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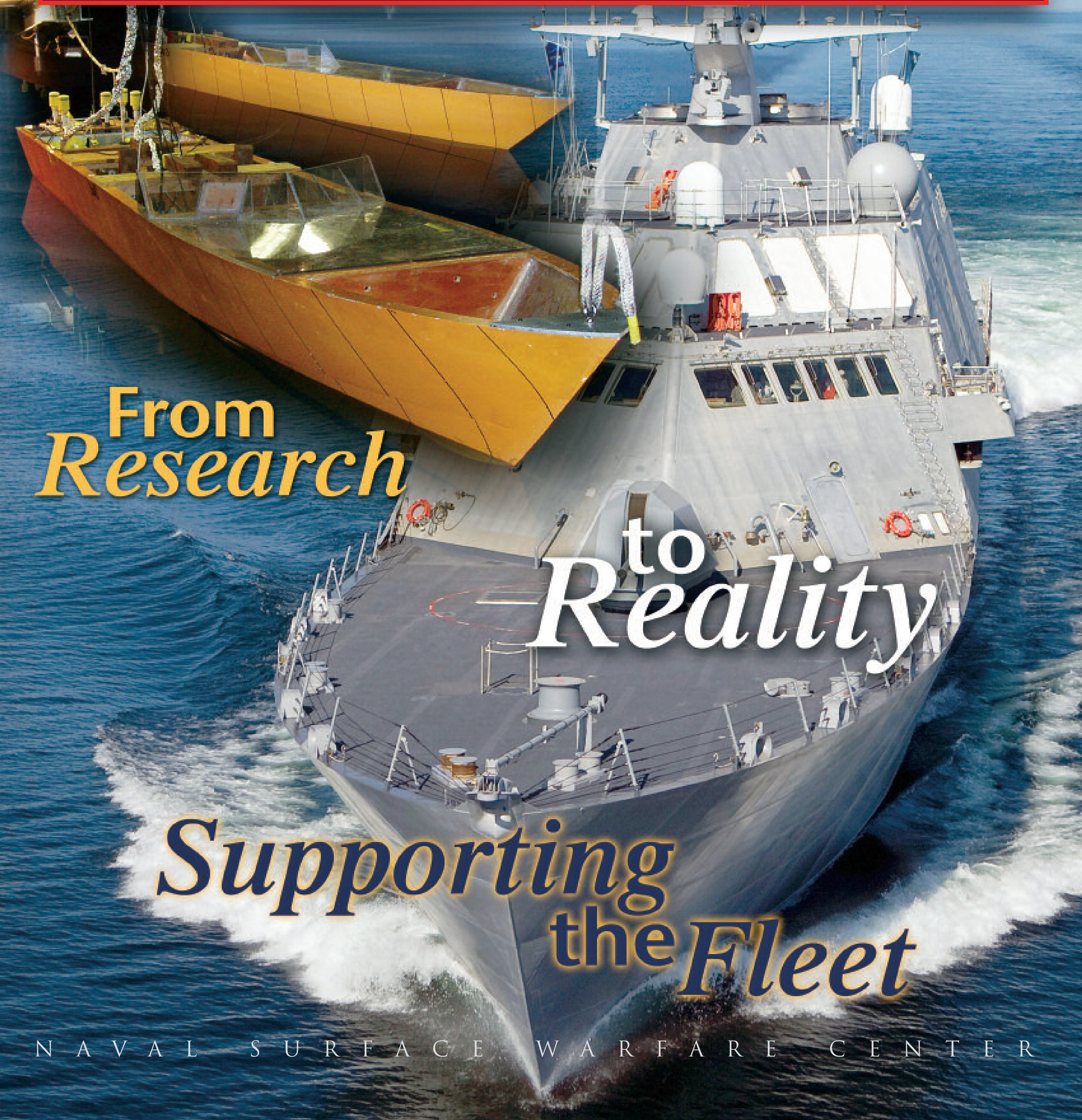

From Research to Reality

Supporting the Fleet

NAVAL SURFACE WARFARE CENTER

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FROM THE TOP

SUPPORTING THE FLEET– THEY FIGHT FOR US; WE WORK FOR THEM

By Captain Mark W. Thomas, C. Randy Reeves, and Captain Alexander S. Desroches

The fleet is the main focus for every U.S. Navy shore command–not just the ships but the Sailors as well. For more than a century, Naval Surface Warfare Center (NSWC), Carderock Division, has achieved and sustained excellence in supporting ships and ship systems to ensure the U.S. Navy's superiority on the seas. And in so doing, we help assure the safety and security of the Sailors who bravely operate these vessels, carrying out the fleet's global role in strategic deterrence and defense.

NSWC Carderock Division is the Navy's state-of-the-art research, engineering, modeling, and test center for ships and ship systems. It is the largest, most comprehensive establishment of its kind in the world. Everything we do from the early stages of research and development throughout the life of a ship to the end stages of ship and ship system disposition is done, either directly or indirectly, to ensure the greatest capability for the fleet.

Long known as the place "*Where the Fleet Begins*," Carderock Division's mission includes basic research and development (R&D) and science and technology (S&T). Our focus is transition–where best to allocate our resources for the greatest benefit to the fleet. It requires a certain amount of risk to push the envelope, balanced with a payoff in new technology actually coming to fruition. In all cases, we must keep our customers' requirements at the forefront of our thinking–while exploring new ideas. Our S&T and R&D work is focused on meeting the customers' requirements through innovation and solid risk management.

The future in naval technology is important, but also crucial is our ability to maintain the present force. Through in-service engineering (ISE), test and evaluation (T&E), and life cycle management (LCM) we focus on helping the fleet maintain its forward presence. With more than 100 land-based engineering sites, the Carderock Division can test out new technologies, as well as changes to equipment, systems, and software. The importance of testing shoreside can not be overstated. Using these sites we can work out "the bugs" before the technology ever reaches the fleet–thus ensuring the ships can deploy and the Sailors can stay online. Some test sites are also used to train precommissioning crews.

Carderock Division is also directly involved with the fleet through in-service engineering (ISE) and distance support. On any given day, we have between 100 to 200 engineers and technicians shipboard throughout the world. Additionally, we have on-site representatives in the major homeports, serving as on-the-spot eyes, ears, and hands for the Division. We also play a leading role in planning and conducting acoustic trials on ships, submarines, and marine vehicles. Division engineers design, develop, and support the systems used to acquire, process, and analyze the signature data shipboard. This allows the fleet to maintain its tactical advantage.

Beyond the ships, the Navy also operates small boats and craft. Carderock Division exercises design and engineering authority for U.S. Navy combatant craft and boats, often operating in direct support of special forces and special operations abroad. For ships and boats, alike, the Division provides critical maintenance engineering and integrated logistic support.

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On the cover: Carderock Division is the Navy's state-of-the-art research, engineering, modeling, and test center for ships and ship systems. Everything we do from the early stages of research and development throughout the life of a ship to the end stages of ship and ship system disposition ensure the greatest capability for the fleet.

Model images provided by Tim Smith,
NSWC Carderock Division
and U.S. Navy photos.
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NSWC Carderock Division.

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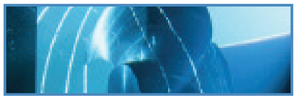

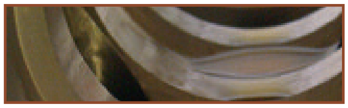

TECHNOLOGY AND INNOVATION

FROM THE TOP:

SUPPORTING THE FLEET (Continued from inside cover)

From their desks, our engineers provide distance support on a myriad of ship systems. Quarterly, the Division's Ship Systems Engineering Station responds to approximately 450 Remedy tickets, averaging nearly six per day. Additionally, through our technical feedback response systems, Sailors can provide feedback to resolve any discrepancies or propose improvements to PMS procedures, as well as technical manuals. Understanding fleet needs is paramount, and through on-site representatives, ship visits, shipboard testing, and good two-way communication with the Sailors, Carderock Division gains that understanding.

"*They Fight for Us; We Work for Them,*" is the mantra which helps us keep our eyes on the big picture. An important aspect of our support is an emphasis on the Sailor, as well as the Marine, Soldier, Airman, or National Guardsmen. They are the country's greatest assets, and we must ensure they have the right equipment, the right knowledge, the right software, and the right support to do their jobs. Some of our employees are serving as reservists, guardsmen, or individual augmentees in theater. And shoreside we must keep them ever-present in our thinking. To help reduce the risk for people at sea, we are expending much research and development effort on reduced manning and unmanned technology for the future. This technology will also benefit non-Navy entities engaged on the front lines, as will other technologies with which the Division is involved.

Whether we're talking S&T, design support, acquisition support, ISE, or LCM functions, it's not technology for the sake of technology. It must always relate back to our prime objective, which is supporting the fleet–the people on the front line. This issue of SEAFRAME illustrates some of the ways Carderock Division is providing that support to the fleet.

U.S. Navy photo collage by Gloria Patterson, NSWC Carderock Division.

CAPTAIN ALEXANDER S. DESROCHES ASSUMES COMMAND OF NSWCCD, SHIP SYSTEMS ENGINEERING STATION

By

Leslie Spaulding

Captain Alexander S. Desroches relieved Captain Mary J. Logsdon as Commanding Officer, Naval Surface Warfare Center, Carderock Division–Ship Systems Engineering Station on August 21, 2008.

Desroches graduated with distinction from the University of Missouri-Rolla with a bachelor's degree in science in petroleum engineering and was commissioned as an Ensign upon graduation from Officer Candidate School. He later earned simultaneous master's degrees in naval engineering and mechanical engineering. He has also completed Submarine Officer Basic School and Diving and Salvage Officer training. In 1989, he laterally transferred to the Engineering Duty Officer community.

Desroches has served as the Interior Communications Officer, Damage Control Assistant, and Communications Officer aboard *USS Batfish* (SSN 681); the Engineering Officer on *USS Darter* (SS 576); and more recently as a nine-month combat individual augmentee assigned to Joint CREW Composite Squadron ONE in Iraq. Shoreside, he has served as Nuclear and Non-Nuclear Ship Superintendent at Mare Island Naval Shipyard; Diving and Salvage Officer and Material Officer on the staff of Commander, Submarine Development Squadron Five; Test and Evaluation Manager for the *Virginia* Class Program (PMS 450); Ship Readiness Analyst for OPNAV; Submarine Maintenance Program Manager and Budget Officer for COMPACFLT N43; Engineering and Planning Officer for Pearl Harbor Naval Shipyard and Intermediate Maintenance Facility; and Chief of Staff for Logistics, Maintenance, and Industrial Operations Directorate, Naval Sea Systems Command.

Desroches wears the *Bronze Star, Meritorious Service Medal* (four awards), *Navy Commendation Medal* (four awards), *Navy Achievement Medal* (two awards), and various unit and service decorations.

BUSINESS

LEAN SIX SIGMA

Refining the Planning Process by Mapping the Technical Capabilities

By

Leslie Spaulding

The U.S. Navy has adopted Lean Six Sigma as a business approach to transformation. With a need to be dominant, flexible, and capable of responding to diverse missions and threats, while ensuring sea-based power projection in many environments, the Navy must increase its readiness and assets while working within constrained budgets. Lean Six Sigma offers a method for preventing waste while fostering a culture of continual process improvement.

As the Navy's provider of full-spectrum naval architecture and marine engineering, Carderock Division must offer responsive, innovative, and cost-effective technical solutions to the warfighter in support of the

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LEAN SIX SIGMA (Continued from page 3)

LEAN

Lean logo by Gary Garvin, NSWC Carderock Division.

Navy’s future needs. In that role, we are the Navy’s technical lead in seven core equities: ship integration and design; hull forms and propulsors; machinery systems; structures and materials; environmental quality systems; vulnerability and survivability systems; and signatures, silencing systems and susceptibility. These core equities reflect the support we provide through our skilled people and specialized facilities. Within these core equities, Carderock Division offers 24 distinct technical capabilities. The largest core equity area is machinery systems, which is comprised of eight technical capability areas. As the technical capabilities are at the heart of the Division’s work, it seemed only natural to look at each of them through the eyes of Lean Six Sigma. The Command’s Technical Director C. Randy Reeves directed the core equity area leaders to map their technical capabilities. With responsibility for the largest core equity area, the Division’s Machinery Engineering and Research Department management, supported by dedicated Lean Six Sigma black belts, pioneered the approach to mapping technical capabilities.

An integral part of the Lean Six Sigma process is planning. Since adopting the Lean approach several years ago, Carderock Division has tried several approaches to planning the year’s continuous improvement events. By “mapping” the Machinery Systems Core Equity’s eight technical capability areas, leadership could clearly define what technical areas would benefit most from continuous process improvement. By approaching Lean through the technical capabilities, leadership was no longer hemmed in by organizational lines of responsibility–instead the effort looked at all contributors to any given technical capability process. Additionally, this approach allowed leadership to bypass the smaller “administrative issues” and focus more on its technical work–the area that directly impacts the fleet.

Mapping is a way to visually document a process at a high level. Within this core equity, each knowledge area within each technical capability was mapped using a process called SIPOC, which shows the process beginning with suppliers’ inputs and working through the products or services received by customers. The acronym comes from the column headings on a SIPOC chart: suppliers, inputs, processes, outputs, and customers. Each knowledge area lead charted this information and supplied the completed SIPOCs to the Division’s Continuous Process Improvement Office. The effort resulted in approximately 80 SIPOCs. In addition, each knowledge area lead indicated the percentage of resources spent on any given effort–which was later used to determine which work processes would benefit most.

Through this mapping process, the Continuous Process Improvement Office black belts, working with the technical capability and knowledge area leads were able to consolidate work within knowledge areas, grouping common work that could be collectively improved and standardized. One effort that came out of this consolidation was a program management value stream analysis. Although the areas of work were common, there were

Machinery Systems Core Equity Area

Technical Capabilities

- **Surface and Undersea Vehicle Machinery Systems Integration**
- **Surface and Undersea Vehicle Mechanical Power and Propulsion Systems**
- **Surface and Undersea Vehicle Electrical Power and Propulsion Systems**
- **Surface and Undersea Vehicle Auxiliary Machinery Systems**
- **Surface and Undersea Vehicle Hull, Deck, and Habitability Machinery Systems**
- **Surface and Undersea Vehicle Machinery Automation, Controls, Sensors, and Network Systems**
- **Advanced Logistics Concepts and Hull, Mechanical, and Electrical (HM&E) Life Cycle Logistics Support**
- **HM&E for Undersea Vehicle Sail Systems and Deployed Systems**

some challenges. For example, each program manager must meet the customer's requirements and expectations–which vary from platform to platform. Despite these variations, it was found that the process itself could and should be standardized.

As a result of mapping the technical capability areas, improvement events were defined and scheduled. Some of these events are underway, while others are scheduled into FY 09. One rapid improvement event that resulted from the mapping involved the Configuration Changes/Configuration Control Review Board Process used to review and evaluate all submarine sail system configuration changes under Carderock Division's cognizance. This event led to an updated and expanded process that eliminates variance by removing ambiguous direction and steps that are no longer valid. This variance resulted in workarounds and inefficiencies. Additionally, metrics were added at natural break points to validate the payback.

Beyond the continuous improvement effort, the SIPOCs developed by each knowledge area lead now serve as a management tool, allowing them to track their work efforts and adjust more easily as workload shifts from one area to another. It will also help them determine if the right resources are being applied to the right areas and can be used as a baseline going forward into next year.

The bottom line is that this mapping of technical capabilities will help the Machinery Systems Core Equity leadership to improve its processes and reallocate resources where necessary to ensure their customer, the Warfighter, is receiving a reliable and timely product at an affordable cost.

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CUSTOMER ADVOCACY

WARFARE CENTER CUSTOMER ADVOCATES

Aligning to the Navy's Enterprise Framework for Better Efficiency and Effectiveness

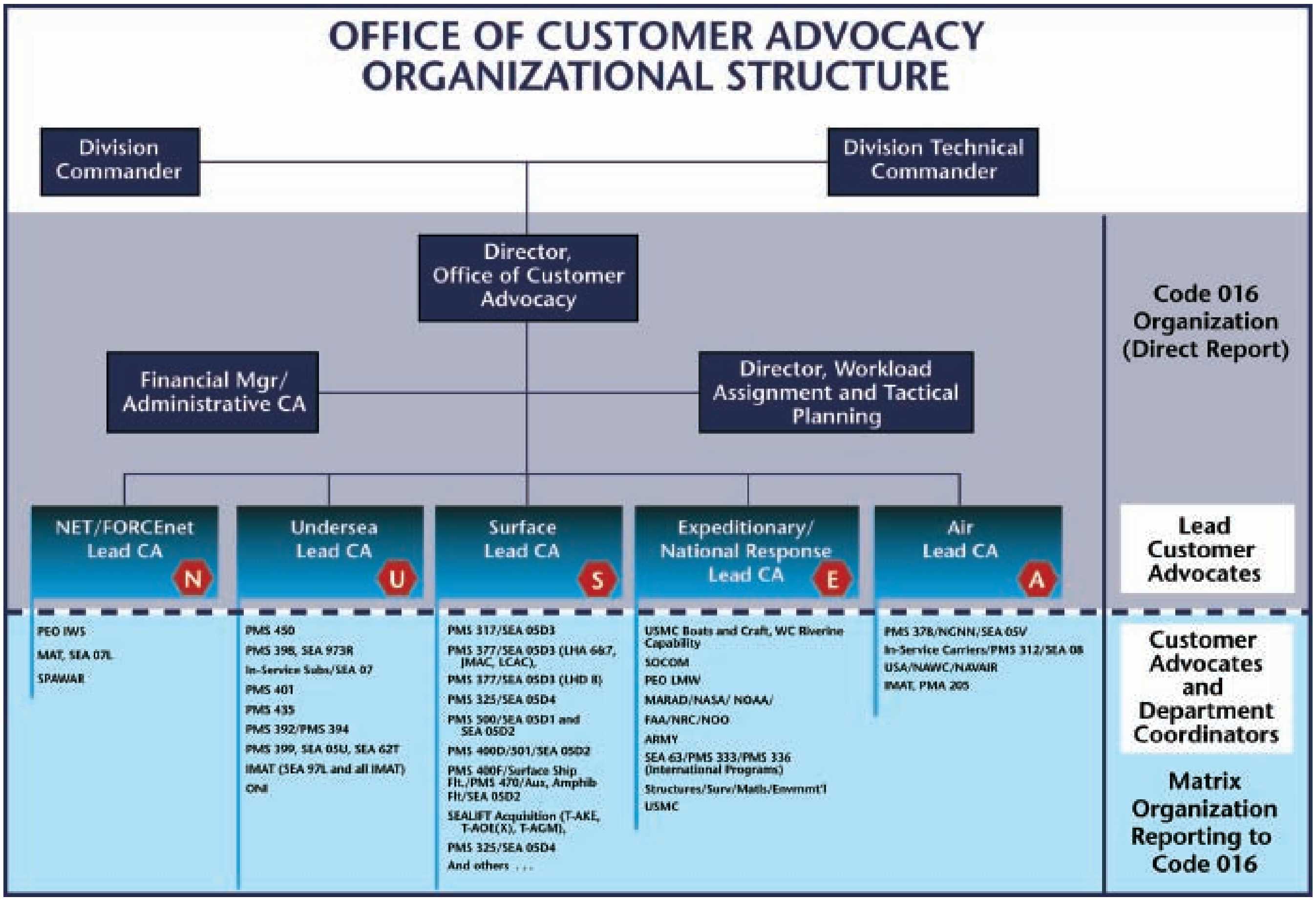
By Ronald Warwick and Leslie Spaulding

In late 2006, Vice Admiral Paul Sullivan, who was then Commander, Naval Sea Systems Command, approved sweeping changes to the construct of the NAVSEA Warfare Centers (WFC) management. Called the "next evolution in WFC management," these changes were designed to better steward the long-term business and technical viability of the WFC sites. This construct would also streamline work management at the national level, help the WFCs stay technically relevant to today's and tomorrow's warfighters, and ensure an efficient and effective interface for promulgating common processes.

This next evolution encompassed several initiatives that would better support the Navy's "Enterprise" framework, as well as NAVSEA's transformation to a competency aligned organization. It would also result in more efficiency and effectiveness. The changes included assigning a Senior Executive Service (SES) technical director to each WFC

WC CUSTOMER ADVOCATES (Continued on page 6)

WC CUSTOMER ADVOCATES (Continued from page 5)



division, developing five SES-level Warfare Center Executive (WCE) positions to support NAVSEA's Program Executive Offices (PEOs) and other major customers, and developing a full-time SES-level Corporate Business Executive position.

As part of the change in Warfare Center management, customer advocates (CAs) were realigned to serve as principal agents of the WCEs. These advocates provide overall project management and oversight for all projects under their cognizance at their divisions. They are responsible for maintaining a national perspective, acting as a smart buyer and honest broker, and under the direction of the WCE, assuring work is assigned to the appropriate WFC site(s).

The customer advocates are responsible for managing the WFC division relationships with sponsors, program offices, and foreign national contacts (in the case of foreign military sales). They negotiate cost proposals and tasking for all program work performed at their division and collaborate with other WFC division sites on program-specific initiatives and proposals.

In support of the Commanding Officer/Division Technical Director, these advocates work closely with technical project managers and engage in meaningful cost, schedule, and performance discussions with the customers. The CAs keep the WCE apprised of overall project status, issues, new requirements, and significant changes in workload.

Customer advocates are responsible for speaking on behalf of the division regarding workload commitments, including changes in scope for existing workload. To support both the Division Technical Director and the Warfare Center Executive, the CAs conduct workload forecasting and participate in division strategic workload and technical capabilities planning. They work with the WCEs on national strategic assessments, long-term master planning, and work acceptance and assignment packages.

To this end, Carderock Division established the Office of Customer Advocacy, and with WCE concurrence, established a lead customer advocate for each Warfare Center Executive. *(See the Office of Customer Advocacy Organizational Structure above.)* The Office of Customer Advocacy, with Vince Wagner as Director, reports directly to Carderock Division's Technical Director, C. Randy Reeves. Its primary goal is to implement the Division's

customer relationship management system and ensure seamless customer advocacy across the Division and with the WCE. Lead CAs are responsible for overall coordination and information sharing with their respective WCEs. Additionally, the Lead CAs are responsible for:

- Serving as primary interface between Carderock Division, customer(s), and their respective WCE(s).
- Establishing CA plans and goals to manage customer relationships for their respective area.
- Providing WCEs and customer input (demand signals) to Division capacity and capability assessments (e.g., technical, facilities, and business).
- Engaging WCEs in the endorsement of Division investments; and facilitating communicating, and enabling clarification and justification of those investments, as appropriate.
- Managing Division carryover at the enterprise level.

The Office of Customer Advocacy accomplishes two other critical functions. First, the position of Director of Work Assignment and Tactical Planning serves as the focal point for cross-customer driven planning in the Division. And second, the position of Financial Manager and Administrator provides Carderock Division planning and analysis support. The Office of Customer Advocacy is in the process of revising its concept of operations document to reflect the change in Warfare Center management and is developing an intranet site to provide helpful and current customer advocacy information to Division personnel.

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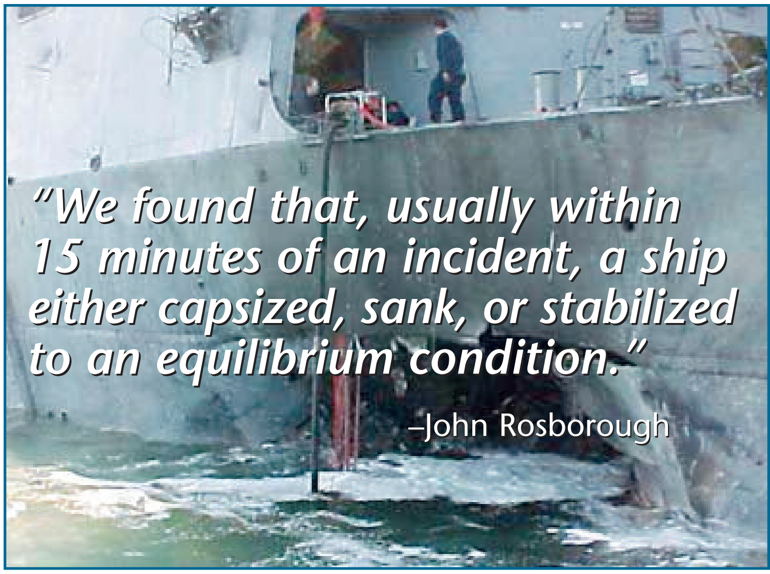
Left: Platforms supported by the Navy's Warfare Center Advocacy.
U.S. Navy photo collage by Gloria Patterson, NSWC Carderock Division.

FLOODING CASUALTY CONTROL SOFTWARE

Helping Ship Crews Decide When to Stay and When to Go

By William Palmer

You're the Damage Control Assistant (DCA) onboard ship and have just sustained a weapon strike. Flooding is occurring, and the commanding officer wants to know whether the ship will survive the hit and remain afloat, or whether it will sink. You need to provide him with an answer. Carderock Division engineers have written a computer program, called Flooding Casualty Control Software (FCCS), which provides just such information to crew onboard Navy vessels. The software lets the user define the kind of flooding, fixed flooding or free communication with the sea. The software then calculates an instantaneous stability solution that determines if the ship will be stable or unstable at the final flooding condition for the given loads and environmental conditions.



> *"We found that, usually within 15 minutes of an incident, a ship either capsized, sank, or stabilized to an equilibrium condition."*
>
> –John Rosborough

Above: Damage sustained by *USS Stark* (FFG 31) following a missile strike. Flooding casualty control software would help crews quickly ascertain the status of their ship and how to respond.

Left and above: Automated solutions provided by FCCS counter not only flooding casualties, but also such events as grounding or drydocking. *U.S. Navy photos.*

John Rosborough, a naval architect and Carderock Division's principal investigator for this project, took a look at damage which occurred to Navy vessels during World War II. "We found that, usually within 15 minutes of an incident," said Rosborough, "a ship either capsized, sank, or stabilized to an equilibrium condition. The fleet had a means of calculating its stability in a damaged condition, but it involved manual calculations and obviously wasn't going to be completed in 15 minutes." Rosborough and his team turned to one of the first naval architectural ship design tools, the Ship Hull Characteristics Program (SHCP) and modified it to calculate current stability, accept real-time input from tank level sensors, and predict whether or not the ship would stabilize.

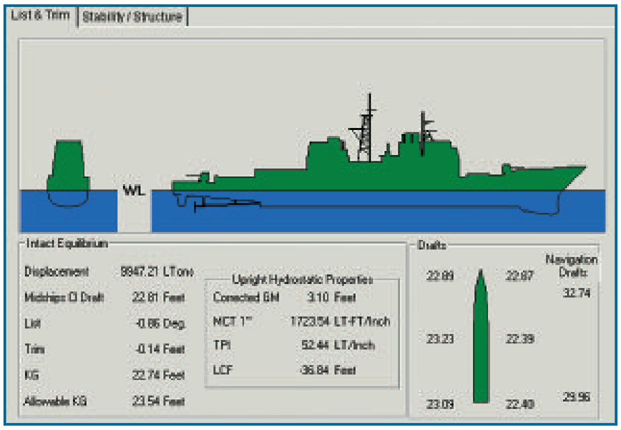
FCCS was first distributed to the fleet in the 1980s when the hot new computer of the time was a Zenith 286. Since then, the program has upgraded to Windows and uses weight and stability databases for almost every Navy ship class. The software is not restricted to assessing a weapon casualty–ship stability is affected during high winds or seas, executing a turning maneuver, experiencing a peacetime grounding, or lifting very heavy cargo over the side. To create an accurate stability picture, all loads, such as liquid loads, cargo, or embarked vehicles, on the ship need to be known. The software is flexible enough to automatically accept tank levels and fluid types, either from tank level indicators or manually from a user. It automatically calculates weight and center of gravity for all liquids presented in the calculation.

Regular (fuel oil separate from clean ballast) and compensated fuel oil system ships (fuel oil over water) can be represented by the program. Dry loads, such as aircraft, ammunition, stores, cargo, amphibious assault gear, and vehicles such as Landing Craft Air Cushions (LCACs), are documented. The vessel's commanding officer has displays indicating basic hydrostatic and current draft information. The program performs intact and damage stability analyses based on the current loading and extent of damage and provides green-yellow-red evaluations of stability and buoyancy limits and criteria. Some evaluations of stability limits and criteria are weighed against predefined values, such as limiting drafts and displacements. Other stability criteria are calculated on the fly using the ship's hull form, compartment definition, current weight, center of gravity, and current environmental conditions, such as the ability of a ship in a particular weight/stability configuration to withstand a 100-knot wind. The longitudinal bending moment of the ship, another concern on some classes of ship, can be evaluated for different sea states.

The software has many useful features to make the lives of Sailors much easier. One of these features is an automated expended liquids report, which details the volume of total liquids remaining onboard. Another is the daily draft report, which the ship's DCA draws up for the commanding officer. Also, ships' crews normally man what is termed a sounding watch, where each of the hundreds of onboard tank levels are manually measured and recorded. FCCS automatically measures tank levels

FLOODING CASUALTY CONTROL (Continued on page 10)

FLOODING CASUALTY CONTROL (Continued from page 9)



Intact Equilibrium

Displacement	8947.21 LTons
Midships Cl Draft	22.81 Feet
List	-0.86 Deg.
Trim	-0.14 Feet
KG	22.74 Feet
Allowable KG	23.54 Feet

Upright Hydrostatic Properties

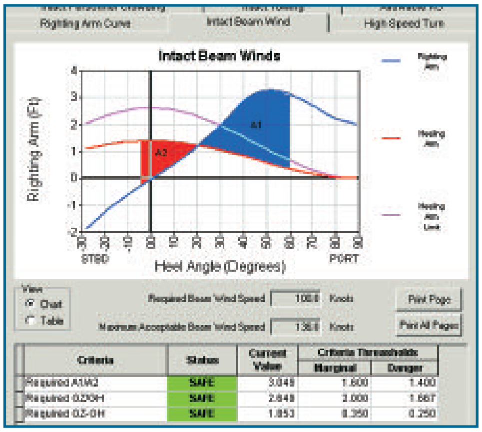
Corrected GM	3.10 Feet
MCT 1"	1723.54 LT-FT/Inch
TPI	52.44 LT/Inch
LCF	-36.84 Feet

Drafts

		Navigation Drafts
22.89	22.87	32.74
23.23	22.39	
23.09	22.40	29.96

Stability

Foundering	SAFE
Capsize	SAFE
GM	SAFE
KG	SAFE
Excessive List	SAFE
Displacement Limit	SAFE
Draft Limits	SAFE
Beam Winds	SAFE
High Speed Turn	SAFE
Towing	MARGINAL
Crowding	SAFE

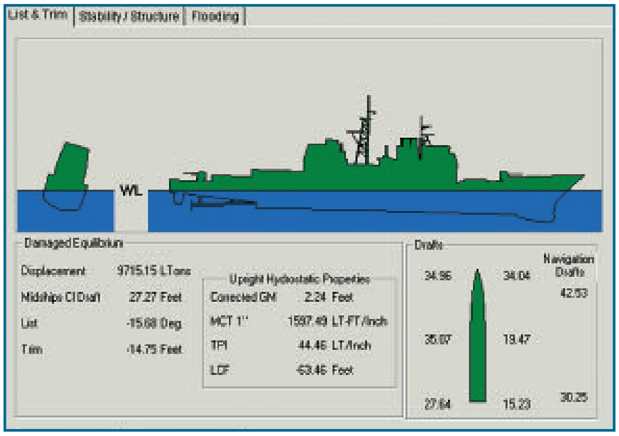


View
● Chart
○ Table

Required Beam Wind Speed 100.0 Knots

Maximum Acceptable Beam Wind Speed 136.8 Knots

Criteria	Status	Current Value	Criteria Thresholds	
			Marginal	Danger
Required A1/A2	SAFE	3.049	1.600	1.400
Required GZ/OH	SAFE	2.649	2.000	1.667
Required GZ-OH	SAFE	1.853	0.350	0.250



Damaged Equilibrium

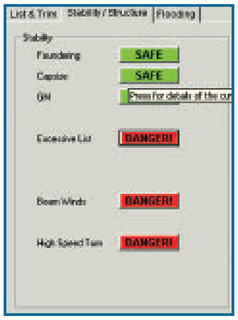
Displacement	9715.15 LTons
Midships Cl Draft	27.27 Feet
List	-15.68 Deg.
Trim	-14.75 Feet

Upright Hydrostatic Properties

Corrected GM	2.24 Feet
MCT 1"	1597.49 LT-FT/Inch
TPI	44.46 LT/Inch
LCF	-63.46 Feet

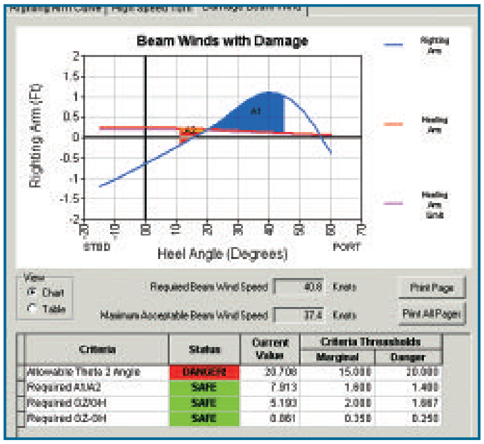
Drafts

		Navigation Drafts
34.96	34.04	42.53
35.07	19.47	
27.64	15.23	30.25



Stability

Foundering	SAFE
Capsize	SAFE
GM	Press for details of the cur
Excessive List	DANGER!
Beam Winds	DANGER!
High Speed Turn	DANGER!

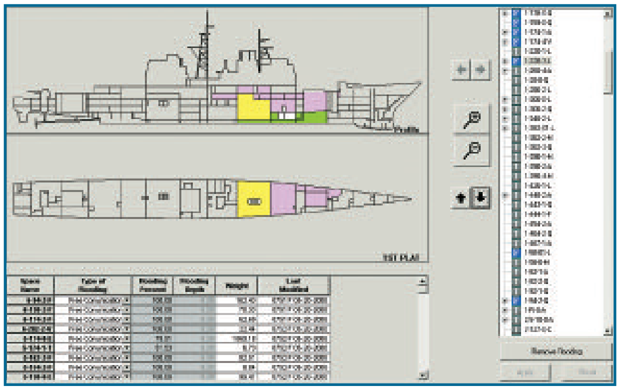


View
● Chart
○ Table

Required Beam Wind Speed 40.8 Knots

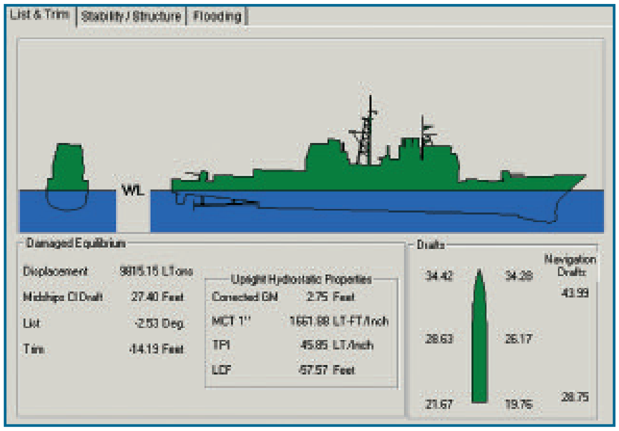
Maximum Acceptable Beam Wind Speed 37.4 Knots

Criteria	Status	Current Value	Criteria Thresholds	
			Marginal	Danger
Allowable Theta 2 Angle	DANGER	20.708	15.000	20.000
Required A1/A2	SAFE	7.913	1.600	1.400
Required GZ/OH	SAFE	5.193	2.000	1.667
Required GZ-OH	SAFE	0.861	0.350	0.250



On this page: Screen output from the Flooding Casualty Control software. Upper panels show a particular ship in a "normal" trim and list configuration. Middle panels show flooding, and the result on the ship's stability. Panel with pink and yellow shading shows spaces affected by the flooding. Bottom panels depict the correction of the ship's stability by the application of an Intelligent Decision Aid solution to counter the flooding. Corrections sometimes comprise counter-flooding unaffected spaces to restore stability.

Graphics provided by John Rosborough, NSWC Carderock Division.



Damaged Equilibrium

Displacement	9815.15 LTons
Midships Cl Draft	27.40 Feet
List	-2.53 Deg.
Trim	-14.19 Feet

Upright Hydrostatic Properties

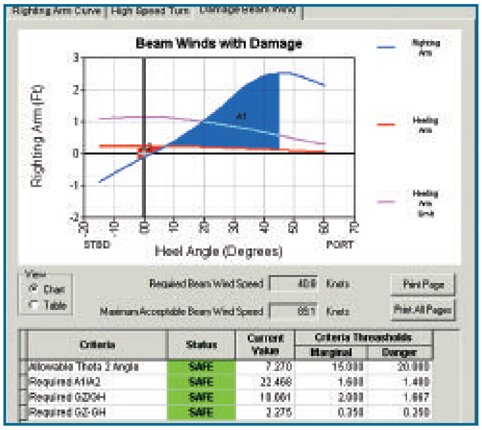
Corrected GM	2.75 Feet
MCT 1"	1661.88 LT-FT/Inch
TPI	45.85 LT/Inch
LCF	-57.57 Feet

Drafts

		Navigation Drafts
34.42	34.28	43.99
28.63	26.17	
21.67	19.76	28.75

Stability

Foundering	SAFE
Capsize	SAFE
GM	SAFE
Excessive List	SAFE
Beam Winds	SAFE
High Speed Turn	SAFE



View
● Chart
○ Table

Required Beam Wind Speed 40.8 Knots

Maximum Acceptable Beam Wind Speed 85.1 Knots

Criteria	Status	Current Value	Criteria Thresholds	
			Marginal	Danger
Allowable Theta 2 Angle	SAFE	7.270	15.000	20.000
Required A1/A2	SAFE	22.468	1.600	1.400
Required GZ/OH	SAFE	10.061	2.000	1.667
Required GZ-OH	SAFE	2.275	0.350	0.250

on ships which use radar-based tank level indicators, which relieves Sailors of the need to man the sounding watch. The software can store multiple loading configurations and calculate projections of where the ship might be in a given situation.

Once a ship's stability is compromised, a software add-on to FCCS uses damage control rules to display damage control actions which most quickly bring the ship to a stable condition. The software, called the Intelligent Decision Aid, "walks" through compartments and tanks which could be used to re-trim the ship and quickly calculates actions to be taken, such as deballasting a space or flooding a tank. Other software modules include stability calculations for drydocking and when a ship runs aground. In the grounding event, different types of grounding can be specified, such as the ship being grounded on a single pinnacle, two pinnacles, or a shelf. The grounding module was developed concurrently with the United States Coast Guard.

An additional module, the Hull Structural Survival System (HSSS), not yet fielded to the fleet, provides a means of evaluating the remaining structural capacity of a ship's damaged hull girder. The module uses the Carderock Division's Ultimate Strength (ULTSTR) computer program and helps the user graphically define the damaged structure and then calculate the remaining ultimate bending and shear capacity of the undamaged structure as a function of sea state. The Intelligent Decision Aid is designed to work with both the stability and HSSS module (when present) to improve damage stability and reduce stress to the hull girder without compromising the safety of either one.

Currently, FCCS is planned for installation aboard each ship of the *USS San Antonio* (LPD 17) Class. Although databases installed on these ships only apply to the LPD 17 Class, Rosborough's team has databases for almost all Navy ships currently afloat. The software is also planned to be integral to the DDG 1000 and both LCS designs. The LCS application will be stand-alone, but the DDG 1000 FCCS will be the basis for a larger damage decision assessment module.

But this is not the end of the line for future FCCS capabilities. While current calculations are based on an end-state equilibrium model, a Carderock Division research effort has produced a time-domain progressive flooding model called Advanced Stability Algorithms (ASA) which calculates stability of the ship at every time step. This program is designed to not only predict the time to a critical event, such as capsize or sinking, but it will also identify when those critical events could happen before a stable equilibrium condition is reached. Currently the ASA program is a desktop design tool that has been used to provide flooding calculations for the ex-*Oriskany* Reef-Ex, flooding model validation of the ex-*Peterson* testing, and risk mitigation for the ex-*Saipan* testing. All these projects are recent SINK-EXs conducted by the Navy.

For appropriate implementation of FCCS/ASA capabilities onboard ship, flooding sensors in major spaces would give an instantaneous readout of all liquid levels. The FCCS/ASA program will extrapolate those rising levels, in the case of flooding, to identify possible points in time when the ship will either become stable or unstable. The DDG 1000 could be one of the first ships to include ASA-type capabilities, having both the computational power and the necessary compartment flooding level sensors to obtain the appropriate level of accuracy.

Rosborough says faster-than-real-time software response times are needed for the program to be of use to the crew. "We have reduced the analysis portion," he comments, "to virtually no time at all and reduced data gathering time to small amounts. It's well within the range of upcoming capabilities that we could have appropriate sensors capable of reporting flooding levels inside larger spaces. The sensor signals could be fed back as direct data and would greatly improve the exactness of the stability calculation."

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HULL FORMS & PROPULSORS

DESIGNING PROPULSORS

Excellence in Propulsor Design Gives Naval Forces a Needed Edge

By Dr. Scott Black

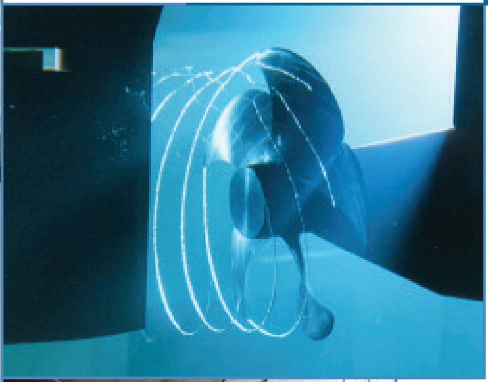
Propulsor development combines science, engineering, a bit of art and a lot of team effort. The propulsor is the link that turns energy from the machinery plant into the hydrodynamic forces that propel the ship. Propulsors must generate these forces while also meeting a host of mechanical, structural, hydroacoustic, and hydrodynamic requirements. The propulsors' performance in these areas must be evaluated both analytically and through model testing during design. Even seemingly mundane design issues like how the propeller will be installed can become a critical issue if it takes too long or requires special tools.

Propulsors used for Navy programs range from the one-inch diameter model propulsors used on RHIB models for launch and recovery testing, to the more than 25-ton, 20-foot diameter propellers used to propel aircraft carriers or submarines. At model scale, propulsors are used for signature, structural, powering, cavitation, seakeeping, and maneuvering testing. At full scale, they propel our fleet in the performance of any and all desired missions.

Naval Surface Warfare Center, Carderock Division (NSWCCD), has long been at the forefront of designing propulsors for the U.S. Navy, other nations, and commercial vessels. Over the years, these designs have ranged from conventional merchant and supply ships simply interested in high efficiency to complex combatants and submarines with a myriad of performance and interface requirements for speed, signatures, vibration, weight, and service life. NSWCCD's long history of leading the development of propulsor technologies is highlighted in some of the following examples:

- Published a propeller series, which included data from 177 16-inch bronze propellers. The information was subsequently used to guide many early designs.
- Developed cavitation bucket diagrams to help predict the onset of cavitation in non-uniform inflows.
- Lifting surface corrections showed how three-dimensional effects should change the ideal angle of attack and camber of propellers, which had previously been designed using lifting-line or blade-element approaches.
- Used skewed blades to significantly reduce propeller-induced vibration and noise, while improving cavitation and performance with no loss of efficiency.
- Brought together cross-discipline experts to discover why a controllable pitch propeller, installed on *USS Barbey* (FF 1088), lost its blades in 1974. The resulting research in propeller blade loads and stresses

New CVN class propeller being installed on CVN-77.
Photo courtesy of Scott Black, NSWC Carderock Division.



Above: NOAA Fishery Research Vessel propeller operating at low pressure in the Large Cavitation Channel for cavitation visualization.
Photo by Peter Congedo, NSWC Carderock Division.

Left: DDG-51 class Advanced Technology Demonstrator (ATD) propeller on DDG-87.
Photo Courtesy of Scott Black, NSWC Carderock Division.

during maneuvers continues to influence the design of controllable pitch propellers throughout the world.

- Developed blade sections and custom blade section design philosophy for propellers leading to improved cavitation inception and thrust breakdown performance in modern propellers.
- Discovered how propellers interacted with the hull boundary layer through pioneering work on the measurement and computation of effective wake
- Provided new information to help optimize the hydrodynamic and hydroacoustic performance of designs through experimental methods of measuring a propeller's inflow in the towing tank with Pitot tubes and later by Laser Doppler Velocimetry
- Provided insight into viscous effects on propeller hydrodynamics through measurement of blade boundary layers on rotating propellers
- Used measurements of tip vortex flows from propellers as an international benchmark for the validation of viscous flow solvers.

Propulsor development is one of the areas of expertise at NSWCCD that requires contributions from all of its technical departments. While the design and testing groups that lead propulsor development reside in NSWCCD's Resistance and Propulsion Division, the interaction, integration, and complexity of propulsors require cooperation and communication with the rest of the Division's workforce.

The Carderock Division not only serves the propulsor development needs of the U.S. Navy but also those of other navies and non-military applications. The success of the National Oceanic and Atmospheric Administration's Fisheries Survey Vessel in meeting stringent international acoustic requirements for monitoring fish counts was due in part to the design of a propeller by Carderock Division propulsor experts. This propeller has low radiated noise and is cavitation free throughout its operating range.

NSWCCD hydrodynamic facilities were used for evaluating the performance of propulsors for Dutch, Korean, Egyptian, and other foreign warships. The Division has performed collaborative propulsor research and testing with universities, private industry, other laboratories, and foreign navies on topics such as delaying cavitation inception, improving performance predictions, incorporating alternative materials, and developing new propulsor concepts.

DESIGNING PROPULSORS (Continued on page 14)

DESIGNING PROPULSORS (Continued from page 13)

The Navy is always striving for more efficient, higher-speed, and quieter ships. To achieve these goals, innovative propulsors that operate as integral parts of the overall ship system are needed to maximize performance. The need to develop these propulsors resulted in NSWCCD fostering a dedicated team of analytic and experimental researchers and designers. These engineers understand the multitude of inter-relations that must be balanced to create optimal propulsor solutions for today's Navy and the fleet of the future.

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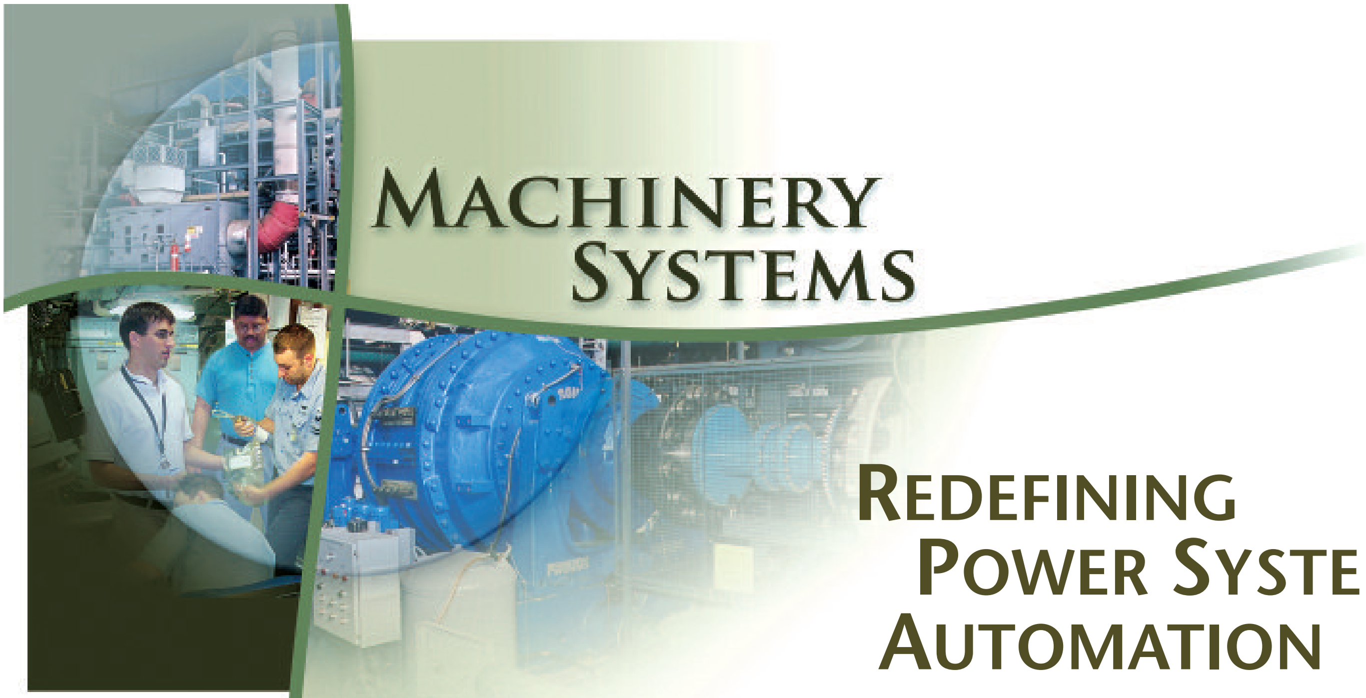


MACHINERY SYSTEMS

REDEFINING POWER SYSTEM AUTOMATION

Innovation in Electrical Power Management and Reliability

By Jason Adams and David Borowski

Automation is the buzzword for naval vessels. From boiler controls to navigation, systems offer computer-controlled operation that demands less and less human interaction. Advances for legacy shipboard electrical power generation and distribution systems, however, have been minimal. Although robust control components were always the most critical design criteria, graphical human machine interfaces (HMI) combined with a complete suite of power management functions were not available to Navy ships–leaving functional but cumbersome systems compared to today's standards.

Now, the Navy has raised the bar. Sponsored by PEO Ships (PMS 470), the Navy worked to improve the reliability of power needed to support mission critical command, control, communications, computers, combat systems and intelligence (C5I) loads. Carderock Division's Machinery Research and Engineering Department

USS Blue Ridge (LCC 19) enroute to its final stop to Shimizu, Japan, May 30 2008, ending a six-week tour in the Pacific rim area of operations.
U.S. Navy photo.

designed and installed a power management platform (PMP) aboard *USS Blue Ridge* (LCC 19)–a ship which was commissioned in 1970. By integrating and implementing comprehensive power management functions–such as zero power transfer, protective relaying, auto recovery, and precise real/reactive load sharing–with easy-to-use graphical user interfaces, PMP redefines power system automation. Additionally, PMP meets the stated original design intent of "supplying a system that enhances the ship's war fighting capabilities, allows for system graceful degradation, increases situational awareness, and reduces the operational burden imposed on Sailors during normal and casualty situations."

The LCC 19's original electric plant was comprised of six separate electrical source groups identified as #1 EDG (emergency diesel generator), #2 EDG, #3 SSDG (ship's service diesel generator), Alpha SSTG (ship's service turbine generator), Bravo SSTG, and Charlie SSTG. The turbine and ship's service diesel generators make up a ring bus, while the two emergency diesel generators are radial connections off the main bus. The electric plant control console provides for only the SSTGs with no means to integrate or automate. This causes plant management to be awkward and cumbersome under casualty conditions, with little room for system graceful degradation. The previous control system's ability to automatically react to a casualty or electrical fault was non-existent. Minor casualties in the system often cascaded and resulted in not only a loss of electrical power to vital C5I loads, but an unacceptably long period of time to restore electrical power.

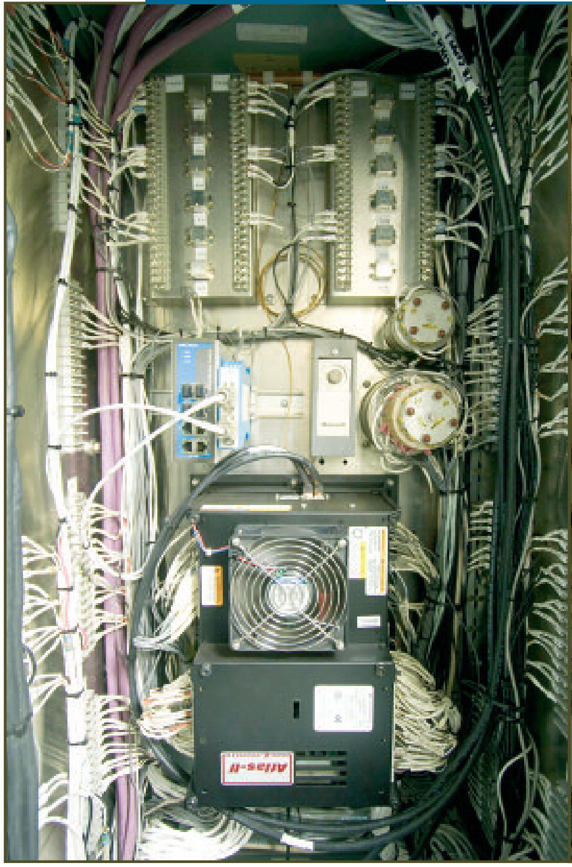
Below: This SSDG is monitored and controlled by the PMP both locally and remotely.
Photo by Jason Adams, NSWC Carderock Division.

Right: *USS Blue Ridge* (LCC 19) homeported in Yokosuka, Japan.
Photo by Jason Adams, NSWC Carderock Division.

Six PMP units were co-located with their associated ship's generators and switchgear. One PMP was placed in each of the emergency diesel spaces, one was placed in the ship's service diesel space, and three were placed in the main engineering space; one for each SSTG. Each PMP is powered by two vital 115VAC and a redundant 28VDC bus and shares all of its data and control capabilities with every other PMP aboard the ship over dedicated, redundant fiber optic, peer-to-peer pathways. This design topology creates a physically distributed, virtually centralized electric plant control system that enables the entire electrical power plant to be controlled from any generator location under varying casualty situations, while maintaining the full stand-alone capability of each source group.

Comparing new to old is shocking. For example, if A and B turbine generators are carrying the entire ship's load and an operator wanted to bring the #3 ship's service diesel generator into play the following would occur. The operator would walk down to the #3 SSDG space and start up the diesel engine. Once the engine was brought up to speed and creating power, the engine speed would have to be manually adjusted (up or down) until both source groups were synchronized. Then the operator would be required to close the breaker to finally bring the SSDG onto the ship's bus. On the new PMP system, an operator in any of the generator spaces can press the button for the "3SSDG" on the main screen and then press "RUN WITH LOAD." The engine start sequence, speed synchronization, and operation of the breaker will

REDEFINING POWER SYSTEM (Continued on page 16)



Above: The Sailors' electric plant situational awareness was very limited with the analog electric plant controls providing basic SSTG only information prior to installation of PMP.

Left: The main Enclosed Operating Station now has one unit with two redundant touch screens providing complete situational awareness and control of all machines (SSTGs-SSDGs) and switch gear covering entire electric plant.

Far Left: With a PMP rear panel removed, the brains of the system are exposed.

Photos on this page by Jason Adams, NSWC Carderock Division.

REDEFINING POWER SYSTEM (Continued from page 15)

occur remotely and automatically, saving precious time in a casualty situation.

LCC 19 Electrician's Mate Master Chief James Burke, who was instrumental in coordinating the PMP installation with COMSEVENTHFLT, provided direct assistance and valuable insight during the design, testing, and shipboard training of the new system. He commented on both the installation and testing, stating "*I personally have never experienced a project of this magnitude in my career. Six planned power outages were scheduled over the course of a year with COMSEVENTHFLT battle watches being shifted for a total of eight days. Other than that, it was business as usual for staff. I can equate this project to re-wiring a 10-story building while keeping the lights and televisions on and the phones working. A total of 10 seconds of power downtime was seen during testing that was not planned (return from sea trials), a remarkable feat considering the scope of this project. Marine turbine history was made January 15 (2008) as three steam-driven turbines were paralleled with shore power all by the press of a button. The ship paralleled back and forth with shore power with combinations of all six generators 10 times that evening. The ship's electrical control system works as advertised. 'Power Reliability' has definitely been improved as triple redundancy is now provided to critical C5-I loads on Load Centers 22 and 42, dedicated 60-Hz and 400-Hz loads on the forward and aft IC switchboards. Uninterruptible power supply battery backup is now provided to Crypto Room, UHF/EHF Radio Room, WSC-6, and WSC-8.*"

The LCC 19 installation was completed in January 2008. The ship deployed that same month and is currently enroute to her homeport having accumulated four months of successful underway operation with the new PMP system. Engineers from Carderock Division will be returning to the ship to review equipment status and to obtain crew feedback for their experience with the installed electrical plant hardware and operation of the PMP system.

Below: Each diesel generator has one PMP mounted next to its respective switchboard. Pictured is the #1 EDG PMP.

LCC 19 is not the only ship to benefit from the PMP's capabilities. Starting in the fourth quarter of 2008, the electric plant controls on LSD 41/49 Class ships will be upgraded with a PMP system as part of the Mid-Life Upgrade Program. The existing, cumbersome system will now feature full monitoring of diesel engine and generator operational parameters and true automatic synchronizing across all distribution and shore power breakers. It will also provide for interface to the machinery control system (MCS), along with a multitude of other features that will enhance war fighting capabilities. PMP, like the system installed on LCC 19, will allow for electrical plant/system graceful degradation, increased situational awareness, and reduced operational burden on ship's force. MCS will receive all the data points of the power system, as well as provide control requests to power system equipment. The design provides for multiple levels of fail-safes by using dual fiber optic peer-to-peer communications, multi-managed breaker control from individual PMPs, and local PMP HMIs and switchboard controls.

All ship classes can and will benefit from the capabilities provided by PMP. The PMP system redefines the foundation of power system controls and maximizes the performance and reliability of any shipboard power system. The automated features of PMP provide significant benefit to the ship that will be realized during normal steaming and especially during battle conditions/casualty mitigation. PMP has breathed new life into shipboard power generation and distribution systems. The PMP installed on LCC 19, as well as the system planned for installation on LSD 41/49 Class ships has become the new standard of excellence.

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MACHINERY SYSTEMS

USS RONALD REAGAN MACHINERY CONTROL SYSTEM

Unique Design Addresses Long-Standing Rudder Concerns

By David Reed and Bart Kleczynski

Since *USS Ronald Reagan's* delivery into the Navy fleet, the carrier has experienced chronic problems with control and monitoring of some of its machinery. Processing the rudder position is one of the most visible. Because this was the first carrier with an all-digital propulsion/navigation system, different methods for indicating rudder position were used than on previous carriers. During the *Reagan's* recent phased incremental availability (PIA), an overhaul and redesign of several machinery control and navigation elements occurred. This article chronicles some of the decisions made during a rather unique design process which successfully addressed many long-standing concerns of the ship.

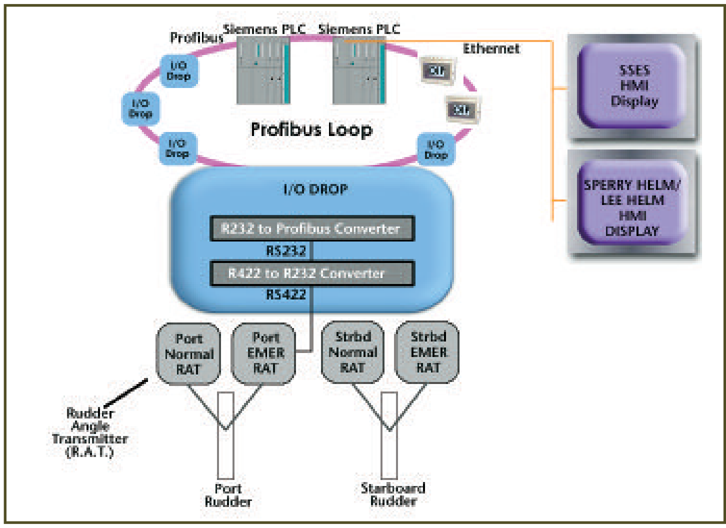
USS RONALD REAGAN (Continued on page 18)

USS Ronald Reagan (CVN 76) makes a high-speed turn, which was made possible by architectural changes to the ship's machinery control system. *U.S. Navy photo.*

USS RONALD REAGAN (Continued from page 17)

The original system, known as DDCN, combined the Machinery Control System (IC/SM, JP5 fuels, other DC monitoring and control) with the Navigation Network. This system was vastly complex in size and function compared to any previous control system. The system's cornerstone was four servers designed to communicate with all the PC control stations on the ship, as well as communicate with the programmable logic controllers (PLCs) which provided the smarts to monitor and control a 6000+ signal system. The stability of these servers and the architecture of the PLC and input/output (I/O) system caused a stream of CASREPs and HASREPs, which led to a permanent ship rider from Naval Surface Warfare Center, Carderock Division, Ship Systems Engineering Station (NSWCCD-SSES) embarking on *Reagan's* every underway.

Commonly, this ship rider would be called to the bridge to watch the helmsman, sometimes for hours at a time, due to problems with the way rudder position was being reported. It might lag its ordered position by 10 seconds or simply flip from left 30 degrees to right 30 degrees for no reason. The performance of the rudder was enough of a concern that in one instance, a replenishment at sea (RAS) was aborted.



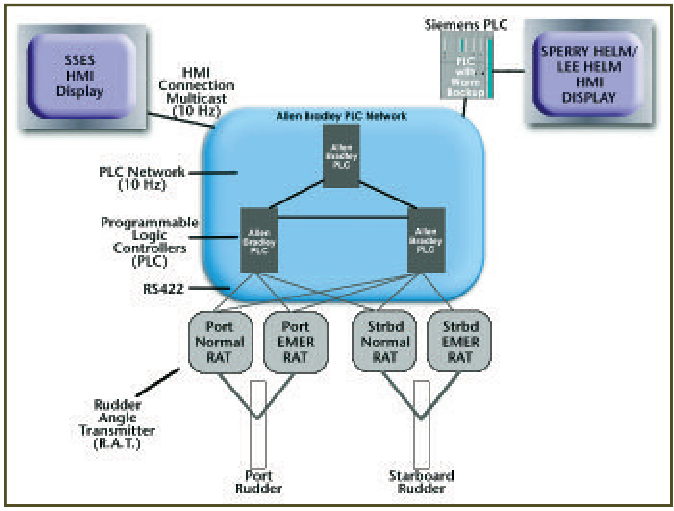
Pre-November 2006 Rudder Design.
Graphic provided by David Reed, NSWC Carderock Division.

The delivered control system provided little redundancy with the rudder feedback system. Each of the carrier's four rudder angle transmitters (RATs) was wired through two signal converters into separate I/O enclosures located throughout the aft portion of the ship. These I/O enclosures were organized and connected together in a Profibus "ring" topology, which caused inadvertent and frequent loss of data. A major weakness of this architecture is that multiple "breaks" within the ring can cause a loss of communications between components. With the *Reagan's* Profibus rudder angle system, this weakness created a risk that upon ring breaks the rudder signals would be cut off from the PLCs which processed them. (Please refer to the pre-November 2006 rudder design diagram on previous page).

The PLCs that processed the rudder data worked in a "warm backup" configuration. This is a custom original equipment manufacturer (OEM) software configuration that provides a level of redundancy in the smart layer of the system. These PLCs would then forward the data to the helm computer over ethernet where the rudder was controlled. The problem, inherent to this warm backup system, was that false failures were sensed by the PLCs all of the time. The PLCs would constantly take control from one another creating momentary outages at the helm.

In several of the design reviews held at NSWCCD-SSES, it became apparent that the navigation subsystem demanded a higher performing system than MCS. A separate network was created for the navigation system, and a new set of PLCs was dedicated to navigation signal processing, of which the shipwide rudder angle displays were paramount.

Early in the design process, it was found that there were insufficient resources to reengineer and recertify the proprietary ship control console (SCC) and steering control system (SCS) in time for the CVN 76 phased incremental availability (PIA). Engineers from NSWCCD-SSES's MCS (CVN and New System Development) Branch and Navigation Systems and Integration Branch worked together to determine that the existing interfaces to the helm would remain in place until a replacement system could be developed. This meant that the scope of the project would keep the existing Siemens PLCs which fed the helm. These PLCs would still communicate to the helm, but everything else about them could be changed, along with everything else between the PLCs and the rudder.



Post-November 2006 Rudder Design.

Graphic provided by David Reed, NSWC Carderock Division.

To handle the rudder/navigation signals, a design for three Allen-Bradley (AB) PLCs was established. Instead of using a remote I/O configuration found in the earlier design, each PLC was treated as a separate processing point, existing in the field I/O enclosure and sharing its local inputs and outputs with the other PLCs in the navigation group. One PLC was installed in the island area of the ship, and the other two were placed in the two after steering rooms. Instead of tying each RAT to a different I/O drop, all four RAT signals were brought in to both aft steering PLCs. For added signal redundancy, each PLC was also dual-homed to two different network switches.

The RAT signal/network interconnections and inter-PLC messaging required a method of establishing one set of valid data to send to the helm. To accomplish this task, one of the PLCs would have to become a master data aggregator for the group. Through engineering design methods, such as fault analysis and Karnaugh Maps, a rank-in-order master logic algorithm was developed for the PLCs. At full system health, the lowest numbered PLC would take mastership, while the other two PLCs would act as data providers and monitor the health of the master PLC. If the master PLC loses connection to the network (through a double failure of its network cards), the second-lowest PLC becomes the master. To avoid any possibility of multiple masters, the master PLC will relinquish its role if it cannot see any other PLCs on the network. The rudder signal selection algorithm was also designed for the master PLC to use its local RAT signal connection, unless it calculated a problem with it. Then, it will use the rudder data from the other PLC (always available through the inter-PLC messaging). The master PLC would then relay all of its data to the Siemens PLCs.

For network messaging, user datagram protocol (UDP) multicast was selected as the method of choice for several reasons. First, because of the higher network traffic rates, UDP uses less packets than transmission control protocol (TCP) to convey the same data over the wire. The trade off in choosing UDP, is that the message sender has no confirmation the recipient received the message. Testing proved that one or two missed packets

USS RONALD REAGAN (Continued on page 20)

USS RONALD REAGAN (Continued from page 19)

will not affect the visual performance of the helm (the rudder or any change in data occurs very slowly). The second reason for using multicast is its subnet-independence. A message sent on one of the PLC's network modules will reach all ethernet interfaces on all PLCs, and every message will be received. This gave the system even more redundancy.

The UDP messaging implementation was then extended to the interface between the Allen Bradley and Siemens PLCs. A standard messaging process was developed which would allow the Siemens PLC to write data to the AB PLCs and vice versa. This was achieved using defined UDP message formats and rates, along with the appropriate routines to handle errors in communication and casualty states where some PLCs might no longer be present on the network. With months of laboratory testing, this interface between two very different and proprietary systems was made seamless.

One of the driving requirements from the start was to create a PLC design that would be simple to maintain and troubleshoot. To achieve this, all the PLC enclosures were designed with the same hardware, and one software program was developed that could be loaded on all three PLCs. The program keyed off of the PLC's IP address, the only difference between PLCs, to determine which unit it was in the mastership process. Furthermore, the code is stored on a flash card inside the PLC module, which allows easy replacement of CPU modules, with no need for extra configuration by the Sailor. This makes configuration control, as well as maintenance, very easy on the operator. It also extended great benefits during code development and testing (since changes only had to be made to one project file).

For maintenance and troubleshooting, a web-server-capable PLC hardware was chosen. This allowed for the development of a PLC-based web page, containing many PLC diagnostics. The PLC's web page can be accessed from any PC on the network and displays current PLC configuration and status, the state of all the hardware modules in the PLC rack, and the PLC's communication/mastership status with the other PLCs in the group. A troubleshooting database was later added to the web page. Upon any fault in the network, the web page would display in plain English, what the different faults mean, how they affect the system, and how to troubleshoot to correct the problems. The web page source-code, like the PLC program itself, is also stored in only one file.

Major changes were also made to the Siemens PLC, which remained from the old system to keep the helm interface the same. All MCS functions, including the communication rings of I/O and messaging to the data servers, were removed. Code was stripped down to the bare minimum, to perform solely the task of translating the Allen-Bradley PLC multicast to the helm message and vice-versa. Because the PLC no longer had to perform any task of hardware management or control code, all of its resources could be allocated to the communications processing. Implementing this via UDP created very impressive throughput. The PLC could process more than 100 messages a second, and this extra step between the AB PLCs and the helm only added 100ths of a second to the rudder signal's total time in transit.

With all of these changes in place, *USS Ronald Reagan* underwent a very successful sea trial. These design changes, along with many others to the MCS and navigation systems, created a stable, maintainable system.

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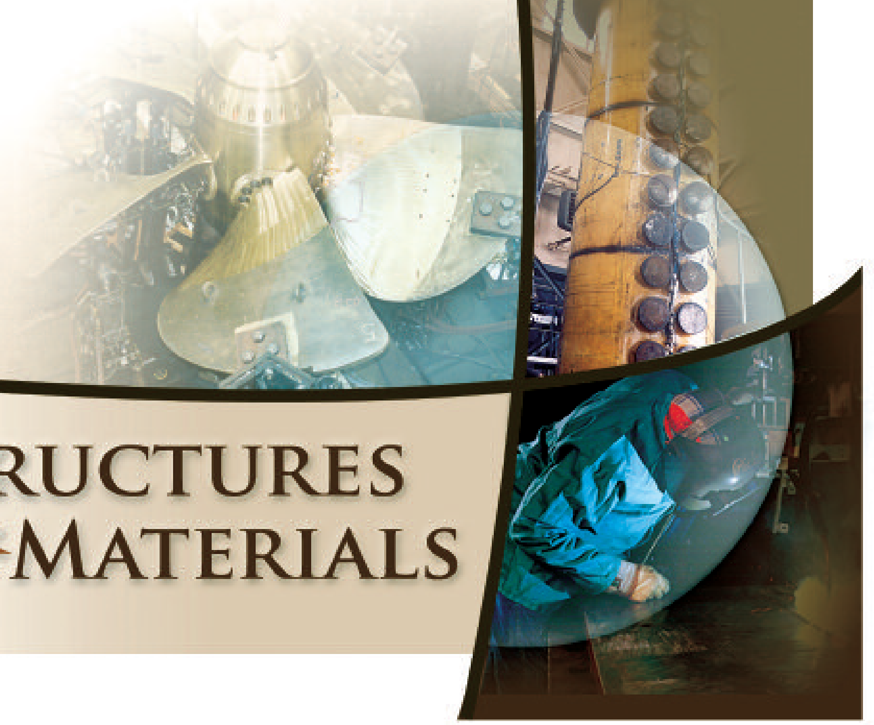
The *Nimitz*-Class aircraft carrier *USS Ronald Reagan* (CVN 76) makes a turn after the completion another cycle of flight operations.
U.S. Navy photo.

SWEATING THE SMALL STUFF

Sticking Manual Valves Can Threaten SUBSAFE Systems



STRUCTURES & MATERIALS

By
Leslie
Spaulding

In the 688 Class submarine a valve problem surfaced in the hydraulic system, which could pose safety problems if not addressed. Originally thought by ship's force to be the valves, themselves, the valves were replaced at a considerable cost to the fleet. But the new valves soon began to stick as well. Naval Surface Warfare Center, Carderock Division Ship Systems Engineering Station (NSWCCD-SSES) engineers were called in to resolve the issue.

Entering an availability, ship's force aboard *USS Louisville* (SSN 724) reported the sticking valve issue. A manually operated valve is considered to be "sticking" when excessive force is required to operate the handle on the valve. Each sub's hydraulic system has approximately 210 control valves. The hydraulic system aboard the 688 Class is the ship's life force. It is used to operate everything—steering system, mast, antenna, diving system, etc. Over time hydraulic control valves have increased in cost and range in price from $25K to $250K. The overhaul of a valve could run $10K to $15K. Simply replacing or repairing the valves is costly and is not guaranteed to resolve the issue.

Fully inspecting the valves, SSES engineers determined that the issue was not with the valves and suspected that the problem would probably be found in the oil. The oil was found to be releasing gas (or off-gassing). Entrained gas and gas pockets can impact valve performance.

"This discovery opened some eyes," remarked SSES engineer Erin Murcko. "We began wondering if other ships in this class or elsewhere in the fleet were having this problem. Information began trickling in that indicated the problem may be affecting other ships within the 688 Class as well."

With 46 ships remaining in the class, this oil issue must be addressed. The issue resulted from a change in Navy maintenance philosophy. In the early years of 688 Class service (1960s to 1970s), each submarine completed an overhaul every eight years. During that overhaul, the hydraulic system would be completely dismantled and refurbished, and the oil would be replaced at that time. The first few ships of the class went that route. Due to the expense of this process and with maintenance dollars dwindling, the Navy determined in the early to mid-1990s that a "fix when fail" philosophy toward maintenance was a better approach–replacing complete

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SSN 724—*USS Louisville* docked.
U.S. Navy photo.

SWEATING SMALL STUFF (Continued from page 21)

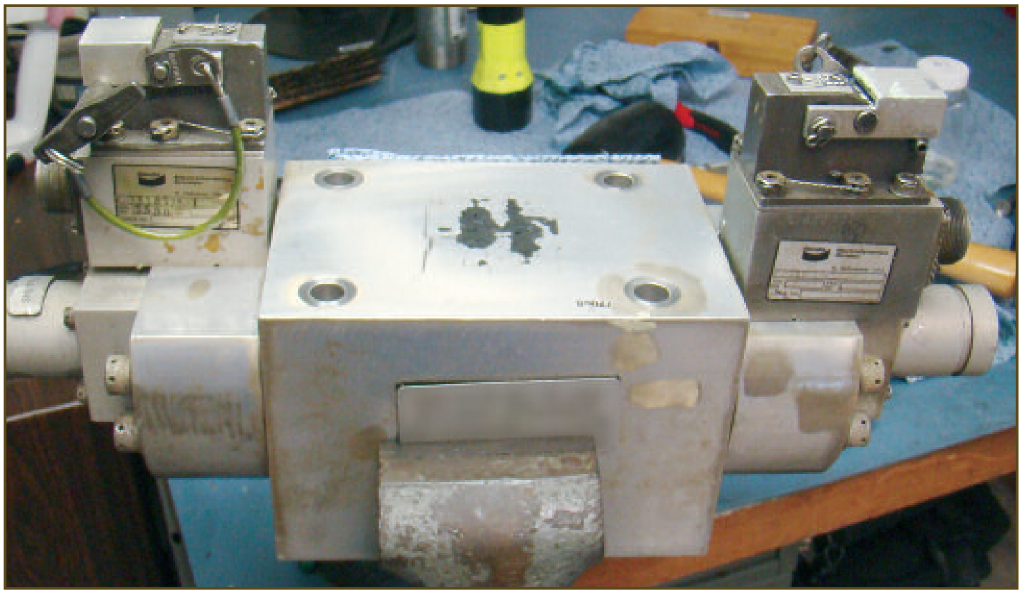
overhauls with depot modernization periods during which systems were upgraded.

Although the oil has been "topped off" or replenished over the years, the sub's hydraulic system had not been fully cleaned nor the oil totally replaced. "Some of the oil may have been there for 10 years or more," explained SSES engineer Ed Walling. "Oil just doesn't last that long. It begins to degrade." This degradation is not so easily detected.

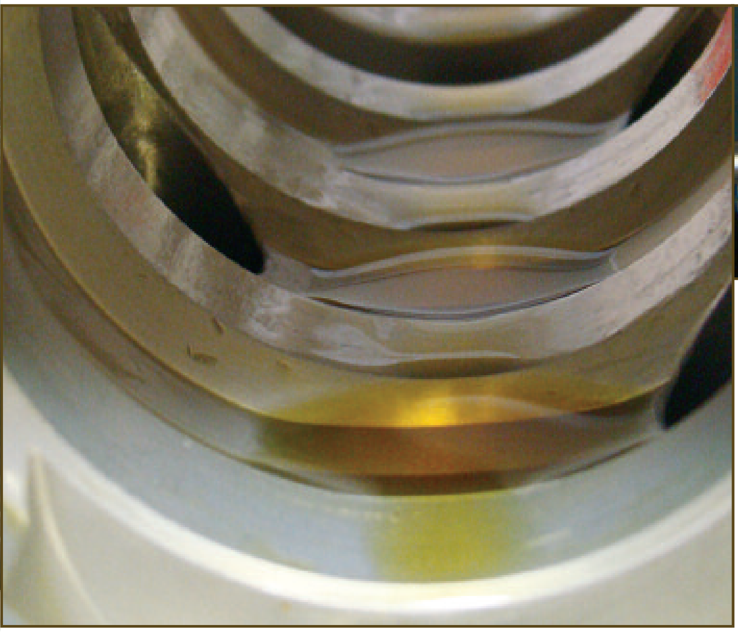
It's important to note that the degraded oil does not damage the valves, or any other equipment, but it appears to be causing the valve handles to stick during manual operation. When a valve sticks, the operator must put greater than normal force on the handle. For hydraulic control valves that are within SUBSAFE systems, which use pilot actuation rather than manual lever actuation, NSWCCD-SSES requested that fleet operators report on sticking valves. Although there have been no reports to date of pilot operated valves failing to operate in a manner that adversely impacts the timing of the SUBSAFE flood closure system, the criticality of these systems requires reporting of this information.

To resolve the problem, *USS Louisville* underwent a complete hydraulic system hot oil flush, and the oil is being replaced. Due to the unplanned nature of the work, the cost for this "fix" was more expensive. It also impacted the ship's initial availability schedule. With the problem now identified in the fleet, SSES engineers are exploring the possibility of incorporating routine oil changes during maintenance periods. Given proper planning, the cost and impact to ship's schedule can be reduced.

"When you need that system, it has to work now," explained Walling. "There is no time to work the sticking out–the system is needed immediately to ensure the ship's safety and the safety of its Sailors. It is more



Right: Showing a solenoid operated hydraulic control valve.
Photo courtesy of Erin Murcko, NSWC Carderock Division.



Above: Slide and sleeve assembly–the internal moving components of the valve.

Left: Internal view of the valve body.
Photos courtesy of Erin Murcko, NSWC Carderock Division.

than just a little problem, and ship's force needs to understand the importance of reporting it."

To this end, NSWCCD-SSES is developing a class advisory which will inform the hydraulic system operators in the fleet about the problem. Sailors will be required to report all sticking valves. There is a tendency to just "live with the problem" and manually work the valves. Resolution of this issue is beyond the scope of ship's force ability. The sticking valves indicate oil degradation, which requires oil replacement at the next major availability. SSES is also looking at the possibility of using a "bleed and feed" procedure on ships not scheduled for availability in the near term. Using this procedure, a large portion of the old oil could be bled out and new oil fed into the system. It was recently implemented on *USS Key West* (SSN 722), which is not due for a major availability for two years.

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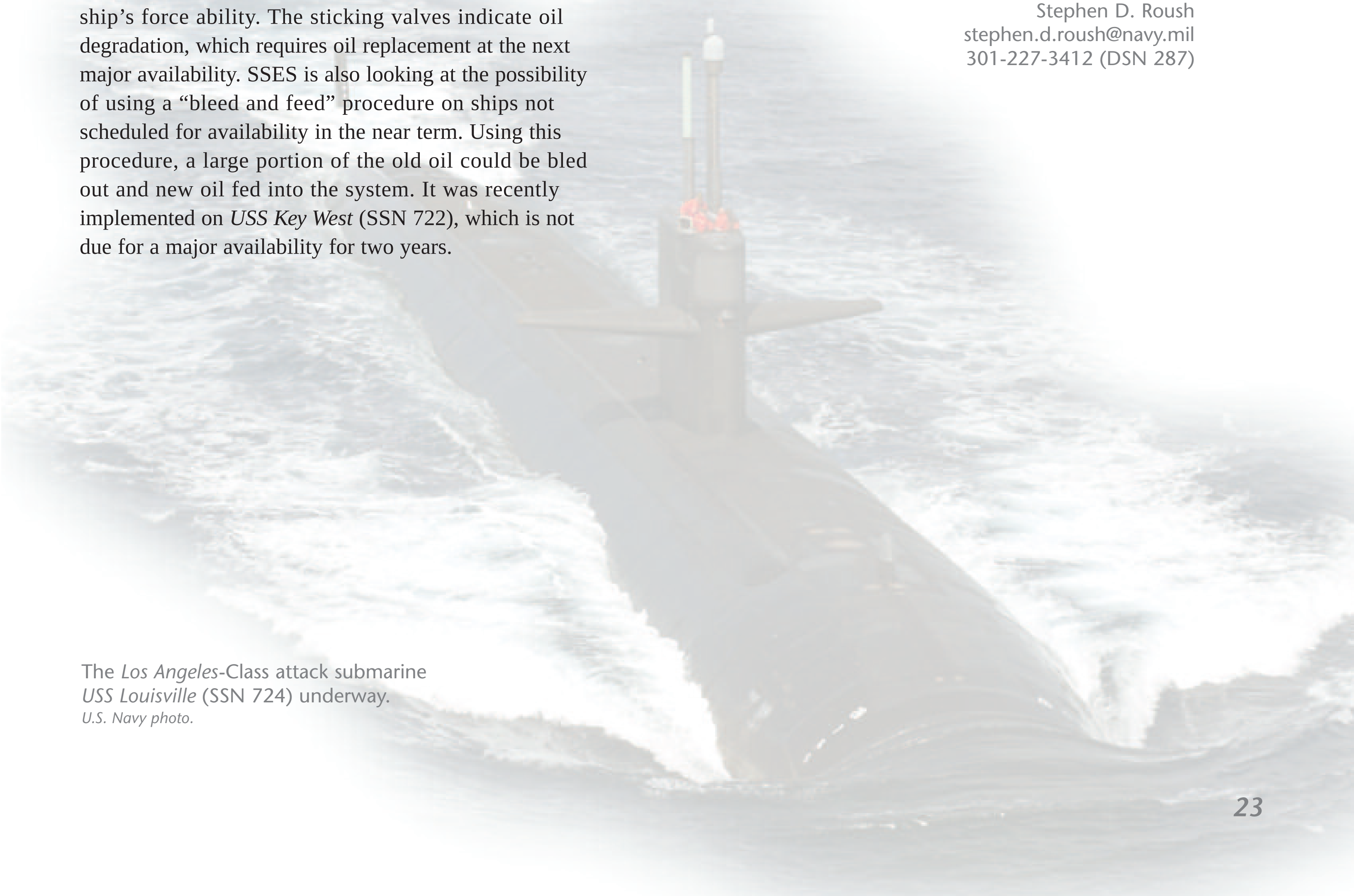

The *Los Angeles*-Class attack submarine *USS Louisville* (SSN 724) underway.
U.S. Navy photo.

ENVIRONMENTAL QUALITY SYSTEMS

ENVIRONMENTAL STEWARDSHIP

Minimizing the Navy's Impact on the Future through Smart Acquisition Decisions

By Leslie Spaulding, Mary Jo Bieberich, and Dr. Scott Sirchio, Ph.D.

To ensure that the Navy's newest ships operate in an environmentally responsible manner, scientists and engineers from the Naval Surface Warfare Center, Carderock Division (NSWCCD), are working closely with Program Executive Offices and shipbuilder design teams during all phases of acquisition. They manage the execution of the environmental protection, safety, and occupational health (ESH) planning and systems engineering efforts for several of the Navy's major ship acquisition programs, including, the Guided Missile Destroyer (DDG 1000), Mobile Positioning Force, Future (MPF(F), and the LHA 6. These programs are building mission-tailored ships designed for interoperability with the maritime military services, the joint forces, and international partners to provide the highest level of security possible.

NSWCCD's ESOH managers lead integrated product teams and working groups; draft programmatic documentation; develop and implement environmental

From left: The guided missile cruiser *USS Princeton* (CG 59), the Military Sealift Command (MSC) fast combat support ship *USNS Bridge* (T-AOE 10), and the nuclear-powered aircraft carrier *USS Nimitz* (CVN 68) perform a connected replenishment at sea (CONREP) for transferring fuel and supplies.
U.S. Navy photo.

protection and pollution prevention strategies; assess feasibility of new waste management and treatment technologies; review contract deliverables and design documents; and identify ESOH risks and risk mitigation strategies. With a more global approach, the ESOH managers' mission will enable ships of the future to meet the challenges of new operational concepts as articulated in "*A Cooperative Strategy for 21st Century Seapower*," which can be found on-line at www.navy.mil/maritime.

The Division's ESH managers also focus on hazardous material reduction and material substitution related to the design and construction of new ships. In that vein, the environmental managers work with shipbuilder design teams to minimize or eliminate hazardous substances, thus, keeping the ship compliant, making it more environmentally friendly, as well as safer for shipboard personnel.

As good stewards of the environment, the Navy has developed a list of chemicals for acquisition programs that is used to prohibit and control hazardous substances throughout the ship's life cycle. For example, on the DDG 1000, one effort has focused on eliminating the use of cadmium, a known carcinogen, which is on the "Prohibited List." With the endorsement of the design team, the ESOH manager was able to recommend an effective alternative material. The recommendation was incorporated into the design, and today, a new, technically acceptable, but less hazardous, material is replacing cadmium aboard DDG 1000.

Standardization and consolidation are other means, in addition to substitution, of reducing the number and types of hazardous materials. This approach has a significant and direct impact on storage and disposal of hazardous materials throughout the lifetime of the ship.

The ESH managers work with their corresponding design teams to identify and mitigate system safety and occupational safety hazards throughout each phase of acquisition. Risk assessments are performed in accordance with MIL-STD-882, System Safety Practices. Once mitigations are implemented, the residual risk is assessed for acceptance by the appropriate naval authority. For example, when considering noise control aboard DDG 1000, the team has assessed each manned space in the ship to ensure that the cumulative noise does not exceed the allowable limits for that space. A major contributor to shipboard noise can be a poorly designed, constructed, or operated ventilation system. A ventilation system can contribute significantly to shipboard noise, but with proper control and monitoring during construction, these contributions can be reduced dramatically, allowing the crew to communicate efficiently and effectively while underway.

Other concerns, important to ESH managers, center on international conventions and agreements that protect marine mammals and migration patterns of certain birds. One such concern involves the testing and evaluation of new radar, sonar, gun, and missile systems. Without proper planning in testing, these systems can have a significant impact on the surrounding environment. The U.S. Navy is committed to proper planning, and execution under the appropriate test conditions, which minimizes environmental impacts and allows the Navy to conduct business with applicable environmental laws, regulations, and permits.

As these examples demonstrate, the goals and responsibilities of the Division's ESH managers are many, but consistent. "Ultimately, we're making it safer for our Sailors, and friendlier for the environment," explained Dr. Scott Sirchio, DDG 1000 ESH manager. "We, the Navy, lead the maritime industry in environmental compliance, ensuring that our ships are welcomed in all ports of the world from an environmental standpoint. Sustaining Navy readiness, while protecting the environment, is critical. We have the enormous responsibility of designing our ships to be safer to the environment and to the Sailor."

Communication is the key to effectively reducing a ship's impact on the environment. The ESH managers for each acquisition program share their efforts and findings with one another for standardization of best practices. They interact with Naval Sea System Command's Technical Warrant Holders and NSWCCD's in-service

ENVIRONMENTAL STEWARDSHIP
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ENVIRONMENTAL STEWARDSHIP (Continued from page 25)

engineers, to better understand the environmental issues facing today's fleet, with the intention of solving these problems for future ships. ESH managers also work with acquisition representatives in the Joint Services, sharing findings and accomplishments that help minimize DoD's footprint on the environment.

NSWCCD ESH managers are working in concert with the U.S. Navy's acquisition community to enable the fleet of the future to meet the global operational objectives outlined in "*A Cooperative Strategy for 21st Century Seapower*," with minimal impact on the environment.

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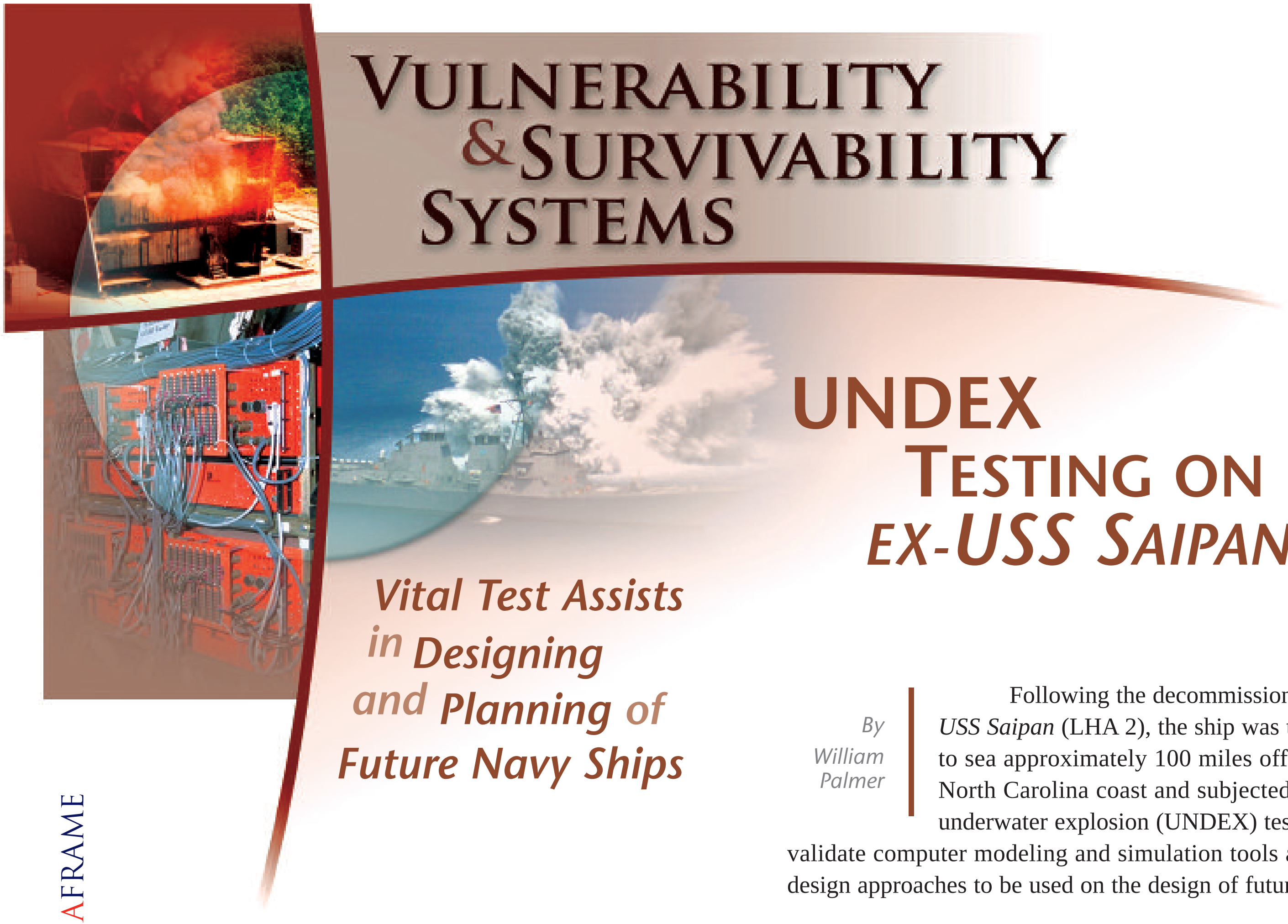


VULNERABILITY & SURVIVABILITY SYSTEMS

UNDEX TESTING ON EX-USS SAIPAN

Vital Test Assists in Designing and Planning of Future Navy Ships

By William Palmer

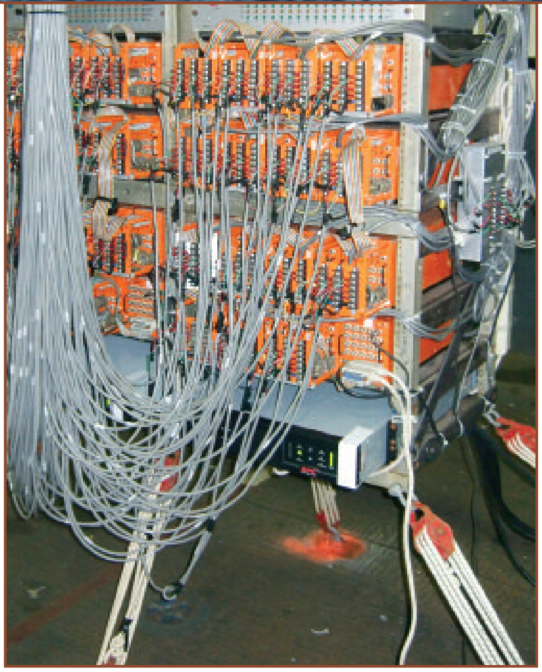
Following the decommissioning of *USS Saipan* (LHA 2), the ship was towed to sea approximately 100 miles off the North Carolina coast and subjected to underwater explosion (UNDEX) tests to validate computer modeling and simulation tools and design approaches to be used on the design of future ship

Top: Ex-*USS Saipan.*
Photo by Steve Rutgerson, NSWC Carderock Division.

classes. Carderock Division personnel led this test effort, which included managing test operations, instrumenting the ship with an array of sensors to record its response to the tests, and conducting modeling and simulation analyses and design studies.

Several analysis tools and methods were employed in conjunction with this test series. The most detailed of these studies included using the Dynamic System Mechanics Advanced Simulation (DYSMAS) analysis code to model the response of the entire vessel to the UNDEX. Detailed analyses to determine the validity of current design procedures were also carried out using NASTRAN, an acronym for the structural analysis modeling code developed by NASA.

From a data acquisition perspective, these tests were a major success. A total of 315 data channels measured acceleration, velocity, strain, and pressure. Test personnel reported that 99% of the channels were viable through the test (considered a phenomenal success in UNDEX testing). Over 12 miles of cabling, sensor data were fed to self-contained digital data recorders, which were controlled via a wireless Ethernet network from a remote vessel at a safe distance from the UNDEX. The ex-*Saipan's* masts and superstructure were instrumented, as well as the helicopter hangar, the main deck, and several locations below decks. Within three to four hours after each test, Carderock Division personnel completed all processing data and provided it to analysts.



Above: Data acquisition equipment.
Photo by Bill Wolfe, NSWC Carderock Division.

Ten seconds of data were recorded. (Although the most critical responses from the events occur within about two seconds, responses from most items reacting to the force of the UNDEX have dissipated after that point in time). Each test accumulated approximately 315 megabytes of time series data. At this time, validation testing has been completed, and although analysis is still ongoing, personnel agree that the model predictions have been confirmed by these tests.

UNDEX TESTING (Continued on page 28)

Below: Shock test of Ex-*USS Saipan* plume shot.
Photo by Rebecca Buxton, NSWC Carderock Division.

UNDEX TESTING (Continued from page 27)

Another major achievement was that the UNDEX test group executed the test expeditiously. Work on ex-*Saipan* was done in two phases. The first phase was performed immediately as the ship was being decommissioned in April 2007. The second phase was performed during the final preparation stage at Moorhead City, N.C., which required approximately six weeks to complete. Total time from decommissioning to completion of testing was approximately three months, a major record in the conduct of an UNDEX test. The results from these tests are already being used to update Navy design procedures and to assess several survivability aspects which can be applied to both current and future ship designs.

The ex-*Saipan* test signifies that Carderock Division, using leading edge technology in conjunction with efficient use of available resources, maintains its edge in the world as a leader in naval architecture and marine engineering.

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SIGNATURES, SILENCING SYSTEMS, & SUSCEPTIBILITY

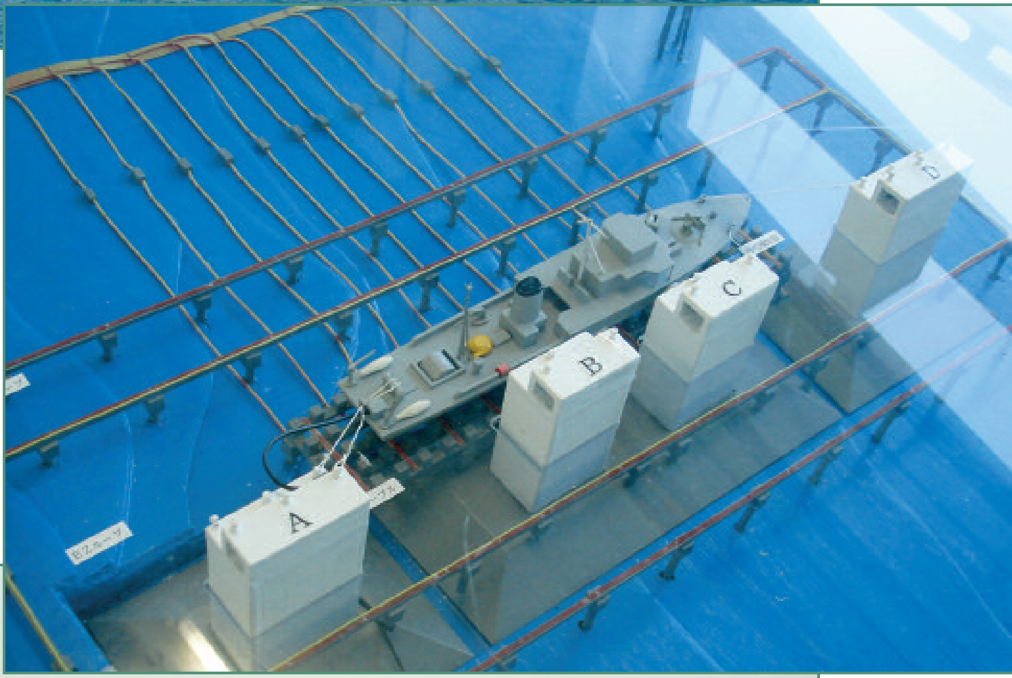
SUPPORTING THE MINE COUNTERMEASURES FLEET

United States/Japan Collaborate on Degaussing Solutions for MCM Class Vessels

By William Palmer

Carderock Division personnel conducted mine countermeasures (MCM) magnetic stray field measurements, eddy current measurements, and a degaussing system calibration earlier this year at the Japan Maritime Self-Defense Force (JMSDF) Electromagnetic Roll (EMR) facility at Yokosuka, Japan. The Navy has a joint agreement with JMSDF to use their EMR facility, which is collocated with the JMSDF deperming facility and alongside the

Above: *USS Patriot* (MCM 7), an *Avenger* Class mine countermeasures ship, is pushed into place at the deperming station in Yokosuka harbor.



Right: A model representation of the Japanese Electromagnetic Roll (EMR) system at Yokosuka.

Below: The arrangement of the EMR system mooring pylons. Ships are pushed against the pylons, then the steady state, dynamic, and eddy-current magnetic fields are measured.

Photos on this page provided by Dominic Prunesti, NSWC Carderock Division.

MINE COUNTERMEASURES (Continued on page 30)

MINE COUNTERMEASURES (Continued from page 29)

Navy-operated joint use magnetic silencing range in Yokosuka. The personnel also participated in validating facility upgrades and enhancements.

At the Japanese facility, MCMs are positioned over a dense bottom-laid grid of electromagnetic sensors and a coil system to simulate ships roll to generate the eddy currents and to sense stray magnetic fields. The magnetic fields produced by the stray fields and eddy currents were measured over this grid.

Dominic Prunesti, one of the Carderock Division investigators who oversaw the degaussing efforts in Japan, said the dense sensor grid allows for calibration of the more complex degaussing system of MCM ships. “On the MCM ships,” he said, “you have a wooden hull, so you can magnetically ‘see’ all the individual ferrous and conductive objects onboard. There is a triaxial coil system around each major individual object for magnetic compensation.”

Although sensor and data acquisition software were not changed out, three computer systems were replaced with a single faster computer which saved equipment cost, although the software needed reconfiguration by Shimadzu, the original equipment manufacturer vendor. The new computer could also accommodate several data acquisition processes which formerly had to be performed separately. Even though the Navy is in partnership with the JMSDF, signatures of Navy vessels stored on this computer are protected by physically transporting the computer to secure Navy facilities when not being operated by U.S. personnel at the facility. A second computer is planned to be installed and tested as a backup system.

Carderock Division personnel made three trips to the facility over a period of a year and a half. Although most features of the facility are modernized, determination of induced magnetic fields is currently accomplished by very basic methods. Analysts say the facility’s software appears to have the capability to conduct such an analysis, and they anticipate that with future tests the Japanese and U.S. personnel will learn how to exploit these features in the software. The personnel who went to the facility gradually learned that it is designed to conduct eddy current measurements only and were successfully able to drive the facility coils to conduct induced magnetic field measurements.

The Carderock Division team’s Japanese language skills were non-existent, which made the assignment difficult. After working through schematics and system drawings and noting cause-and-effect responses, the U.S. technical team obtained an understanding of facility operations and the JMSDF personnel understood what the U.S. technical team was trying to accomplish.

American operators found that the facility processes magnetic field data differently. U.S. EMR systems perform digital signal processing, whereas the Japanese EMR system measures multiple magnetic components and then applies analog signal gains to each measurement channel. “We had the ship in the slip,” said Prunesti, “and did eddy current measurements. We could no longer do any of our induced measurements because their system applied gains with no way to back them out.”

As a result of Carderock Division and JMSDF efforts, the mission was successful, with the MCM’s signature levels adjusted to within applicable OPNAV requirements. Partnering with the JMSDF, Carderock Division is able to support MCM ships homeported in Japan. In addition, this collaboration helps the Navy engender best practices and lessons learned with our allies.

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TECHNOLOGY & INNOVATION

A NOVEL PROPULSION SYSTEM FOR UNMANNED UNDERWATER VEHICLES

An Idea to Enhance Present-Day Unmanned Vehicle Designs

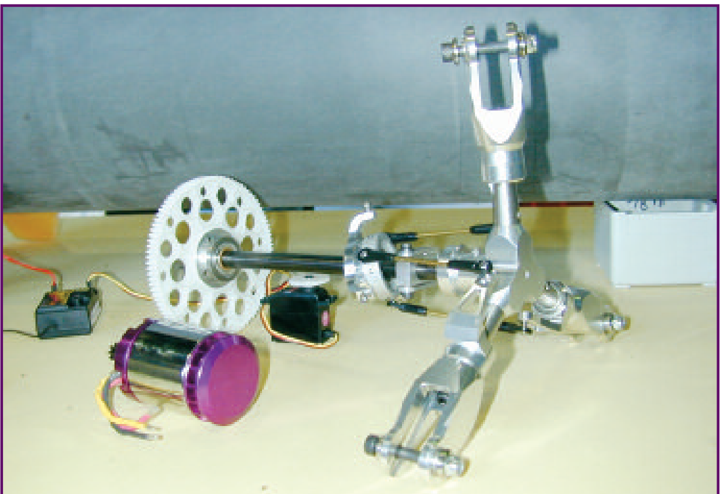
The autonomous vehicle with the Haselton propulsion system, which underwent testing recently.

By Dr. Benjamin Chen, Stephen Neely, Kurt Junghans, and David Bochinski

Snyopyzed By William Palmer

Carderock Division joined forces with the United States Naval Academy (USNA) and the Naval Undersea Warfare Center to develop and demonstrate a novel highly maneuverable propulsion system for unmanned underwater vehicles (UUVs). The team envisions that this vehicle can stop and hold a position, reverse, rotate or revolve without forward motion. An added benefit of this concept is to increase operational range. The design also provides operational flexibility and reduced fuel consumption through propulsion thrust vectoring. This project is funded by Carderock Division's In-house Applied Research (IAR) program, sponsored by the Office of Naval Research.

Typical UUVs, which are equipped with a single propeller or a pumpjet and control surfaces, provide conventional maneuvering capabilities such as ahead/reverse and ahead/reverse turn operations. However, they are not able to perform unconventional maneuvering such as tight tactical maneuvers, recovery operations, and station keeping. In addition, the residual torque generated by the single propeller needs to be balanced by the control surfaces. The angle of attack of the control surfaces can be as large as 9° to 10° to counter-balance residual torque. This results in generating

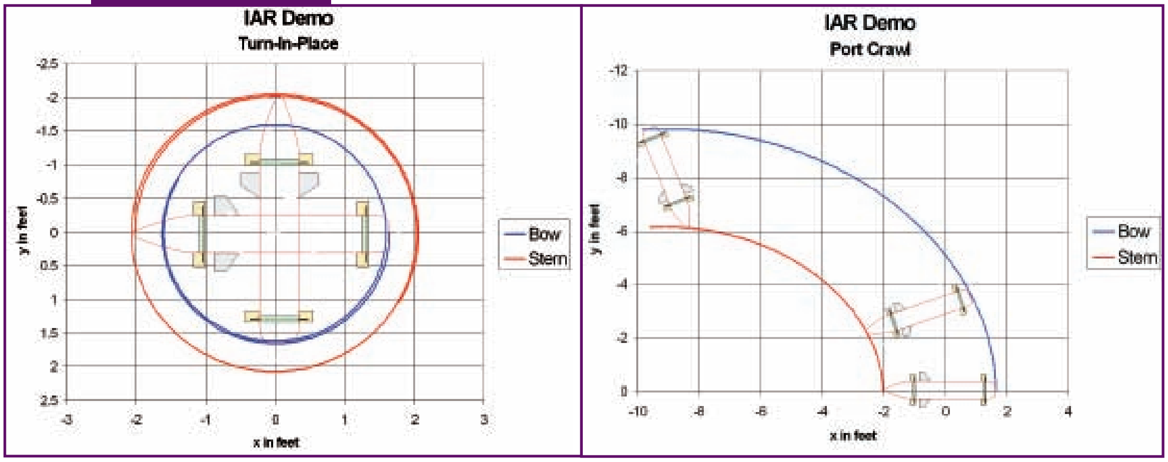


Left: The cyclic pitch control system for each of two propulsors on the vehicle. The system was comprised of a modified radio control helicopter control system.

Right: This image shows the vehicle in Carderock Division's Maneuvering and Seakeeping Basin, undergoing maneuvering tests.

Photos courtesy of Dr. Ben Chen, NSWC Carderock Division.

PROPULSION SYSTEM (Continued on page 32)



Far left: This simulation image shows the position of the vehicle during a turn-in-place maneuver.

left: A representation of a crawl maneuver to port. This operation was particularly complex for the vehicle's control system to perform.
Images courtesy of Dr. Ben Chen, NSWC Carderock Division.

PROPULSION SYSTEM (Continued from page 31)

additional drag, thus increasing the fuel consumption. Future UUVs require more unconventional maneuverability than is possible with current configurations.

This concept uses Haselton bow and stern large-hub propellers, which provide a large moment arm between the two propellers, giving them leverage with which to maneuver the craft. The propellers rotate in the contrarotating mode, while using cyclic blade pitch to produce side forces. This novel propulsion system executes conventional maneuvers such as ahead/reverse and ahead/reverse turns, as well as unconventional maneuvers such as sideways translation, turn-in place and station keeping. The concept originated in the 1960s and may have fallen out of favor due to mechanical complexity or control issues. However, the idea was deemed worthy of revisiting today, given advances in control systems, electric motors, and electrical actuation.

Two major tasks related to this project were accomplished in FY 07 and part of FY 08. The first task was to demonstrate the maneuvering capability using an initial demo vehicle, which was tested at Carderock Division's West Bethesda site. Optimal proof-of-concept performance was not required for the initial demo vehicle design. The second task was to develop and validate a preliminary design and analysis tool for the cyclic pitch propeller.

The vehicle dimensions were 44 inches in length and 8 inches in diameter with X-stern stabilizers. The bow and stern propellers each had three blades. The hydrodynamic design conditions called for turning the propellers at 400 RPM (revolutions per minute) to move the vehicle at 3 knots. The propellers were fabricated using stereo lithography apparatus (SLA) material. An effective cyclic pitch propeller mechanism was found among hardware normally used for recreational model helicopter designs. The initial demo vehicle was then tested in the NSWCCD Maneuvering and Seakeeping facility. All maneuvering modes were evaluated using visual observation of the vehicle trajectories.

A preliminary cyclic-pitch propeller force model was developed based on a simple wing theory and extended to the propeller application. The multi-vortex code was employed as the maneuvering and control simulation model to predict vehicle trajectories.

A turn-in-place operation was conducted, and the measured and predicted starboard turn-in-place were in agreement. It was a challenge to perform sideways translation, which required each propeller to generate the right amount of force to balance all of the moments and to produce only a side force. At least two difficulties occurred during the test operations. First, the propeller settings, under the existing test setup, could not be altered for balancing the propeller moments during the maneuver. Second, the attempt to produce more side force with the stern propeller also produced a thrust imbalance thus moving the vehicle forward.

Test results show that the measured and the predicted trajectories agree qualitatively for all maneuvering modes except the port sideways mode. A preliminary cyclic-pitch propeller force model, an initial demo vehicle, and budgeted testing were conducted, and they demonstrate that the novel propulsion system (Haselton propeller concept) is viable for UUVs to provide high maneuvering operations and possible fuel savings.

Future work is planned to refine this concept. This includes the preliminary cyclic pitch propeller force model refinement and validation, propeller thrust and torque measurements, a controller design and installation to provide stable maneuvers, and test apparatus integration.

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SHIP INTEGRATION & DESIGN

This core equity applies specialized expertise for surface and undersea vehicle design including early concept development, assessment and selection of emerging technologies, integration of selected technologies into optimized total vehicle designs, and evaluation of those technologies and designs for cost, producibility, supportability, and military effectiveness.

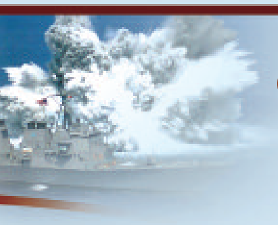
MACHINERY SYSTEMS

This core equity provides full-spectrum technical capabilities (facilities and expertise) for research, development, design, shipboard and land-based test and evaluation, acquisition support, in-service engineering, fleet engineering, integrated logistic support and concepts, and overall life-cycle engineering.

HULL FORMS & PROPULSORS

This core equity provides the Navy with full-spectrum hydrodynamic capabilities (facilities and expertise) for research, development, design, analysis, testing, evaluation, acquisition support, and in-service engineering in the area of hull forms and propulsors for the U.S. Navy.

VULNERABILITY & SURVIVABILITY SYSTEMS



This core equity provides full-spectrum capabilities (facilities and expertise) for research, development, design, testing, acquisition support, and in-service engineering to reduce vulnerability and improve survivability of naval platforms and personnel.

ENVIRONMENTAL QUALITY SYSTEMS

This core equity provides facilities and expertise for research, development, design, human systems integration, acquisition support, in-service engineering, fleet support, integrated logistic concepts, and life-cycle management resulting in mission compatible, efficient and cost-effective environmental materials, processes, and systems for fleet and shore activities.

SIGNATURES, SILENCING SYSTEMS, & SUSCEPTIBILITY

This core equity specializes in research, development, design, testing, acquisition support, fleet guidance and training, and in-service engineering for signatures on ships and ship systems for all current and future Navy ships and seaborne vehicles and their component systems and assigned personnel.

STRUCTURES & MATERIALS

This core equity provides the Navy with specialized facilities and expertise for the full spectrum of research, development, design, testing, acquisition support, and in-service engineering in the area of materials and structures.

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