



# R&D Center Delivers **BIG PUNCH**

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Through its wide-ranging portfolio, Coast Guard R&D generates significant returns on investment.

**D**iscussions on research and development (R&D) can vary based on the audience. Some may think of modern tech startups that research app development or new ways to engage across social media. Others picture a sterile work environment where

breakthrough medications are created, improved, and tested. And of course, there may be those who imagine high-tech labs inventing state-of-the-art gadgets and machines. All these images are accurate, as are many more. R&D is one means by which an organization can

U.S. COAST GUARD (GRANT DEVUYST)

**An aviation survival technician deployed to Alaska for Arctic Shield 2015 uses an infrared camera during a search-and-rescue exercise led by the Coast Guard Research and Development Center (RDC). Coordinates from an unmanned aircraft system lead the way to the simulated survivor in the icy waters below.**

grow and adapt, and governments, industries, and other organizations are constantly investigating and researching with the aim of making a discovery that can lead to either the development or the improvement of new tactics, technology, and procedures.

The Coast Guard R&D program has been a significant force multiplier for the strategic, operational, and tactical levels of the service. From developing more effective ways to conduct operations to looking for new systems to address growing issues within the Maritime Transportation System, Coast Guard R&D has been an agile capability within the service. At any given time, the program is working on more than 70 projects that support Coast Guard requirements across all mission areas, pursuing technologies that provide incremental improvements as well as those with the greatest potential to strategically transform the way the Coast Guard does business.

The program also leverages partnerships with academia, other government agencies, and private industry to anticipate and research solutions to future technological challenges. Partners include the Department of Homeland Security (DHS), university-based Centers of Excellence, national labs such as the Oak Ridge and Pacific Northwest National Labs, and private industry.

Focusing not only on traditional Coast Guard missions such as search and rescue and oil pollution response but also emerging threats such as cyber security, the service's R&D program has had multiple successes based on an understanding of national strategies and operational needs.

### Little-Known Successes, Big Impact

The Coast Guard Research and Development Center (RDC) is the sole facility in the Coast Guard performing research, development, test, and evaluation (RDT&E) that supports the service's 11 statutory missions. Return on investment is a key element of every project, and that "return" can take many forms, ranging from creating more effective, efficient, and focused operations to offering options to decision makers on courses of action. Since its inception, the RDC has had a string of successes;



U.S. COAST GUARD (CORY J. MENDENHALL)

**The U.S. Coast Guard's Science & Technology Innovation Center officially opens with an inventive flourish at the RDC in New London, Connecticut, on 5 May. The firing of a vessel-entangling device, designed to stop a fleeing craft, marks the occasion.**

however, these have not always received broad visibility within the Coast Guard. In addition, although the impact on the maritime public is significant, few Americans know about these good-news stories.

For example, during the mid-1970s the RDC developed an oil identification system (OIS) that can distinguish the unique properties of oils and determine if a relationship exists between samples of spilled oil and a suspected source. OIS has enabled the Coast Guard to identify sources of oil that have been illegally dumped into the ocean, resulting in accountability and prosecution of offenders.

The RDC also developed the visual and sensor “sweep width tables” used in the Search-and-Rescue Optimal Planning System (SAROPS). SAROPS is a software program all Coast Guard command centers use to develop search planning. The RDC recently expanded the program to include the unique requirements inherent in ice searches, which, if successful, will enhance an air crew’s ability to conduct rescues in areas such as the Arctic. This will give the responding Coast Guard assets better tools to find and rescue people in the water, where every second is precious.

The RDC also is able to provide senior leaders unbiased, academically rigorous analysis that can be used as a part of the strategic decision-making process. The Center was at the forefront of analysis of unmanned aircraft systems for the national security cutter. Its alternatives analysis underscored that, based on requirements, a proposed vertical takeoff and landing platform would not be the right fit, avoiding more than \$1 billion in prospective acquisitions.

In addition, the RDC collaborated with the DHS Science and Technology Center of Excellence at the University of Southern California to develop the Port Resilience Operational Tactical Enforcement Counter Terrorism (PROTECT) project. This was the first widely accepted use of game theory in port, waterways, and coastal security (PWCS) mission planning and spawned changes to the *Maritime Security Response Operations Manual*. By changing times, locations, and activities of individual patrols, PROTECT inserts an element of uncertainty in an adversary’s decision-making chain, while also introducing an element of deterrence. Similar in approach to community-oriented policing that concentrates on areas with highest risk while varying activities and engagement, PROTECT was a spring board to greater randomization of security activities within a port. The operational impact is an increased Coast Guard on-the-water presence, which the general public has noticed. To quote a water-taxi operator in Boston, “I have been in this harbor for a few years. Lately I see you guys all the time. . . . where did you get all the boats?”

These success stories are part of a larger narrative in which the RDC’s research leads to innovation that directly affects operations. Investment in the RDC helps shape Coast Guard operations.

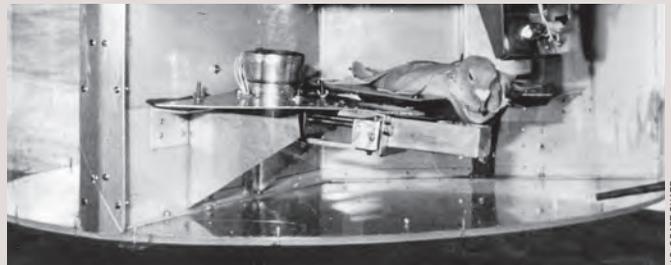
## A Coast Guard RDC Sea Story

During the 1940s, pigeons in a Tufts University laboratory demonstrated the exceptional ability to pick out certain shapes and colors in exchange for food. In the late 1970s and early 1980s, the Coast Guard decided this ability could be useful in searching for persons and equipment in open water. In Project Sea Hunt, Navy scientist Dr. Jim Simmons trained pigeons to conduct search-and-rescue missions from Coast Guard helicopters.

Three pigeons in a small observation bubble on the underside of a helicopter were positioned so they covered the 360 degrees under the aircraft. The pigeons were trained to recognize objects floating in the water and to communicate with the helicopter pilots by pecking a key that would help guide the pilots to the targets. The birds were 93 percent accurate at locating objects floating at sea—human flight crews were accurate 38 percent of the time—and their false positive rates were extremely low. When combined with human searchers, the success rate was nearly perfect. Eventually, the Coast Guard recognized the value of Simmons’ pigeons and called this project “the best daylight search system” yet developed.

Unfortunately, two helicopters crashed, which either destroyed or damaged the pigeon system. Project Sea Hunt never got out of the testing phase and was ended in 1983 because of federal budget cuts. Though innovative in theory, the project ultimately proved impractical.

The RDC’s efforts supporting search-and-rescue missions continued, however, and in 2015 the RDC tested an electronic sensor system on board H-60 and H-65 helicopters. This forward-looking infrared radar (FLIR) ball provided a similar capability to that of the pigeons, as its sensors could detect differences in light and contrast not easily seen by the human eye.



First, carrier pigeons, then . . . search-and-rescue pigeons! An RDC-trained avian asset is lowered into the Project Sea Hunt helicopter observation bubble, from which the bird could communicate with the pilot by pecking a key. “The birds were 93 percent accurate at locating objects floating at sea. . . .”



## Support to Western Hemisphere Strategy

The *U.S. Coast Guard Western Hemisphere Strategy* confronts challenges in the United States' most important geographic theater of operations, to include combating criminal networks, securing U.S. borders, safeguarding commerce, and building partner-nation capacity. To support this strategy, the RDC is exploring applications of small unmanned aircraft systems to increase offshore presence by enhancing surveillance capability and reach from cutters and small boats. In addition, probabilistic-based search models are being explored to improve patrol tactics in a given geographic area. The output from these models incorporates optimal tactics assuming that the adversary will adapt when reaching a certain threshold of failure. The primary objective is to analyze the findings derived from modeling and simulation runs to better understand the adversary's tactical shifts and leading indicators so Coast Guard operational commanders can improve the efficiency and effectiveness of their interdiction mission patrols. Follow-on research will determine whether adjustments to equipment and asset capabilities and/or capacity might be needed.

As planners look at the results, they will be able to determine the optimal asset mix. This information, coupled with queued intelligence, presents a formidable capability to address narcotics and human smuggling and will enable the Coast Guard to position assets where they can best effect interdictions. In many ways the RDC's effort channel Sun Tzu's belief: "When we are able to attack, we must seem unable; when using our forces, we must appear inactive; when we are near, we must make the enemy believe we are far away; when far away, we must make him believe we are near."



**Top:** The RDC, in coordination with Naval Warfare Systems Command, deploys a Wave Glider Unmanned Surface Vehicle during an Arctic oil-spill exercise. **Bottom:** Crew members of the USCGC *Healy* (WAGB-20) retrieve the USV glider unit, which can propel the device thousands of miles through the ocean using wave motion as its only power source.

The RDC continues to develop and maintain the Coast Guard Maritime Operational Effectiveness Simulation (CGMOES) application. This initiative addresses the need for an easy-to-use, streamlined capability for routine Coast Guard-wide asset allocation and force-structure decision support. The project's objectives include providing quick answers to senior leaders' force-structure questions driven by Congress regarding eliminations and additions of asset classes, as well as changes in mission priorities. CGMOES support to Coast Guard fleet acquisition programs yields the most impact. Currently, the RDC is providing the Commandant with the results of the RDC's Fleet Mix Analysis study to inform the multibillion-dollar offshore patrol cutter acquisition, one of the largest potential acquisitions in the service's history. In terms of its return on investment, CGMOES significantly improves the Coast Guard's ability to conduct trade studies to support acquisition efforts and assists operational commanders with strategic force lay-down options.

### Cyber Strategy in the Maritime Domain

The *U.S. Coast Guard Cyber Strategy* aims to strengthen the cyber security of the nation's maritime domain and further develop a robust internal cyber-security capability. In support of this strategy, the RDC is developing a conceptual framework and visualization tool that can accept sourced command, control, communications, computers, and information technology (C4IT) component data (hardware, firmware, and software) to more quickly and effectively assess the Coast Guard's cyber-security posture.

The RDC also is undertaking cyber-security initiatives that support the Maritime Transportation System. Efforts in this area are helping to establish a sound framework of cyber-security documentation, procedures, and tools in support of maritime critical infrastructure. Specific work includes analysis of cyber-security documentation tools, an assessment of port-facility network vulnerabilities, and an analysis of supervisory control and data acquisition and integrated control system vulnerabilities.

In addition, the RDC is leveraging both DHS Centers of Excellence and other major universities to advance maritime cyber research. Recently, the Coast Guard's Deputy Commandant for Operations selected three research areas for the American Military University, Rutgers University, and the University of Southern California to address: developing maritime cyber-security information-sharing protocols to meet the needs of industry and government, exploring how best to promote the use of sound cyber risk-management principles in the maritime domain, and researching threats and vulnerabilities modeling to better understand maritime cyber. The results of these efforts were scheduled to be briefed in late July. The second phase of this initiative will explore new research topics involving maritime cyber. The RDC's collective effort

on cyber security is a return on investment not only for the service but also for elements of the Maritime Transportation System. Moreover, engagement with multiple university partners highlights forward-leaning research to address the service's needs through new thinking infused with academic rigor.

### Arctic Operations

The *U.S. Coast Guard Arctic Strategy* has three goals: to increase domain awareness, improve governance structure and capabilities, and broaden partnerships necessitated by the Arctic's growing maritime usage. To support this strategy, the Coast Guard called on the RDC to conduct a high-latitude study of future Coast Guard mission and resource requirements in this new priority operational area. This study has become the foundation for a variety of Arctic initiatives, strategy, and the major acquisition of new 21st-century capabilities (i.e., polar icebreakers) for this emerging region of the U.S. exclusive economic zone.

The RDC has orchestrated a number of efforts to demonstrate and evaluate technologies and methods to enhance Coast Guard mission performance in the remote and harsh Arctic environment. This includes evaluating various unmanned systems' capabilities to detect, monitor, and track oil spills for response, as well as teaming manned and unmanned systems in support of search-and-rescue operations. "The Arctic technology evaluations provide [the Coast Guard] with the synergy of working with the researchers and learning which ways they need to reach out to the Alaskan native communities as they research what really impacts those local people here," explained Sudie Hargis, the tribal liaison for Coast Guard District 17.

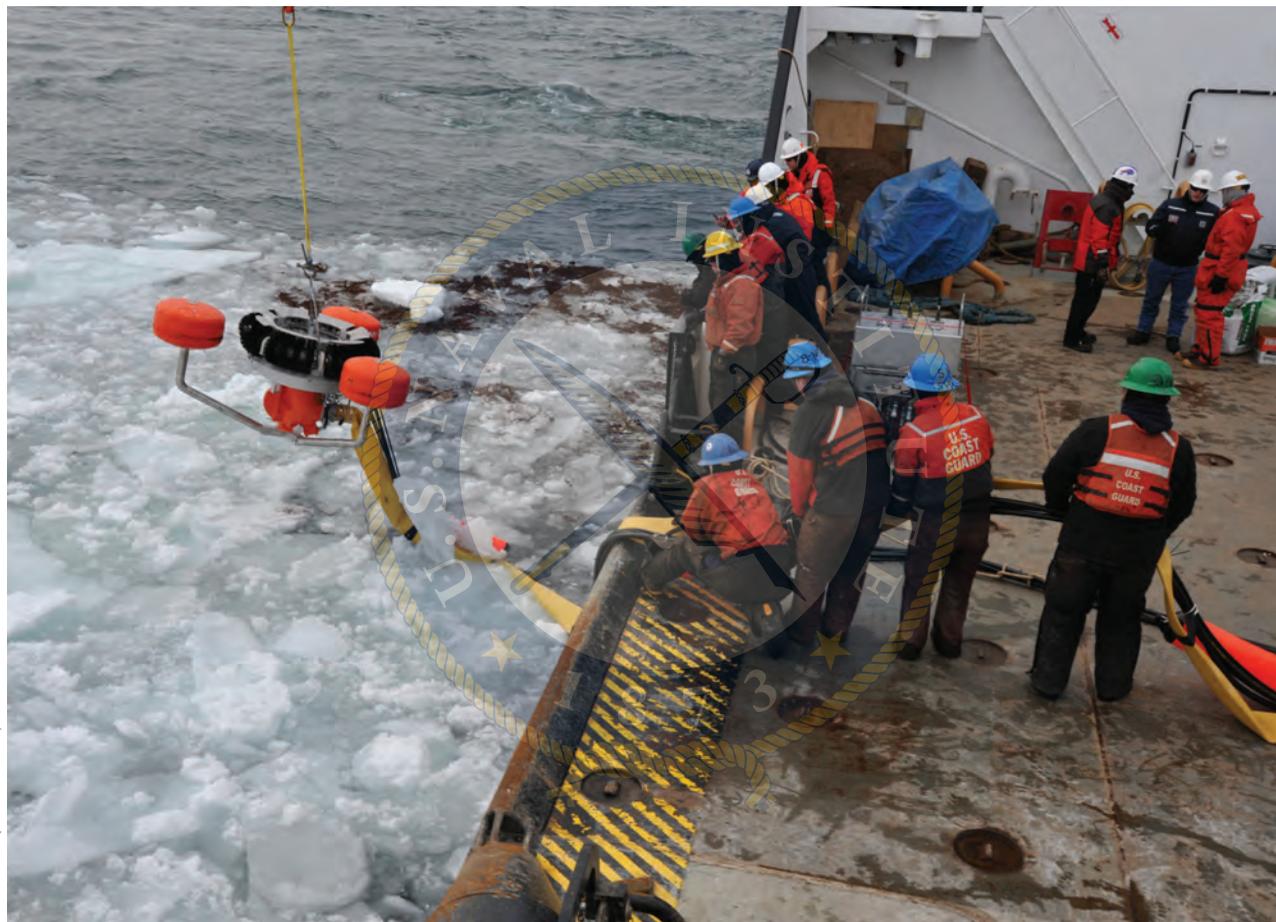
The RDC also completed modeling predictions to determine Coast Guard communication coverage using high-frequency radio throughout the Arctic region. The modeling results highlighted how the radio frequency propagation of the Arctic affects range, clarity, and consistency over time. Field-based experiments using new and existing satellite options such as the Department of Defense's Mobile User Objective System and Distributed Tactical Communications System, as well as experiments with new antennas, were conducted in various inland locations to identify ways to improve connectivity.

The Arctic Navigational Safety Information System (ANSIS) functional design project established a mutually agreed-upon design of the prototype system for near-shore ANSIS, which has the potential to enhance mariners' capability to identify, assess, and mitigate navigational risks and to improve the Coast Guard's maritime domain awareness in the Arctic region. The RDC established a three-year, renewable cooperative R&D agreement with the Marine Exchange of Alaska to define, develop, test, install, and monitor a next-generation navigational safety information system for the Arctic.

## Energy Renaissance Action Plan Support

The Coast Guard's *Energy Renaissance Action Plan* guides the service in ensuring the maritime safety, security, and stewardship of U.S. energy production and transport by focusing on incident prevention, preparedness, and response capabilities. To support this action plan, the RDC is implementing and analyzing a 21st-century electronic navigation technology (e-Nav) that takes advantage of electronic data systems, communications, and navigation capabilities, making it less reliant on physical aids. e-Nav technology will be set up and operated along a section of the Western Rivers system, and electronic aids to navigation (e-AtoN) and electronic

As part of its effort to detect and mitigate oil within the water column, the RDC partnered with the Bureau of Safety and Environmental Enforcement to find and remove oil down to 10,000 feet. The first part of the effort focused on the development of detection systems to identify and track subsurface oil spills. The partners developed and tested two prototypes (optical and sonar) that can detect small droplets of oil at high resolution in all environmental conditions—offshore, near shore, and in rivers—and mark subsurface oil for possible removal. The next phase of the project will focus on developing a technology, technique, or strategy to reduce the impact of oil within the water column on the surrounding environment and/or manmade



U.S. COAST GUARD (MATTHEW SCHOFIELD)

Crew members of the USCGC *Hollyhock* (WLB-214) test an oil-skimming device during an RDC-led project in the Straits of Mackinac. “The true strengths of the RDC’s testing efforts are found in the field.”

maritime safety information (e-MSI) will be provided to mariners in a test area. This effort will provide the Coast Guard, Army Corps of Engineers, and other partners with experience in distributing navigation information to users through the Automatic Identification System (AIS). The project’s outcome will inform the development of Coast Guard policy and authority requirements for delivering information to support safe navigation, a core Coast Guard mission. This effort will decrease the number of buoys the Coast Guard maintains and increase transparency on U.S. waterways.

structures. The mitigation prototype testing and concept development will provide the Coast Guard and its partners with improved operational performance and resilient response execution.

On the response front, the RDC’s mobile technology research is improving the collection and integration of information during large-scale “incidents of national significance,” such as a major oil spill. Combining tablet technology with a mobile ad hoc network, the RDC continues to refine ways to facilitate response and coordinate multiple crews covering different areas and

tasked with different jobs during large-scale incidents. What is the return on investment? The California Office of Emergency Services is using this technology now with great results. The RDC continues to explore and evaluate this capability with DHS first responders and Massachusetts Institute of Technology Lincoln Laboratories. This research will provide responders and decision makers with the timeliest, fused information readily available.

### Turning Research into Innovation

Each of these projects comes to the RDC from operators in the Coast Guard. The RDC solicits research ideas from all levels of the organization. With the Coast Guard's 11 statutory missions as guidance, these ideas serve as the primary vehicles for project creation and innovation. Once received, ideas are formally reviewed, prioritized by Coast Guard needs and requirements owners, and developed into executable project plans.

The true strengths of the RDC's testing efforts are found in the field. The RDC considers the field to be its lab space, and much of its most effective test and evaluation work is performed on board operational Coast Guard assets. During project development, test, and evaluation, the RDC works with the Coast Guard's Atlantic Area (LANTAREA) and Pacific Area (PACAREA) within the service's standard operational planning process (SOPP) to identify assets—including cutters, boats, aircraft, and subject matter experts—to support field activities. The SOPP is the formal methodology the service uses to assign assets to missions.

Five years ago, the RDC began integrating its asset requests into the operational planning document development and request-for-forces processes. Through dedicated engagement with LANTAREA and PACAREA, assets quickly are identified to field-test new technology, techniques, tactics, and procedures. This ongoing engagement has benefited both research and operations—

the RDC understands the constraints operators are under, and the operators see and experience firsthand how the RDT&E program supports tactical operations. The RDC currently is using Coast Guard assets to test new investigative tools to locate and prosecute search-and-rescue hoax call violators. The feedback from operators is vital, especially as the goal is to transition projects into implementation in the fleet.

### An Evolving Asset

Since its inception, the RDC has been a valuable and agile asset to the Coast Guard. In the 1970s and early 1980s, the RDC focused on modernizing the service's aids-to-navigation and search-and-rescue capabilities. Supporting these missions continues to be an important part of the RDC portfolio. In the 1980s and 1990s, several high-profile oil spills resulted in spill response becoming a major research area. In the late 1990s and the 2000s, the RDC shifted its focus to support cutter acquisitions and to improve the efficiency of a wide range of Coast Guard operations. Following the attacks of 11 September 2001, military and civilian RDC personnel provided staffing, expertise, and a big-picture look at homeland defense. Since then, the RDC has pursued new products that will assist the Coast Guard in protecting U.S. ports and enhancing homeland security.

During the 2010 Deepwater Horizon oil spill, the RDC quickly stood up an independent analysis and technology assessment program to provide technical assistance to the incident command on the evaluation of specific emergent technologies and the thousands of ideas received from the general public. The RDC's contributions earned the RDT&E Program the Coast Guard Commander Joel Magnussen Innovation Award for Management in 2011.

The Coast Guard's mission set always is evolving, and the RDC plays a critical role in ensuring the Coast Guard can continue to effectively and efficiently perform its services to the American people. The RDC has pushed the boundaries, working with multiple elements within DHS, with Coast Guard partners, and in the Coast Guard to ensure the deck-plate level operators are prepared for this evolution. The unit's command emblem includes its motto, which represents the heart of the RDC: "From here, you can see tomorrow." 

**Captain Evans is commanding officer of the RDC. He was a system design and management fellow at the Massachusetts Institute of Technology, where he earned an MS in engineering and management.**

**Lieutenant Commander Nassar is a project manager in the C4IT branch at the RDC.**

**Lieutenant Higbie is a project manager in the surface branch at the RDC.**

**Dr. DiRenzo is the RDC's director of research partnerships and a frequent contributor to *Proceedings*. He previously held the Coast Guard Chair at the Joint Forces Staff College and currently teaches at American Military University and Northcentral University.**

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