Marine Science and Technology Support of U.S. Coast Guard Arctic Operations

Jonathan M. Berkson*, Kenneth J. Boda**, Eric D. Peace*, and Richard L. Hansen***

*U.S. Coast Guard Office of Waterways Management, Washington, DC
**U.S. Coast Guard Office of Cutter Forces, Washington, DC
***U.S. Coast Guard R&D Center, New London, CT

ABSTRACT: **The U.S. Coast Guard currently utilizes applications of marine science and technology to enhance safe and effective operations in Arctic waters. While many advances were developed by academia, industry, and other Federal agencies, the U.S. Coast Guard plays a role in research, development, testing, and evaluation directly applicable to U.S. Coast Guard mission needs. Examples of marine science and technology developments that have improved - or might improve - U.S. Coast Guard operations are described for several applications, including aircraft, surface vessels, ground stations, information products, decision tools, and communications.**

INTRODUCTION

The United States is an Arctic Nation with broad interests in the safety, security, and stewardship of that region [Reference 1]. The U.S. Coast Guard's (USCG) strategic vision is to ensure safe, secure, and environmentally responsible maritime activity in U.S. Arctic waters. Operating in this remote region is challenging due to the vast distances, harsh climate, ice hazards, and a lack of communications and other infrastructure. To operate effectively and safely, USCG requires trained personnel, specialized equipment, carefully planned logistical support and partnerships with Federal, State, local, and tribal agencies. Polar Operational risks can be mitigated through using marine science and technology support to: monitor the environment, protect people, vessels, aircraft and infrastructure from the harsh climate, and create new products, equipment and materiel. This paper focuses on one aspect of Arctic operational requirements: marine science and technology support.

COAST GUARD IN THE ARCTIC

The Coast Guard has a long history of involvement in the Arctic region that began in 1867 with the purchase of Alaska. By today's standards, early equipment and procedures were not optimized for Arctic conditions, but nevertheless USCG (then called the Revenue Cutter Service) was able to perform critical missions and play an important role in U.S.-Alaskan history. Since those early days, USCG has continuously leveraged advances in technology to refine Arctic operations and support systems.

Following World War II there has been limited need for a permanent presence or infrastructure in the region due to ice coverage, limited vessel traffic, and lack of connecting roads and major airfields that could support viable industry. As a result of relatively recent trends of diminishing sea ice and renewed economic interest in oil, gas and minerals, there is speculation that there will be an increase in maritime activities, particularly during the summer months. While USCG will maintain a mobile and seasonal presence in the region commensurate with predicted activity levels for the foreseeable future, USCG must prepare for demands associated with an increased future presence in an unforgiving and relatively unfamiliar operational domain. In that light, there are a number of issues associated with operating current and future cutters, boats, aircraft, and shore structures. Some issues are platform-specific, while others apply to all facets of the Arctic operations system [Reference 2].

MARINE SCIENCE AND TECHNOLOGY SUPPORTING ARCTIC OPERATIONS

This is an overview of science and technology applications that have improved or may improve USCG operations. In general, USCG takes advantage of marine science and technology advancements developed by industry, academia, and other Federal agencies. However, USCG does play a role in research, development, and/or testing technology directly applicable to our mission needs. Research and Development (R&D) activities that may lead to further advancements are highlighted below. The examples illustrated below are being evaluated, and may or may not be adopted for USCG operations or acquisitions. In the Federal acquisition process, budgeting factors, alternate technologies, and applicability to multi-mission operations are considered along with other criteria before investments are made.

Aircraft: For decades, helicopters have deployed aboard USCG icebreakers and flown in Arctic Operations, particularly ice reconnaissance, logistics, and science support. Since 2007, USCG Air Station Kodiak began conducting Arctic Domain Awareness Program flights [Reference 3] to allow more aircrews to experience the high-latitude environment and provide scientists an opportunity to collect data in the Arctic, as shown in Figure 1. This program has resulted in improvements in flight equipment, procedures and operations, as well as knowledge of the Arctic environment. More recently, USCG R&D Center, along with federal, state, local and industry partners, have tested and evaluated both the Puma AE and ScanEagle unmanned aerial systems (UAS) for use in the Arctic, as shown in Figure 2. These systems were tested from shore and at sea aboard USCG Cutter (USCGC) HEALY during the joint civil and federal Search and Rescue Exercise 2015. In one of the tests an aerostat blimp tethered to USCGC HEALY supported communications for UAS beyond line of sight tests, as shown in Figure 3. Lessons learned will help refine the use of UAS for high latitude applications.

Surface Vessels: USCG has operated ships in the ice for well over a century. Each new generation of icebreaker has incorporated advances in technology in terms of naval architecture, propulsion, auxiliary systems, and electronics. Renewed commercial interest in the Arctic has accelerated the development of technologies to enhance polar operations, including vessels operating in ice-covered waters. For instance, advances in radar technology have led to high-resolution, ice-hazard radar that may improve surface transit through pack ice [Reference 4]. Other advances that may be studied include improved bow shapes, low-friction, high-ice-abrasion-resistant hull coatings, ice phobic coatings, and variations in propulsion systems [Reference 5]. Technology has the ability to improve and expand the mission effectiveness of surface ships in ice. The USCG R&D Center is evaluating methods and equipment for surface-vessels to recover spilled oil in the presence of sea ice. Figure 4 shows scientists and USCGC HEALY crew aboard the Arctic Survey Boat retrieving an oil tracking buoy from the ice. Figure 5 shows non-toxic green dye sprayed to simulate oil in the water column in and around ice. It is also testing ice effects on ship-borne boat propulsion systems and equipment to enhance capability and better support high latitude missions.

Ground Stations: Currently USCG has no permanent stations in the U.S. Arctic. Over the past four summer seasons to support Operation ARCTIC SHIELD, USCG has set up forward operating locations first in Barrow, and more recently in Deadhorse, AK. The forward operating locations include hangar facilities for manned air assets, a communications station, and logistical support. The closest deep draft port to the U.S. Arctic is Dutch Harbor, AK, in the Aleutian Islands. Through Operation ARCTIC SHIELD, USCG R&D Center is evaluating facilities and conducting research to inform future decisions for shore-side infrastructure in the region.

Information//Decision-Aids: The Coast Guard benefits from informational products provided by other Federal agencies and international partners, such as weather and ice forecasts from NOAA, Navy, and Environment Canada. We also use data and ice information products from interagency efforts, including the Integrated Ocean Observation System, the National Ice Center [Reference 6], as well as the recently established Arctic Collaborative Environment (ACE), an internet-based environmental research and decision support system. It is anticipated that the high-latitude services of these programs will improve with increased Arctic activity. USCG Arctic operations benefit from experience in Antarctic operations. For example, USCGC POLAR STAR used high-resolution imagery and ice products from the National Ice Center, an interagency center operated by Navy, NOAA, and USCG, to determine the safest route through the ice during their rescue of F/V ANTARCTIC CHIEFTAIN in January 2015, as shown in Figure 6. The ice products are developed from analyses of satellite data and direct ground-truth observations made by vessels and stations in the area. The Coast Guard will benefit from the Arctic Domain Awareness Center (ADAC), a Department of Homeland Security Center of Excellence established in 2014 and led by the University of Alaska Anchorage.

Communications: The Arctic is a region that challenges communications systems. Ionospheric conditions make over-the-horizon radio communications, such as high frequency (HF) radio, more difficult for operators to predictably use in the Arctic [References 7 and 8]. Current satellite communications systems in geostationary orbits are typically too low in the sky for dependable Arctic communications. These factors may be overcome with improvements in technology for both space and terrestrial communications infrastructure. In the summer of 2014, USCG R&D Center and partner organizations conducted a verification test of existing infrastructure and ground stations to validate modeling of HF communications from USCGC HEALY to shore sites and mobile sites. The goal was to determine latitude dependence on other secure communications systems.

Another communications test accomplished was using the Department of Defense Mobile User Objective System (MUOS) for satellite voice and data transfer aboard USCGC HEALY. Figure 7 shows a team member adjusting the UHF antenna during that test.

DISCUSSION: Over the years the U.S. Coast Guard has taken advantage of technology to inform the acquisition process so we can operate equipment safely and effectively in the harsh high latitudes. In addition, the USCG fleet has adapted to changing mission priorities in both Polar Regions, as well as to advances in available technology. Missions in the Arctic have evolved throughout history, to include: maritime patrol in the newly acquired Alaska territory, exploration of the regions vast natural resources, and establishment of defense infrastructure and systems. Today the focus in on USCG's vast multi-mission responsibilities that include search and rescue, oil-spill response, protection of living marine resources, and enforcement of laws and treaties. While operating platforms in the high latitudes, USCG cooperates with interagency priorities for scientific research and survey mapping of the Arctic Ocean seafloor. Technology has evolved from wood, steam, and sails to high grade steel and efficient diesel propulsion. During each era acquisition decisions are made with regards to budgeting constraints and specific mission requirements, fully utilizing the options provided by marine science and technology advances. USCG is always looking to better connect with the academic community, industry, local and tribal entities, and Federal partners. It is expected that the newly established Arctic Domain Awareness Center, a Department of Homeland Security Center of Excellence, will advance that effort.

REFERENCES

1. U.S. Coast Guard , United States Coast Guard Arctic Strategy, U.S. Coast Guard Headquarters, Washington, DC, 47 pages, May 2013
2. R. Hansen, J. Berkson, and K. Boda, The U.S. Coast Guard Research and Development Center evaluates Arctic operational capabilities, *Coast Guard Journal of Safety & Security at Sea*, pp. 77-79, Summer 2013.
3. J. Hyles, USCG Air Station Kodiak's Arctic Domain Awareness Mission Support Operations: A Vital Step Toward Arctic Understanding, *US Naval Institute Blog Archive*, 2014, http://blog.usni.org/2014/04/09/uscg-air-station-kodiaks-arctic-domain-awareness-mission-scientific-support-operations-a-vital-step-toward-arctic-understanding
4. B. O'Connell, Icebreaking Research and Development Projects: Ice Hazard Radar*, Canadian Coast Guard Website* http://www.ccg-gcc.gc.ca/e0014402
5. A. Tunik, Icebreaker Innovations: A brief history of technological advancements in icebreaking, *Coast Guard Journal of Safety & Security at Sea*, pp. 88-89, Summer 2007 [see article #2 in https://www.uscg.mil/history/articles/USCGPolarIcebreakersWojahn2007.pdf]
6. J. Berkson, A Allen, D. Murphy, and K. Boda, Integrated Ocean Observing System Supports Marine Operations: A Look for the U.S. Coast Guard*, Mar. Tech. Journ.* Vol. 44 (6), p. 156-165, 2010
7. S. LaGrone, Lockheed, Coast Guard Tackling Problem of Arctic Communication, *US Naval Institute News*, 2014, http://news.usni.org/2014/08/21/lockheed-coast-guard-tackling-problem-arctic-communication
8. B. Kvamstad-Lervold, What is the problem with communication in the Arctic? Norwegian Marine Technology Research Institute (MARTEK), *MARTEK Website* http://www.sintef.no/home/marintek/projects/maritime/what-is-the-problem-with-communication-in-the-arctic/
9. Arctic Domain Awareness Center, a Department of Homeland Security Center of Excellence, *Homeland Security University Programs Website* https://adac.hsuniversityprograms.org/centers-of-excellence/adac/

FIGURE 1: Air Station Kodiak HC-130 Hercules airplane crewmembers deploy probes above the Arctic Circle during an Arctic domain awareness flight, June 20, 2013. These probes give researchers and USCG a better understanding of Arctic environments and predictability statistics for the following year's summer. (USCG photo by Petty Officer 3rd Class Jonathan Klingenberg)

FIGURE 2: Unmanned Aerial Systems – A NOAA Puma AE is being recovered from the ice during Arctic Technology Evaluation 2013 testing in the Chukchi Sea. (USCG Photo by Petty Officer 2nd Class Grant Devuyst.)

FIGURE 3: Aerostat blimp tethered to USCGC HEALY to support communications for unmanned aerial system's beyond line of sight testing as part of USCG R&D Center Arctic Technology Evaluation 2015. Curvature is due to wide-angle lens (USCG photo by Chris Wiggins)

FIGURE 4: Arctic Technology Evaluation 2014 scientists and USCGC HEALY crew aboard the Arctic Survey Boat retrieving an oil technology buoy from the ice. Oranges were used as a surrogate for floating oil inter-dispersed in the ice. (USCG photo by Leonard Zabilansky, USACE CRREL)

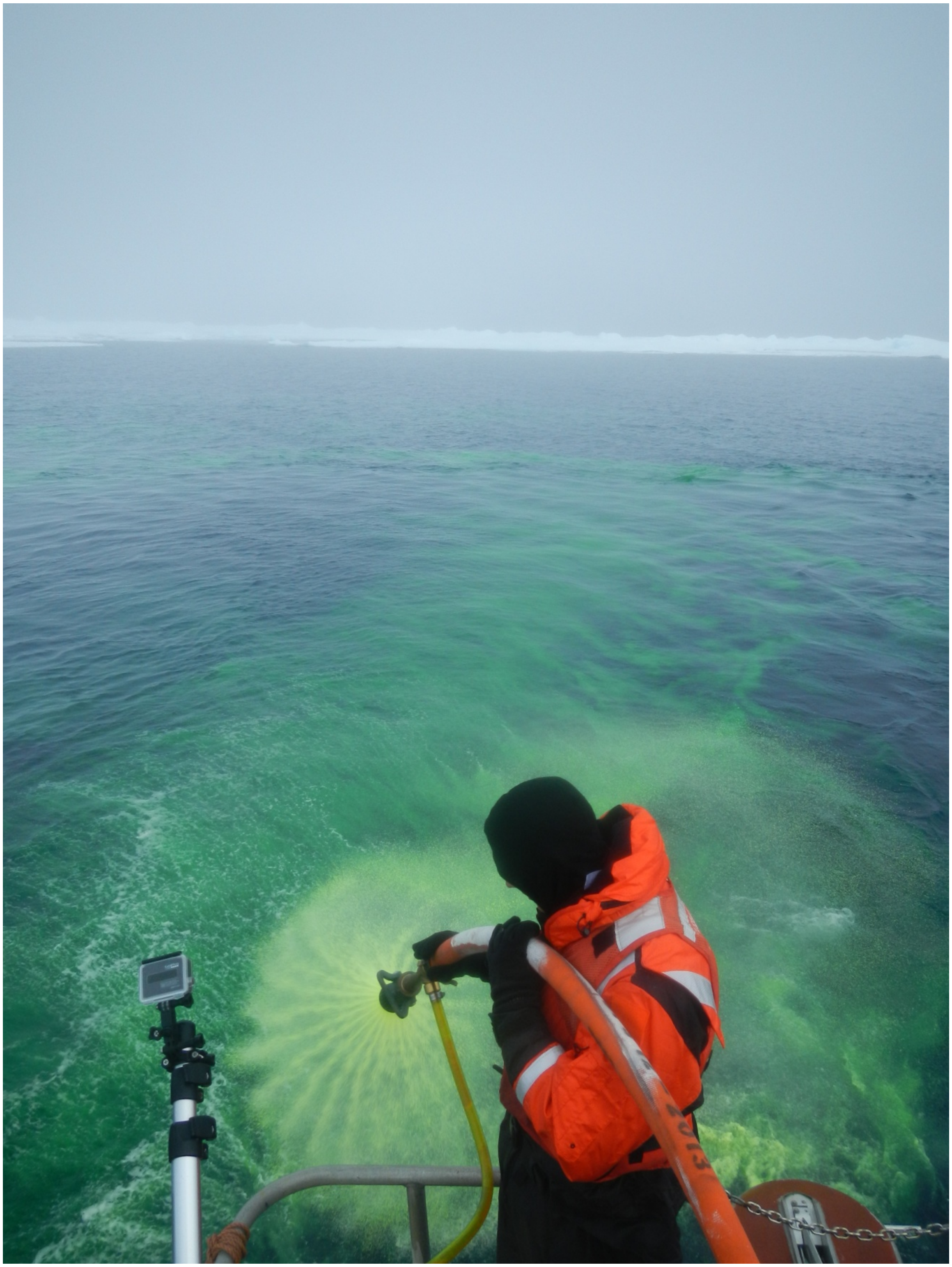

FIGURE 5: Oil Spill: A non-toxic green dye is sprayed to simulate oil in the water the column during oil spill detection testing in the marginal ice zone during Arctic Technology Evaluation 2014. (USCG Photo by Petty Officer 1st Class Shawn Eggert.)

FIGURE 6: Application of high resolution ice products to USCG operations: USCGC POLAR STAR tows F/V ANTARCTIC CHIEFTAIN through the ice during a rescue in the Antarctic. POLAR STAR used high resolution ice products from the National Ice Center to determine the safest route through the ice. (USCG Photo.)

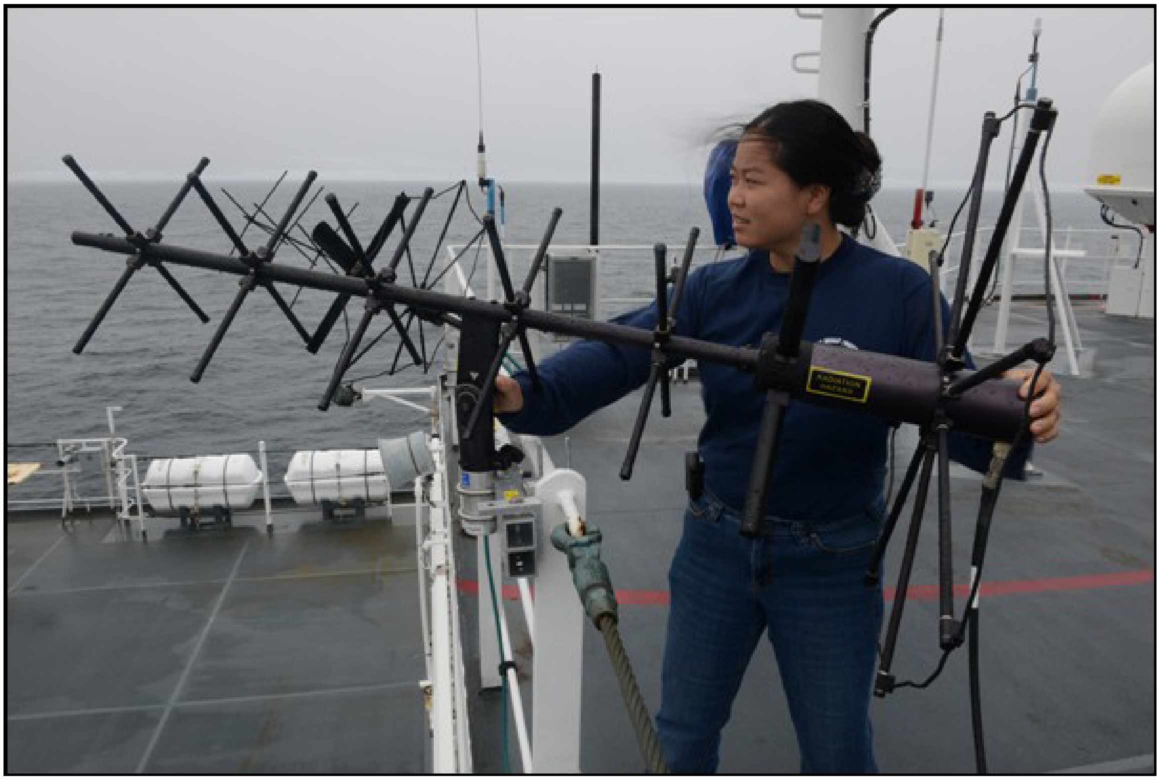

FIGURE 7: Arctic Communications. Amy Sun, Lockheed Martin Company test team member, adjusting a UHF antenna to test MUOS capabilities in the Arctic onboard USCGC HEALY during the Arctic Technology Evaluation 2014. (USCG photo by Petty Officer 1st Class Shawn Eggert.)