical Implementation Guide (STIG). Work to meet these conditions began within 24 hours of receiving the conditional approval, and TISCOM completed a vulnerability scan within seven days. Unfortunately, it took an additional five weeks for MLC to bring their servers into compliance with the DISA Web STIG. By then the first period of surge operations had run its course and come to an end, and a second cycle of surge operations was just beginning. LANTAREA capitalized on this opportunity, and required units in 16 ports impacted by the second wave of surge activities to begin using the ONSS system. Notice was given to CG-6 and the projects' sponsors in Headquarters, and on 10 September 2005 ONSS began operating under the authority of its limited deployment.

UPDATE

Since ONSS came on-line in September, the number of registered users has more than tripled to over 420. As of this writing, 23 units Coast Guard wide were either using the system under the limited deployment authority, or have asked to enter real data for testing, training, or familiarization purposes.

The Project's Sponsors' Representatives drafted and routed an approval memo intended to move the pilot on to the next (e.g., Planning & Requirements) phase of the SDLC process. Although not where the development team would like to be in the SDLC process, the memo represents progress. As of this writing, the memo was still under review by one of the project's sponsors.

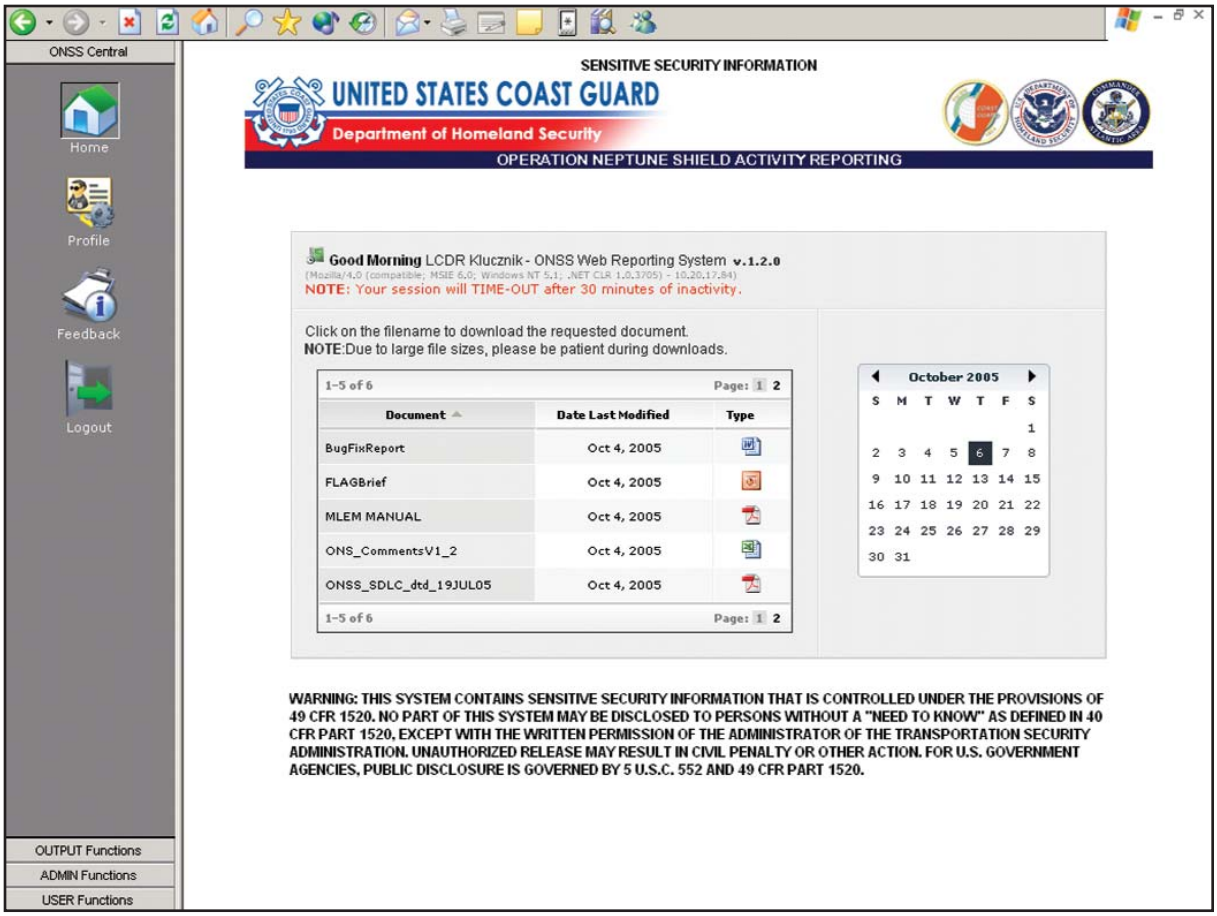
In October 2005, work began on ONSS V 2.0.0, which primarily involved adding Sectors to the process flow along with miscellaneous upgrades to the administrative functions, which included a newly formatted menu selection. The change in menu format was chosen to improve the application's print format. Figure 3 shows the old

horizontal menu list, while Figure 4 displays the new vertical tabbed format that has a look and feel similar to MS Outlook. A GIS map is planned for V 3.0.0.

The latest information on the ONSS pilot is available on the Coast Guard Intranet at: http://webapps.mlca.uscg.mil/lantarea/pwcs. This link was changed since the Fall 2005 article to reflect the application's move from the development server to the production server at MLCA. Please contact LCDR Frank Klucznik at Frank.W.Klucznik@uscg.mil for a guest username and password. This account will allow read only access to the application and access to all system documentation.

Figure 3. Old Menu.

Figure 4. New Menu.



C4IT

Next Generation

USCG photo by PA2 Alice Sennott.

ABSTRACT

The United States Coast Guard is engaged in a project to re-capitalize Reference Station (RS) and Integrity Monitor (IM) equipment used in the Nationwide Differential Global Position System (NDGPS). The Coast Guard in partnership with industry is developing a new software application to run on an open architecture platform as a replacement for legacy equipment. Present commercially available off-the-shelf Differential Global Positioning System (DGPS) RS and IM equipment lacks the open architecture required to support long term goals and future system improvements. The utility of the proposed new hardware architecture and software application is impressive -- nearly every aspect of performance and supportability significantly exceeds that of the legacy architecture. The flexibility of the new hardware and software architectures complement each other to offer promising possibilities for the future. For example, the new hardware architecture uses Ethernet for internal and external site equipment communications. Each Local Area Network (LAN) will be equipped with a router and two 24 port switches. Various levels of password protection are provided to manage security both locally and remotely. While the new software application directly supports the legacy RS-232/422 interfaces to devices such as GPS receivers, a system design goal includes the ability to directly address each device from NCS. With the use of TCP/IP to RS-232/422 port server devices, the system can meet these forward reaching goals while supporting legacy equipment. New system capabilities include remote software management, remote hardware configuration management, and flexible options for management of licenses.

Differential GPS Architecture

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This paper was originally presented at the Institute of Navigation (ION) Global Navigation Satellite System 2005 (GNSS2005) Conference in Long Beach, CA, 14 September 2005.

The new configurable RS and IM architecture is a PC-based emulation of legacy reference station and integrity monitor equipment. It supports fluid growth and exploitation of new signals, formats, and technology as they become available, while remaining backward compatible with legacy architecture and user equipment. Examples of new capabilities include enhanced data management & anomaly analysis, universal "On Change" Reference Station Integrity Monitor (RSIM) message scheduling, improved satellite clock handling, additional observation interval modes, and Range Rate Correction monitoring in the IM. Engineering initiatives under development such as implementation of pre-broadcast integrity are also presented.

This paper details challenges and goals that drove software and hardware design approaches destined to become the backbone of the Next Generation Differential GPS Architecture. Functional differences between legacy and next generation operation are explored. The new DGPS system architecture Will allow the USCG radiobeacon system to continue to deliver and improve navigation and positioning services to our nation and its territories.

INTRODUCTION

The U.S. Coast Guard is part of a team implementing the world's largest ground-based GPS augmentation service.[1] The original mission of the DGPS service was to provide coverage for all harbor and harbor approach waterways throughout the Unites States.[2,3,13] To meet this requirement, the maritime DGPS broadcast network was built. The Maritime DGPS system provides differential corrections along the Atlantic, Pacific, Gulf Coasts, Great lakes, Hawaii, Puerto Rico and the southern Coast of Alaska. An agreement with the U.S. Army Corps of Engineers expanded Maritime DGPS coverage to the inland river system. As the numbers of DGPS users increased, so did demand for coverage. Later a team made up of Federal Highway Administration (FHWA), Federal Railroad Administration (FRA), U.S. Coast Guard (USCG), and other agencies was assembled to sponsor implementation of a Nationwide DGPS (NDGPS) system so as to expand traditional coastal services to the interior of our nation. The Coast Guard was designated as the primary agency responsible for system maintenance and engineering. The NDGPS expansion primarily includes building additional broadcast sites and development of a Nationwide Control Station (NCS).

The 87 broadcast sites currently contained in the NDGPS system provide nearly 100% system wide coverage (Figure 1). Beacon site equipment configurations differentiated by transmitter type:

- (V1): Southern Avionics Corp. (SAC) transmitter with battery backup
- (V2): SAC transmitter with a generator backup
- (V3): RCA transmitter with generator backup

There are two operational Control Stations (CS) located in Alexandria, VA & Petaluma, CA, plus a support &

engineering baseline located at C2CEN [Command and Control Engineering Center] in Portsmouth, VA. Each CS has the ability to manage up to 200 remote broadcast sites and provides 45 days of performance data storage. Coast Guard personnel operate these Control Stations continuously, tracking performance and responding to equipment and communications casualties.

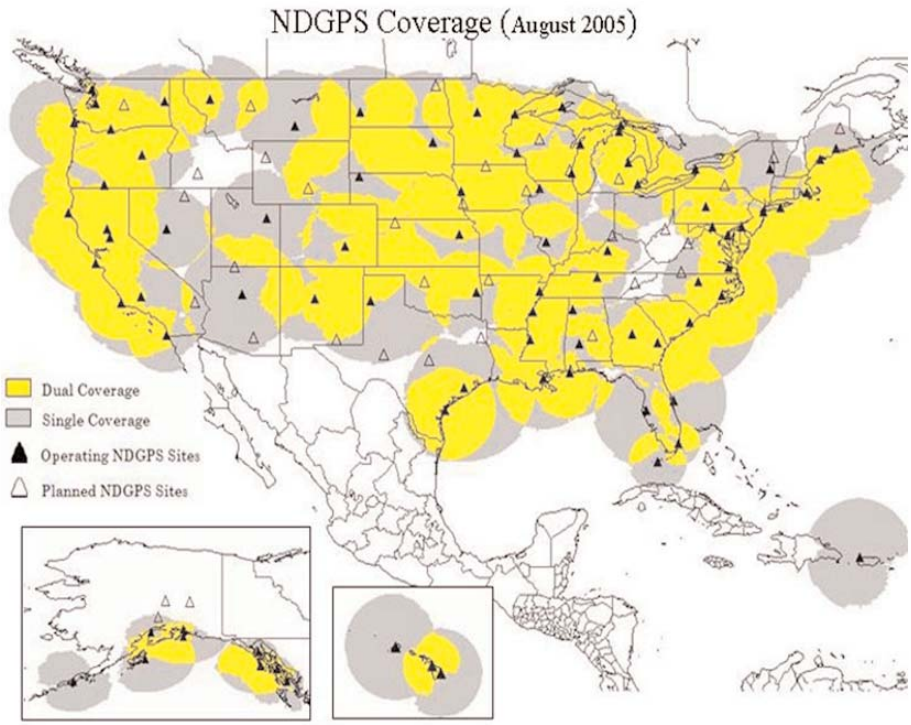

Figure 1.

In addition to supporting safety-of-life navigation, the NDGPS system participates in other infrastructure projects. All NDGPS sites provide GPS measurements to the National Geodetic Survey's (NGS) network of Continuous Operating Reference Stations (CORS) used for precise positioning and to the National Oceanic & Atmospheric Administration's (NOAA) Forecast Systems Laboratory (FSL) where these data are used to drive national weather prediction models.[1, 6] Several NDGPS sites have stable concrete High Accuracy Monuments (HAM) allowing data sent to NGS to be monitored for tectonic plate movement.[1]

C2CEN's NDGPS Integrated Product Team (IPT) is working diligently to increase NDGPS system performance and value. This paper presents those efforts.

NEXT GENERATION ARCHITECTURE

The next generation DGPS architecture was designed to ensure that replacement hardware and software would support continuous improvement geared toward users with ever escalating performance needs while maintaining traditional services. The architecture is designed so that future, higher performance safety-of-life navigation applications can be introduced in stages. To achieve this, the engineering team has adopted flexible system architecture as a design goal.

The engineering team invited industry, academia, and fellow government agencies to participate in several symposia where participants sifted through "best practices" to chart a course for the next generation project.[12] Among the participating government, industry, and academic leaders there was basic agreement that Ground Based Augmentation Systems (GBAS) provide a robust means of data delivery for differential GPS.

System level requirements for the next generation DGPS architecture are based on the US Coast Guard DGPS Broadcast Standard,[3] the RTCM SC-104 standard,[7, 8] and the Federal Navigation Plan.[2] They include the following:

- The design must be easily evolved into a higher accuracy positioning system
- The architecture should be compatible with new mission requirements as they emerge
- No aspect of legacy system performance may be compromised
- Hardware and software should be Commercial Off The Shelf (COTS) products
- Non-RTCM devices should have native HTML interfaces accessible via the WAN
- Devices must support remote operation, configuration, and diagnostics
- Devices must support remote firmware/software patches and upgrades
- The identification of techniques to eliminate Hazardous or Misleading Information (HMI)
- Data Capture during communications outages
- Increase operator casualty recovery options
- GPS antenna performance improvements
- Lower overall acquisition and support costs

These requirements are intended to maximize performance while reducing recurring support cost and are

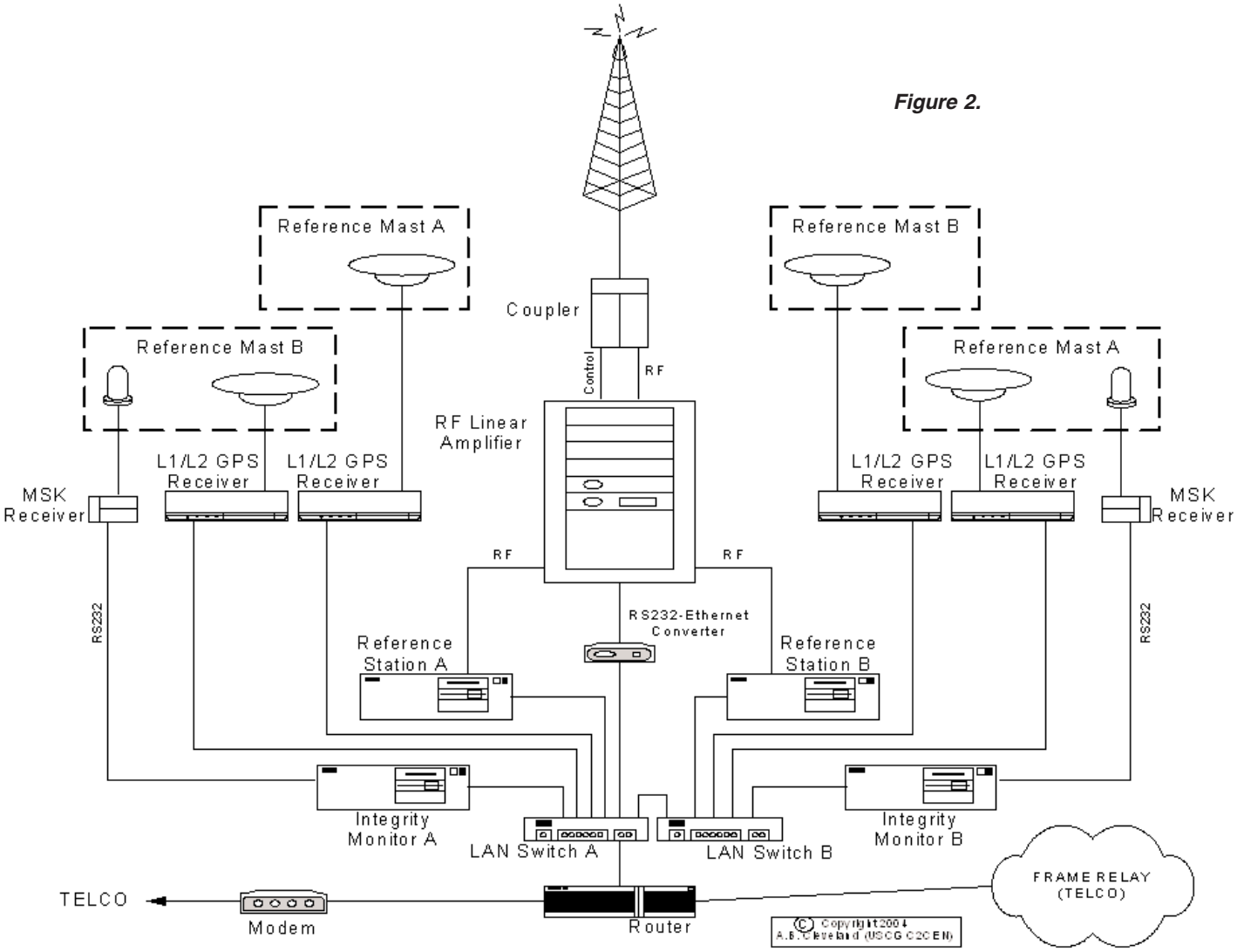

Figure 2.

expected to allow efficient remote management of broadcast sites with minimum technician call-out.

The next generation DGPS architecture (Figure 2) employs server grade personal computers, a new DGPS software application, OEM beacon receivers, and OEM geodetic GPS receivers communicating over an Ethernet. It has been tested in two configurations:

- Version 1.0: Legacy GPS receivers communicating with the DGPS application on serial RS-232 data channels
- Version 1.1: New geodetic grade OEM GPS and beacon receivers communicating with the DGPS application on an Ethernet Local Area Network (LAN)

With the exception of the serial comms used in Version 1.0, all internal and external broadcast site data channels are mapped through two 24 port Ethernet switches. The new system uses serial port servers to interface legacy equipment to the Ethernet. Version 1.1 testing was conducted using serial port servers to interface legacy MSK receivers to the new DGPS software application. The devices are reliable and simple to configure. Software licenses are managed using USB sentinel keys.

The vision for next generation DGPS extends well beyond simply replacing the RS and IM hardware. The project will modernize virtually every component of the system. Major initiatives include:

- Developing a robust DGPS software application
- Engineering an open architecture hardware platform
- Re-engineering comms networks
- Upgrading datalink components
- Continuing development of NCS

The discussion that follows is intended to outline specific features of the vision by detailing many of the issues confronted and the impact of subsequent design decisions on the operation. Potential system improvements, not yet funded, are presented in the Vision for the Future section.

DGPS SOFTWARE APPLICATION

At the heart of the next generation DGPS architecture is a government/industry partnership between the DGPS IPT and The XYZs of GPS, Inc. to develop a commercially viable DGPS RS and IM software application.[16, 12] Development was undertaken in two phases. Phase I

focused on porting legacy RS and IM functions independently onto a PC platform. It used serial RS-232 data communication and honored all constraints imposed by legacy requirements. The Phase II effort expanded the architecture by adding TCP/IP communications, password protection, and a technician friendly Graphical User Interface (GUI). During each phase, engineering testing was conducted and completed with excellent results. Refinement of the new application continues as we move closer to deployment. Most of these refinements have centered on providing an NCS watch stander a clearer picture of anomalous conditions.

The new DGPS software application is modular[16] and is comprised of the components which follow:

- GPS Receiver Interface Module (GRIM): GRIM Interfaces with the GPS receiver and provides GPS observable data to the DGPS Processing Engine in both RS and IM configurations.
- Differential GPS Engine (DGPS_Eng): This module functions as either RS or IM producing RTCM SC-104 messages in its RS role or providing integrity monitoring (i.e., RSIM messages) in its IM role.
- XYZs MSK Modulator Program (XYZ_MM): This program obtains RTCM messages from the DGPS Engine and modulates them to excite the transmitter.
- Demodulating Receiver Interface Module (DRIM): DRIM interfaces with the MSK Demodulating Receiver providing demodulated RTCM messages to the DGPS Processing Engine in IM role.
- DGPS Monitor (DGPS_Mon): This module monitors the above modules providing broadcast site technicians with real time system performance information.

In the RS configuration, the software application uses all modules except DRIM. In the IM configuration, the application uses all modules except for XYZ_MM.

In the legacy system, the RS and IM functions resided in proprietary GPS receiver hardware and firmware. Modifications required lengthy and costly development cycles. Once a change was approved for system wide implementation, then maintenance technicians were typically required to visit each remote broadcast site during installation. To facilitate remote management of the new software application, each module was engineered to be completely self-contained. Each executable file requires no external library or operating system file to run, other than those operating system files required by the operating system itself and those required to support the onboard PC hardware (such as device drivers). All code required by the application is contained within the executable file. Additionally, these executable files were engineered for compactness. The largest is DGPS_Eng.exe at 3.4 megabytes. Small application size combines with Ethernet mapping to make the application remotely upgradeable. A remote technician uses system networking facilities and "places" an upgrade file in the correct directory of the desired target PC, then performs a partial reset from NCS to populate it with the sites specific operating parameters.

As an example of performance improvements, the new DGPS software takes a slightly modified approach to managing observation intervals used to trigger certain alarm conditions. In the legacy equipment, a position error threshold of 10 meters, having an observation interval of 10 seconds, required that the threshold be exceeded for the entire 10-second observation interval, without interruption, in order for an alarm message to be sent to NCS. To illustrate this notion, we will describe an anomalous condition and describe how both the legacy and new systems would react. Picture a cluster of IM generated position fixes plotted on a chart. Because of an anomalous condition, the center of mass of these points is 12 meters from the origin of the plot; where the origin represents the known IM position. On that chart is painted a 10 meter circle to represent the maximum position error before an alarm is triggered. If one plots the instantaneous positions generated under this scenario, a cluster of points are plotted around the 12 meter center of mass. Some of these points would clearly fall outside of the 10 meter circle, while many would not. In the legacy implementation, those points that fall inside of the 10 meter circle cancel the possibility of an alarm message, when they occur within an observation interval. Thus, even if just one solution falls inside of the 10 meter solution error maximum over the observation interval, (and all the rest are outside) an alarm will not be generated. The new software application implements a "rolling window" average which compares the average solution over the observation interval against the alarm threshold and generates the alarm when the average exceeds the threshold. Clearly, if one is interested in more instantaneous information, one simply reduces the observation interval.

The new DGPS software application offers additional Range Rate Correction (RRC) management options tailored to optimize DGPS performance in a post Selective Availability (SA) environment.[4, 5] Studies have shown that small RRC values transmitted to the user over the datalink actually produce more noise in the user's position solution than would be present without the RRC corrections.[14] The new DGPS software application allows the service provider to force RRC to zero for any RRC less than a configured threshold. The DGPS IPT is recommending that operators force RRC to zero when they are below a 5cm/sec threshold. There are two conditions when RRC may rise above 5cm/sec:

- When a satellite is observed on the horizon through

many more miles of troposphere
- When anomalous satellite activity is actually being detected and corrected by the RS

Service providers will now have the option of zeroing small RRC values, while still allowing beneficial larger RRC corrections to be sent.

The new DGPS software application contains an improved RS and IM clock handling process. The application tests all satellite clocks against each other seeking convergence in a process similar to Receiver Autonomous Integrity Monitoring. This enhanced clock testing ensures that an anomalous satellite does not cause an entire beacon site to become unavailable during an event. The application leverages the known (not necessarily static) RS and IM GPS antenna positions to be extremely precise when identifying suspect clock activity. With this approach system users should rarely see a DGPS beacon become unavailable during a satellite event.

Since it was envisioned that a broadcast site technician would never configure data channels manually, a software installer was developed to manage this complexity by automatically determining a site configuration based upon the technician's responses to a few simple installer questions:
- What is the router's IP address?
- Is this PC to be configured as an IM or an RS?
- Is this installation for Side A or B?

In the unlikely event that data channel mapping becomes corrupted, beyond the backup and restore facilities within the software itself, a technician would simply reinstall the application. This approach masks possible configuration complexities from the technician while maintaining complete flexibility.

Data management and anomaly analysis has been improved significantly. Phase II implemented a system of "ring buffers" within the software application. The new ring buffers capture all GPS and datalink data generated by the RS or IM in a daily file stored for a specified number of days. When a site experiences an anomaly, a control station operator can use the networking facilities of the system to retrieve data files built during this event. These data files can be locally replayed as if in real-time but at selected higher speeds to condense the analysis period. In addition to RSIM and RTCM messages regenerated at the time of an event, the new RS can be set.

The new DGPS software application allows RSIM[8] feedback messages to be sent to NCS "on change." When scheduled, any RSIM feedback message containing a satellite flag will be sent to both RS and NCS. In the legacy system, RSIM feedback message scheduling is only allowed from RS to IM. Having flagged feedback messages captured in the NCS database greatly enhances operator understanding of broadcast site behavior. In addition, the new DGPS software application offers universal "On Change" RSIM[8] message scheduling. The control station operator is allowed to schedule RSIM messages traditionally used by the NCS to configure the RS and IM to return to the NCS when a parameter is changed on a site using the GUI. Since these "On Change" messages are also triggered when NCS is the origin of a configuration change, these response messages provide an additional positive confirmation in response to the NCS configuration change commands.

The new DGPS software application institutes the RSIM defined full and partial RS and IM resets in the context of a software/PC base architecture controlling receiver and modulation devices:
- A partial reset closes and restarts the DGPS application, then reloads locally stored operating parameters
- A full reset closes the DGPS application, restarts the computer and receivers, and auto-starts the DGPS application loading it with operating parameters received from the NCS database

If NCS is not available, the RS or IM will load the locally saved last known good parameters received from NCS. During resets, the legacy RS produced a mark tone after a reset before RTCM messages began to flow out over the datalink. This prevented the transmitter from automatically switching to the standby RS and IM during the restart process. In the new application, the Digital Signal Processor (DSP) contained in the RS computer will shut down briefly during a full reset. This was deemed beneficial because it causes the transmitter to switch to the standby RS seeking to make the site available before correction age expires in user equipment. The transmitter will not switch sides during a partial reset. In the event that a device (such as a server) stops responding, there are remote power managers installed in the equipment racks. These power managers allow the NCS watch stander to cycle power on any single device in the system remotely. Every effort was made to ensure that the operator has sufficient options available to recover a malfunctioning device without a site visit.

In a DGPS reference station, the UDRE is defined as a one-sigma estimate of the uncertainty in the pseudo range correction. The intended purpose of the UDRE contained in DGPS corrections is to give the user an indication of how much impact, as estimated by RS, that multipath, signal-to-noise ratio, and other non-specific factors had on the generation of a particular correction value.[7] The new application uses the relationship between smoothed and unsmoothed code data to calculate the UDRE. If a GPS receiver does not provide smoothed code data to the application (e.g., legacy

4000IM), the new software is capable of producing its own and restoring the usefulness of the UDRE data to the user.

As the various DGPS software application's modules launch, data channel parameters are loaded from a locally stored file. To remotely "remap" the architecture of a broadcast site, a technician simply uses the system networking facilities to retrieve the sites *.ini files, makes desired changes, and places the files back in their original locations. As an example, to have all four DGPS_Eng iterations (RS-A, RS-B, IM-A, and IM-B) use observations provided by the GPS receiver normally mapped to IM-B, a technician would modify the target IP addresses contained in each server's *.ini files, return them to each device, and perform a full reset. All four devices would then use observables generated by IM-B's GPS receiver. The new DGPS software application offers tremendous flexibility to service providers while requiring no change to the legacy control station or the legacy network architecture.

There are many improvements contained in the new DGPS software application. Each was engineered to improve DGPS performance from within while not requiring new hardware. This approach ensured that enhancements would not only operate seamlessly, but also improve performance for legacy users.[8]

HARDWARE ARCHITECTURE

As stated earlier the Next Generation Differential GPS Architecture's hardware platform was configured in two ways:

- (Version 1.0) Legacy GPS receivers communicate using serial RS-232 protocol;
- (Version 1.1) Next generation geodetic GPS receivers communicate using TCP/IP protocol.

This approach increases the DGPS IPT's options for fielding the new architecture across the entire system, since funding can be unpredictable. Examples of configurations that could be considered are: replacement of Side A, but not Side B equipment; replacement of RS, but not IM equipment; replacement of DGPS function without new GPS receivers; etc. Virtually any blended configuration will work seamlessly.

Next generation GPS receiver hardware requirements were set at levels consistent with commercially available geodetic OEM devices. Currently the system requires dual frequency code and carrier measurements from the DoD GPS constellation of satellites. The architectural design has been kept as general as possible so that observations from other radio navigation sources, such as the European Galileo, could be introduced if desired. The new GPS receiver must support Ethernet TCP/IP communication and be remotely configurable. An HTML interface that facilitates remote operation and diagnostics is considered highly desirable.

The new hardware platform employs server grade OEM computers packaged in one "U" rack mount enclosure. Under the heaviest system requirements load tested so far, processor usage stayed under 7 percent.[16] The RS and IM are fabricated from the same PC configuration; they will be shipped with the required Digital Signal Processor pre-installed. In the event of a PC casualty, the service technician will simply replace it and reinstall the software application. A full reset will load all operating parameters from NCS. This approach greatly reduces maintenance technician training requirements.

In the Next Generation Differential GPS hardware architecture, function of a device will no longer be determined by hardware. It will be determined by software.[12] This means that a broadcast site's architecture can be significantly changed by remotely updating the initialization files used during resets. Not only can device identities be changed, but also any new mapping of data channels could be accomplished remotely without need to visit the site.

The Next Generation Differential GPS Architecture transitions broadcast sites away from serial RS-232/RS-422 communications to an Ethernet LAN. An Ethernet LAN offers many benefits:

- Each CAT-5 cable supports many data channels
- Data channels operate at much higher rates
- All devices can interact with every other device
- All devices are accessible via the WAN
- All data channels are individually configurable

The wide area network will be remapped so that each broadcast site has ownership of an exclusive series of 255 IP addresses. Each broadcast site device will have a unique IP address. Not only will the system continue to use RTCM standard communications, but the new IP address mapping of broadcast sites will allow devices with native HTML interfaces to be accessed remotely.

Single points of failure were a significant design consideration. The team determined that migrating to Ethernet posed very little single point of failure risk, except in an earlier system architecture which used a single Ethernet switch per broadcast. The team determined that such architecture could potentially disable an entire broadcast site due to the single failure of the switch. As a result, the team decided to install separate Side A and Side B LAN switches. A jumper is used to connect the two

LANs, preserving the configuration flexibility of a single switch without the single point of failure risk it poses. The WAN is routed through Switch A. The WAN is not considered to reside in the critical path to site availability, so loss of comms due to a single side switch failure was not deemed to pose a significant risk to the user.

The project calls for all GPS antennas to be upgraded, so Ohio University was contracted to conduct a study of commercially available antenna technology. All antennas tested performed extremely well, but the Trimble Zephyr was deemed to be the best fit for next generation DGPS architecture. Selection was based on high gain, excellent multipath rejection, phase center stability, and low elevation gain roll-off.[15] The Ohio University study is summarized in a paper to be published in the Institute of Navigation meeting minutes.

Remotely addressable power strips mounted in the equipment racks are used to perform "hard" resets. An RJ-45 cable connects each strip to the LAN. The devices have configurable static IP addresses and a remote GUI that opens across the WAN. A remote operator sees each outlet specifically labeled for its use (e.g., RS-A, RS-B, IM-A, IM-B, etc.) and is given three options for each; ON, OFF, and RESET. If a device plugged into these strips becomes unresponsive, the remote operator can remotely cycle power and let it auto-start rather than calling for a technician to travel long distances to the site.

INFRASTRUCTURE IMPROVEMENTS

NCS is used by watch standers to control, monitor, and analyze performance of NDGPS broadcast sites. NCS is a C2CEN product which is based on RTCM SC-104 Standard.[8] NCS's development cycle is continuous. Major NCS modules include:

- NCS_Server: Located at each Control Station, provides real time system monitoring, manages network communications, and builds a database from RSIM message traffic
- NCS_Client: Used by a 24/7 live watch. Provides intuitive watch stander interface, system status information, and remote site configuration and control capability
- NCS_Availability: Tracks system availability by site, opens and closes availability events, evaluates impact of comms outages, and codes failure events for analysis
- NCS_Reporter: Suite of performance analysis tools. Tracks GPS correction quality, datalink performance, equipment failure trends, and allows ad hoc database queries

After initially fielding NCS, the DGPS IPT sought support from the project sponsor to continue support at development levels. As a result, NCS is evolving swiftly into a world class software application capable of efficient system wide command and control. NCS reduces impact of availability threats and has consistently lessened watch stander training requirements with each new revision.

The new hardware platform relies on a dedicate Frame Relay WAN to communicate with NCS providing the watch stander with real time broadcast site casualty and performance data.[1] Under the legacy architecture, the WAN was mapped with a single IP address per broadcast site. Devices appeared on serial ports of the router. In the Next Generation Differential GPS Architecture, the router serves as a gateway and each device has a unique IP address. New broadcast site IP addresses will follow the following scheme - 172.16.XXX.YYY, where XXX is a unique Site ID number and YYY is a number used system-wide to designate a particular device, such as RS-A computer, RS-A GPS receiver, IM-A computer, IM-A receiver, etc. There are a number of benefits to assigning IP addresses to each device:

- Software patches and upgrades can be installed remotely
- Native HTML interfaces will work seamlessly in the background over the WAN
- Comms outages are detected all the way to the device, not just to the router
- 9.6Kb serial comms are not fast enough to pass most dual-frequency GPS observations without compression, but Ethernet has room to spare

Remapping of the WAN offers an immediate increase in system performance and opens many avenues for future improvements.

The Medium Frequency (MF) datalink engineering team is in the process of fielding many improvements[11]:

- A new Antenna Tuning Unit able to compensate for environmental changes at a site
- An RSIM SC-104 standard compliant Remote Transmitter Control Interface (RTCI)
- An improved minimum maintenance industrial battery backup system
- Upgraded and ruggedized transmitter output stage PCBs
- Improved Lightning and Icing protection

The MF datalink offers robust correction delivery to users in virtually any environment. It is quickly becoming one of the most stable and reliable means of ensuring steadfastly available service to safety-of-life navigation users.

Virtually every facet of the NDGPS system is being upgraded or improved. All improvements have been designed to ensure no impact on legacy users, while, at the same time, positioning NDGPS to offer improvements in pos/nav services and capabilities.

VISION FOR THE FUTURE

The Next Generation Differential GPS Architecture has been designed to fulfill legacy requirements while serving as a launch point for innovation. Some of the enhancements presented here should be viewed as long-term investments, while others will be more immediate.

As additional augmentations emerged to meet specific safety requirements of other transportation sectors, these new systems began benchmarking against the older, established systems such as DGPS. This healthy process resulted in the emergence of new system performance paradigms. A paradigm that the Next Generation Differential GPS Architecture team has embraced is the concept of preventing Hazardous or Misleading Information (HMI) from reaching a user. A concern in the legacy NDGPS architecture is that in order to detect an out of tolerance correction, an out of tolerance correction must be sent over the datalink. This means that users likely received the out of tolerance correction as well as the IM. Development is underway on an enhancement called Pre-Broadcast Integrity. Pre-Broadcast Integrity will check RTCM corrections, over the LAN, before they reach the 200 baud data link. In this way the IM gets to evaluate the correctors ahead of time and report to the RS any corrector which should be edited. The Next Generation Differential GPS Architecture is capable of providing at least 5 Hz Pre-Broadcast Integrity checking in the IM without causing any datalink latency. The RS will maintain a pool of 1 Hz correction sets which are fed to the 200 baud modulator as needed. Some valid corrections will be discarded, this is true; but a collateral benefit is that IM integrity checking is stepped up to 5 Hz or faster, thus reducing time-to-alarm. The engineering team is optimistic about the benefits of Pre-Broadcast Integrity. Software coding is underway and a draft supplement to the RTCM SC-104 standard is being finalized.

The legacy broadcast site architecture does not capture or hold any performance data at the site, so during a communications outage, the information that would normally pass to the control station is simply lost.[1] This does not impact site availability, but it does leave gaps in the NCS database. The next generation DGPS architecture allows for the addition of an Autonomous Control Data Logger (ACDL). ACDL will serve two functions:

- Autonomous Control: Initiate basic casualty recover procedures at a broadcast site in the event of equipment casualty during comms outage
- Data Logger: Capture and store all RSIM message traffic normally sent to the Control Station during a comms outage

While DGPS broadcast sites are not dependent on communication with the NCS for user availability, ACDL will ensure that data used to drive operations, maintenance, and engineering projects accurately reflects system performance.

The NDGPS system currently has fielded 348 RS and IM units exchanging RSIM messages with NCS 24 hours a day, 7 days a week generating hundreds of thousands of RSIM messages each month. The current storage capability of NCS is 45 days. After that the data are archived. Before data are archived, an operator can produce any number reports (e.g., availability) or performance plots (e.g., MSK Signal strength). Furthermore he has several powerful tools to process ad hoc queries. After archiving, the data are inaccessible to the operator. Data warehouse development is underway. This will expand availability of performance data from 45 days to 13 months. There are significant challenges associated with the massive volume of data produced by the system, but several promising options are being evaluated by C2CEN.

NDGPS has nearly achieved its goal of 100% continental U.S. coverage and is actively pursuing a strategy to achieve 100% redundant coverage RSIM.[1, 12] The Coast Guard Academy has developed coverage prediction software used by Navigation Center personnel to predict cov-

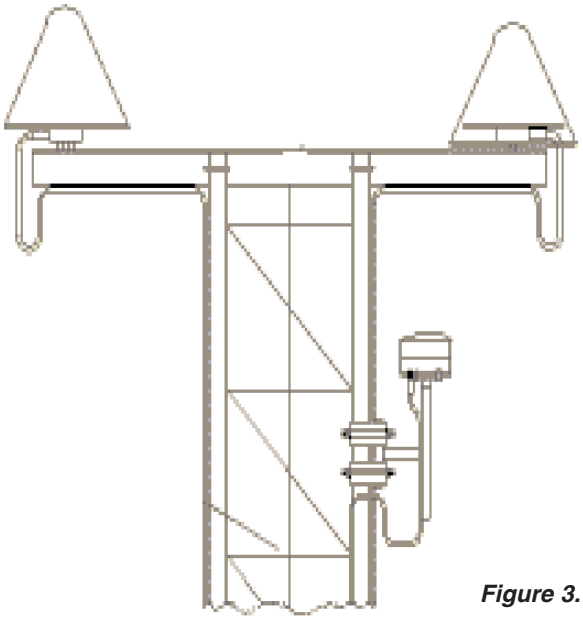

Figure 3.

erage and communicate it to users. The DGPS IPT would like to continue to develop this coverage prediction software so that it is being updated dynamically by NCS to provide real time visual depiction of actual system coverage. Using this information, the watch stander could then remotely raise or lower beacon signal output to fill any coverage gaps that appear as a result of adverse weather or equipment casualty. The software currently exists as a prediction model and the MF datalink team is finalizing work on a remote transmitter control interface which incorporates remote output level control. A convergence of these technologies may allow real time management of NDGPS system coverage.

The Trimble Zephyr was selected as the Next Generation DGPS Architecture GPS antenna. Each broadcast site has four GPS antennas. These antennas are mounted at the top of two masts that have a 60" cross member attached. There is a GPS antenna mounted at each end of the cross member (see Figure 3). The multipath environment can definitely be improved should there be a need to do so to meet more demanding pos/nav specifications. This could, for example, be accomplished by removing the cross member and centering a single GPS at the top of each tower. Possibly increasing the height of the mast would be helpful. In this configuration, a zero insertion loss antenna sharing device would be used to provide antennas to all four GPS receivers. These actions, and possibly others, could improve the site's multipath environment and could possibly reduce the total number of GPS antennas supported in the system.

The Next Generation Differential GPS Architecture can transmit data from an external source on the datalink. This is done by scheduling RTCM 60, 61, 62, and 63 messages defined in the RTCM SC-104 standard as reserved for LORAN. Transmission priorities of these messages are configurable. These messages are also compatible with compression algorithms that may potentially increase information content while reducing the required communication bandwidth. Virtually any type of data such as LORAN Additional Secondary Factors, GPS observables, or IONO/TROPO models can be transmitted regionally or nationally using these.

The NDGPS system discussed so far provides real-time positioning accuracies at the meter level. The horizontal components are possibly accurate to 1 m. (95%), whereas the vertical component is possibly accurate to 2 m. (95%). These numbers represent typical accuracy; more correctly, accuracy is a function of the user's distance from the reference station. These accuracies are substantially better than the system requirement. To some extent this is a result of several factors:

- Better GPS receivers and antennas
- The continuing emphasis on integrity and availability
- Overall system improvements

As a reminder these accuracy levels have been achieved using basic L1 C/A code pseudoranges. There has not been a systematic effort to eliminate reference station multipath, eliminate atmospheric delay differences between reference stations and users; or eliminate orbital error. The reduction of these errors would, obviously, improve the accuracy of the current system.

If the current accuracy exceeds current system requirements what is the motivation for seeking more accuracy? The answer has two parts:

- Ever since S/A was terminated, in the year 2000, there has been spare bandwidth, and bandwidth is precious
- More accuracy can enable new applications which hold the promise to save lives

It seems natural to explore whether or not the bandwidth which has been freed up can carry added data for bringing about accuracy improvements which would enable important applications.

Accuracy improvements can be achieved by eliminating reference station multipath, improving user multipath, improving GPS broadcast orbits or having the reference station broadcast precise orbits, and/or having the reference station broadcast modeling information with respect to atmospheric delays to the user. Multipath improvements require no new bandwidth; the broadcasting of precise orbits would take just 1-2 bytes per second. These changes obviously would yield some amount of accuracy improvement. Broadcasting atmospheric modeling data, on the other hand, would require greater bandwidth and lead to greater accuracy gains. This is being investigated.

The discussion above concerns how to better use legacy facilities. Another avenue under exploration concerns the possibility of adding bandwidth and broadcasting correspondingly more data to the user. In this case one might send the data types discussed in the last paragraph to the user but also send dual code and carrier measurements. One could imagine sending satellite radio navigation data if there was enough bandwidth and benefit. It has been demonstrated in two recent FHWA activities that the above engineering steps could yield decimeter level positioning for users 100 - 200 km., or even more distant, from such a reference station.

SUMMARY AND CONCLUSION

The next generation DGPS architecture will be installed throughout the system within the next two years, but that truly is just the beginning. Every component of the NDGPS system from control station; to communications networks; to the broadcast site GPS, datalink, and infrastructure subsystems is undergoing significant upgrade and will remain the focus of continuous improvement ini-

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tiatives. All of the many projects mentioned in this paper are converging rapidly as they seek to embrace new technology in an effort to provide the greatest value, availability, and accuracy to system users. As performance upgrades are implemented, NDGPS will continue to enhance national infrastructure by remaining an important pillar of the federal government's strategy to save lives through deployment of safety-of-life navigation systems.

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The purpose of this paper is to present initiatives and propose new ideas for exploration. It is not intended to reflect USCG direction or policy. Use of company names, trademarks, or copywrited material is not an endorsement of any product or service.

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Something to Think About

CONVERGENCE

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INTRODUCTION

This paper provides a high level overview of the convergence of the telecommunications and Information Technology (IT) sectors, and discusses the potential benefits and threats to this merger. When developing this material, I assumed that the company this paper was prepared for was not directly involved in the telecommunications or IT business. Consequently, the material is broken down into four distinct sections: convergence defined, recent developments, benefits of convergence and impediments to convergence. It also contains summary and references sections.

CONVERGENCE DEFINED

In the distant past, the telecommunications sector was developed exclusively around telephones and systems designed to transport voice communications over long distances. In the more recent past, IT evolved systems that transported data, image and video information over long distances. Most recently, the word convergence was used to join these two industries as the lines defining each became blurred with every new technological development. The merging of telecommunications and IT represents another step in the evolutionary progression of technology. This progression is destined to unite many disparate and archaic forms of communication in to a single data stream that offers a wider variety of options with unparalleled speed, increased efficiency and at lower cost to the user.

The defining moment that predicted the merger of the telecommunications and IT industries was when telephone systems became digital. Prior to that, analog data streams were incompatible with the efficient digital dataflow of computer systems. However, once the telephone systems shifted to a digital medium, they became nothing more than packet data, which could be processed by computers and quickly transported over long distances via the Internet. Initially, the primary limiting factor was bandwidth. As time and technology have progressed, broadband connections proliferated throughout the world and made the transportation of voice communications over the Internet a practical reality currently referred to as Voice Over Internet Protocol (VoIP).

RECENT DEVELOPMENTS

In the business arena today, VoIP is to the telephone companies what email was to the Post office 10 years ago. VoIP came about as a result of work done by a few hobbyists in Israel in early 1995.[1] Based on their work, Vocaltec, Inc. released the first telephone

USCG photo by PA1 Barry Lane.

software in late 1995.[1] Since that time other hardware and software vendors have jumped on board and propelled VoIP into the mainstream. It is the hottest new technology on the market today and conceptually moves telephone services from slow twisted pair lines to broadband Internet connections. This upgrade is no small feat, and involves new phone equipment, routers, switches, Internet connections, software, etc.[5] However, the gains can be significant. As one example, Coldwell Banker Elite in Stafford, VA., realized an 80% reduction in their monthly telecommunications costs after installing a VoIP system last year.[5] Much of their cost reduction involved replacing 80 business lines at a cost of more than $4,800 a month with three T1 lines at a cost of only $2,250.[5] In addition to the standard voice communications, VoIP also offers real time video and audio conferencing, which is one service that no telephone company could ever provide over traditional twisted pair lines.

VoIP is not a one size fits all solution either. Companies that do not depend on broadband Internet connections may not benefit from switching their entire telephone service over to a broadband solution. Every company must be evaluated on a case-by-case basis and should weight installation, operations and maintenance costs into their cost savings. For those companies who continue to operate without broadband services, IP PPX technology may be a viable solution. A IP PBX solution involves transmitting digital telecommunications over analog phone lines, and is similar to connecting with the Internet through your 56.6k computer modem from home. Although somewhat slower than broadband, data compression software allows for higher data rates than traditional telephone lines and provides video and audio conferencing support as well.[2]

There is also a movement toward pervasive computing, where computers are embedded in to ordinary every day devices.[4] By incorporating "smart" technology in to machines, users are able to remotely communicate and control machines from virtually anywhere on the planet. One current example is the Intelligent Oven, which is marketed by TMIO, Inc. in Cleveland, OH. The company's stainless steel oven refrigerates food until cook time and automatically preheats the oven and cooks the food according to a user-defined schedule. The unique aspect of this oven is that it offers several different interfaces through which the user can change the cook time, temp, etc. These interfaces include traditional push buttons on the stovetop, or digital connections via the Internet or cellular telephone.[10] Other companies are working on other smart machines that will identify when a part is about to malfunction. Recognizing a problem before it occurs, smart technology allows a machine to actively contact an approved repair facility and schedule the repair before the part breaks.[4] This concept applies to an endless list of equipment from manufacturing equipment, to automobiles, to household appliances, etc.

In addition to these relevant business cases, the convergence is also working toward incorporating the human senses into telecommunications. Computers are already capable of hearing and speaking to users, displaying three-dimensional images, and responding to user voice commands. Future enhancements include the ability to interact with simulated computer content through virtual touch and smell functions.[4] These future enhancements will provide an unparalleled experience for users by allowing computers to interact through all five human physical senses.

BENEFITS

The benefits of convergence include lower service costs, simplified and faster provisioning, easier management, less maintenance, improved service, new services and simplification of user life.[2] Many of these benefits are intuitively obvious, while others require some explanation. Lower costs come about as a result of combining service providers. It is less expensive to purchase cable television, telephone service and Internet service from the Cox cable company in the southeastern United States than it is to purchase each service from an individual carrier. This cost savings is a net result of a single company maintaining a common communications link rather than three companies with three times the equipment, personnel and maintenance costs. This concept also spills over into provisioning. It is easier and faster to run a single data line into a location than it is to run three different lines, at three different times, and through three different routs. Utilizing wireless technology lowers installation costs even further by reducing the number of drops installed at each site. Instead of running wires to every computer location, the main drop is centrally located and con-

nected to a wireless router. Additional routers are strategically located in each office space in close proximity to a group of networked computers. This eliminates the need to run extra data lines through ceilings, floors, walls, etc. New services come in the form of video and audio conferencing, which traditional telephone service providers could not offer as well as higher data transfer rates. End users are also provided with access to music and video previously excluded from low bandwidth systems. Easier management and the simplification of user life are achieved by reducing the overall amount of equipment required for a suite of services and providing a single point of contact for questions and maintenance for all of the services received by the user. Technology convergence touts many promises and benefits, which have already been realized by businesses and end users who understand its potential.

IMPEDIMENTS

One of the more problematic impediments of telecommunication convergence is that the new technology has an unproven reliability and availability. Much of the technological advances discussed in this paper are still in their adolescence if not their infancy, and will require refinement and wider scale adoption before the risks involved adopting them are acceptable to many businesses. Historically speaking it is not always advisable to jump on the first train leaving the station. Several well known examples include the 8-Track audiotape, Beta videotapes, Apple Computers, etc., and there are countless more. Contributing to availability concerns is a lack of standards. There are two rivals in VoIP arena alone, which makes it very difficult to decide which horse to bet on when there is no clear winner emerging from the pack. Another major problem is the need for new hardware and software to interoperate with existing systems and capabilities. Systems do not change over night, and there is always a period of time when both systems exist. The exact timeline for this overlap is difficult to predict. Cassette tapes very quickly replaced 8-Track tapes, however, although the DVD formatted movie CDs have been out for quite a while, video manufacturers are still producing VHS tapes for consumer sales. Consequently any new system must be compatible with existing rivals. Regulatory issues are another large concern for businesses adopting new technologies. Although the telephone industry is tightly regulated, there is currently nothing in place to address the VoIP systems being installed today. Furthermore there is no way to even begin to predict the cost of future regulatory changes, taxes, user fees, etc. Although attempts by the U.S. government to regulate pornography on the Internet and charge a fee for every email sent were unsuccessful, that does not mean that future attempts to regulate data flow will be unsuccessful. Finally there are the human factors. The current telecommunications services and equipment are extremely reliable and meet our needs. It is an up-hill battle to convince the company Chief Financial Officer (CFO) and board of directors to invest capital in a new communications system when the current one meets the company's needs. People fear change and will tend to hold on to what they already have; that is a system that works and one that they are familiar with and comfortable using. The impediments to telecommunications convergence are almost as numerous as the benefits, and although some are quite daunting and worrisome, none are insurmountable.

SUMMARY

The convergence of the telecommunications and IT sectors is a natural progression of the evolution of technology. Telecommunication systems involved transporting voice communications over long distances through analog lines, while IT systems involved transporting data, image and video over long distances through digital lines. It logically follows that when traditional voice communications shifted to a digital format, that telecommunications and IT industries would merge because voice communications would be nothing more than digital data to almost any IT system.

Recent developments in convergence include VoIP via broadband and IP PBX transport systems. Although IP PBX still makes use of analog data lines, both VoIP systems

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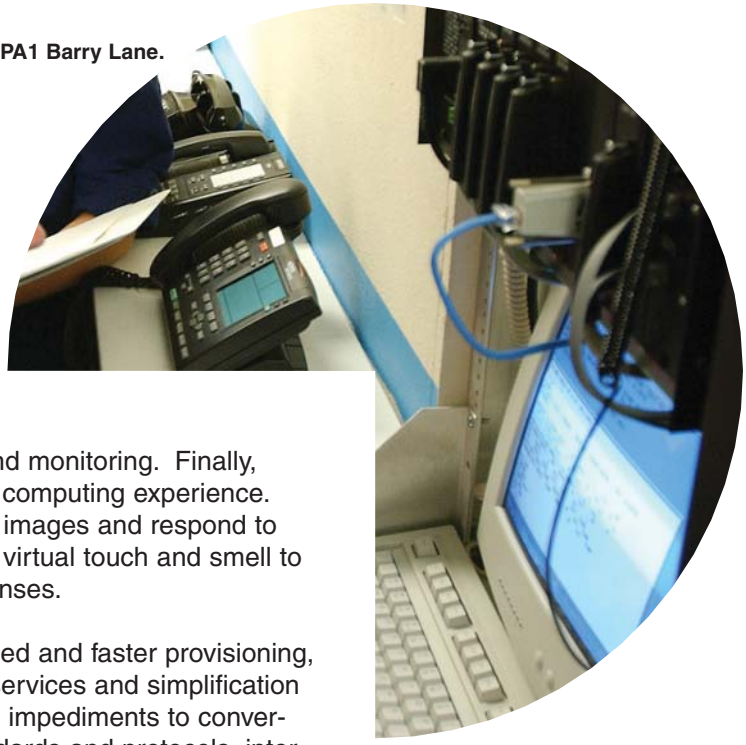

replace traditional dialup telephone services and include video and teleconferencing capabilities that analog telephone service providers could not offer. This is accomplished through use of digital formats and data compression algorithms. Pervasive computing is currently being incorporated into every day devices such as ovens, washers and dryers, refrigerators, beds, etc. to create smart devices. These devices monitor themselves and alert users when there is a problem before the problem occurs. They also provide a variety of access methods, which include traditional push button, Internet, telephone, PDA, wireless telephone, etc. for system configuration and monitoring. Finally, there is a movement to incorporate all five human senses in the computing experience. Currently computers can hear, speak, display three-dimensional images and respond to voice commands. In the near future, they will be able to include virtual touch and smell to enhance user experiences and capitalize on all of the human senses.

The benefits of convergence include lower service costs, simplified and faster provisioning, easier management, less maintenance, improved service, new services and simplification of user life.[2] Many of these benefits are intuitively obvious. The impediments to convergence include: unproven reliability and availability, a lack of standards and protocols, interoperability with existing systems and capabilities, regulatory changes and human factors. The impediments to telecommunications convergence are almost as numerous as the benefits, and although some are quite daunting and worrisome, none are insurmountable.

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