Coast Guard Research and Development Center

Fiscal Year 2023 Portfolio Ramp-Up Research Questions

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January 2022

Homeland Security

NPS-23-E009
2023-2: Platform Cybersecurity Solutions for CG Cutters

Mission Need:

Cyber resilient Operational Technology (OT) systems on CG cutters.

Challenge:

- To keep up with ever-evolving adversarial cyber threats, additional cybersecurity measures are needed on OT systems, including Hull, Mechanical, and Electrical; navigation; and combat systems.
- CG cutters require comprehensive solutions that can detect, respond to, and protect against a multitude of cyber threat vectors.
- Cutter OT systems require sophisticated boundary defense and enforcement capabilities to adequately defend against cyber threats.

Research Question(s):

1. What novel OT cybersecurity systems are ready for deployment (or already deployed) on U.S. surface assets?
2. What are the recommendations to retrofit solutions onto older platforms?
3. What specifications should be included for acquisition of new assets?

NPS-23-E008

2023-8: Cutter-Based Unmanned Aircraft System (UAS) Beyond the National Security Cutter (NSC)

Mission Need:
Operationalizing UAS on flight deck and non-flight deck equipped CG surface assets.

Challenge:
- Implementing UAS technologies that can untether UAS operations from current radar/air domain controller requirements presents an evolutionary leap in our surface fleet's maritime domain awareness capability.
- Different vessel types may require different classes of UAS and will have different launch and recovery capabilities.
- Addressing employment strategies (i.e., UAS operation by vessel crew or deployable teams) and their impact.
- Gaining clear understanding of what roles UAS can realistically assume from manned aircraft.

Research Question(s):
1. What are the CONOPs possible when incorporating UAS on small and large CG surface platforms?
2. What is the return on investment using UAS versus manned aircraft to execute CG missions?

NPS-23-E010

2023-7: Investigate Effects of Wind Farms on Search and Rescue (SAR)

Mission Need:
Qualify and quantify the impact of wind farms on CG SAR.

Challenge:
- There are approximately 30 wind farm installations offshore of MA, RI, NJ, NY, DE, and VA planned over the next 5 years.
- Wind farm turbines generate Wind Turbine Interference on oceanographic High Frequency radar sensors.
- Wind turbines also create regions of reduced wind speeds and high turbulence downwind of the turbines.
- This interference could affect numerous Search and Rescue Optimal Planning System (SAROPS) Environmental Data Server surface current and wind products for drift modeling and search planning.
- Wind turbines will likely impact CG search planning, search patterns, and sensor performance for both aircraft and vessels.

Research Question(s):
1. What is the surface radar profile of spinning wind turbines?
2. What is this profile from assets in space?
3. What are the effects on wind and current in the location of existing wind farms?

NPS-23-E011
2023-13: Persistent Simulation for the CG Workforce
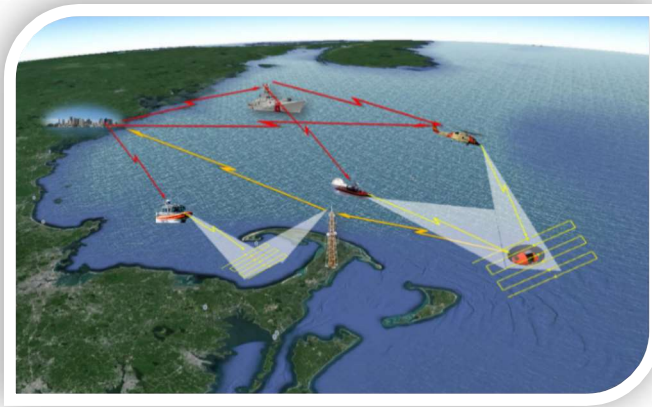
Mission Need:

Forecast strategic workforce needs and inform Human Resource (HR) policy decisions.

Challenge:

- CG-126 lacks ability to adequately forecast workforce demand and supply beyond a 3-year time horizon.
- Current analysis is largely based on Resource Proposals, which cover up to three years in the future. For decisions further out than 3 years, analysts must rely on anecdotal and qualitative information for recommendations.
- There is currently no tool (e.g., predictive simulation model) that can draw on current HR data and help answer questions about the impacts of proposed policies, accession levels, and recruiting levels.
- Without such a tool the CG must commit to policy decisions without the benefits of quantitative analysis, though the full ramifications may not be known until they unfold, often 5-10 years out.
- The CG needs, and will continue to need, Superior Workforce and Talent Management to remain an employer of choice.

Research Question(s):

1. What workforce modeling systems and techniques are in use in industry and government?
2. What CG data is needed as inputs to a predictive simulation model?
3. Where is this data currently located and who is the data steward?

2023-10: Implement Transfer of Search Patterns Directly to Boat Navigation Systems

Mission Need:
Accurate and timely transmission of search patterns to enhance mission execution.

Challenge:
- During the course of a Search and Rescue (SAR) case, a Coast Guard (CG) Sector may calculate one or more search patterns for small boats launched by a station, which are relayed to the small boat via radio, and then manually entered into the Scalable Integrated Navigation System, Gen 2 (SINS-2) which results in delays to execution of the patterns.
- Entering this waypoint data is not only cumbersome, but is also prone to human error which can decrease the effectiveness of the SAR efforts.
- While requirements for SINS were informed based on prior RDC work in 2017 under the Automatic Transport of SAR Patterns Project (8113), operational testing, approvals and implementation and are still required.

Research Question(s):
1. What is the recommended CONOPs for implementing this solution?
2. What are the cybersecurity risks involved, if any?
3. What SINS-2 modifications are necessary, if any?

NPS-23-E014

2023-11: Alternative Energy (AE) Propulsion Systems for CG Surface Assets

Mission Need:

High reliability propulsion systems powered by next generation energy sources.

Challenge:

- Align vessel designs with the Deputy Commandant for Operations/Deputy Commandant for Mission Support research priority of developing service solutions to combat climate change.
- Reduce the logistics burdens of traditional vessel refueling.
- Provide an alternative energy propulsion solution that maintains mission readiness.
- Determine constraints and infrastructure investments for transition to alternative energy propulsion.
- Identify the fire and safety risk mitigations required for alternative energy adoption.
- Inform future design decisions regarding alternative energy use on a variety of surface assets.

Research Question(s):

1. What novel propulsion systems are in use internationally today?
2. How could any of these systems be installed on exiting CG cutters?
3. What are the skills needed and support requirements for these new systems?
4. What would be needed for the CG to adopt nuclear powered solutions?

NPS-23-E015
2022-15: CG Flight Data Recorder (FDR) Exploratory Data Analysis

Mission Need:

Use CG FDR data to improve safety and operational performance.

Challenge:

- CG FDRs capture valuable mishap and non-mishap related structured and unstructured data, but the data is not currently analyzed deeply for potential use.
- There is potential for exploratory analysis of FDR data by incorporating Artificial Intelligence (AI) and Machine Learning (ML) techniques to improve mission safety, mishap reduction, operational efficiency, and develop pre-emptive lessons learned.

Research Question(s):

1. What descriptive, trend, and predictive analytic techniques do DoD and Industry use to conduct exploratory analysis on their FDR systems?

2023-18: Evaluate Visibility of Colors for CG Approved Lifesaving Equipment in Marine Conditions

Mission Need:

Verify/determine optimal color for CG approved lifesaving equipment.

Challenge:

- The last comprehensive CG study of the visibility of approved colors for CG lifesaving equipment took place in 1955 in calm, sunny conditions.
- The visibility of lifesaving equipment colors has not been formally evaluated in varying sea states, light and weather conditions.
- A recently-published study conducted by a well-known lifesaving equipment manufacturer suggests the visibility of yellows and greens exceeds CG-approved red-orange in low-light conditions, and is statistically equivalent in bright conditions.
- The maritime industry has requested the CG authorize other high visibility colors for use on approved lifesaving equipment.

Research Question(s):

1. What international studies have been done to address colors for lifesaving equipment?
2. What is the best test methodology to determine color visibility?
3. How can Low Earth Orbit (LEO) satellite sensors be programmed to detect specific Red, Green, Blue (RGB) colors?

2023-1: Intelligence, Surveillance and Reconnaissance (ISR) Data Networks for Intelligence Analysis

Mission Need:

Automatic, near real-time transfer of Minotaur data to the CG Intelligence Enterprise.

Challenge:

- Data from Minotaur systems currently require manual transfer to Remote Installation Services causing unnecessary system hard-drive wear and failure and delays in delivering operational data.
- Lack of timely data transfer hinders effective use of Artificial Intelligence/Machine Learning capabilities for intelligence analysis.
- Modifications to operational aircraft and cybersecurity assurances both require substantial approvals processes.

Research Question(s):

1. What is the air-to-ground network topology in use by DoD and Industry to transfer ISR data?
2. What tools are employed to transfer ISR data at different classification levels?
3. How can the network topology and classification tools be shared by the CG?

2023-5: Cutter-Based Unmanned Systems (UxS) Integration Analysis
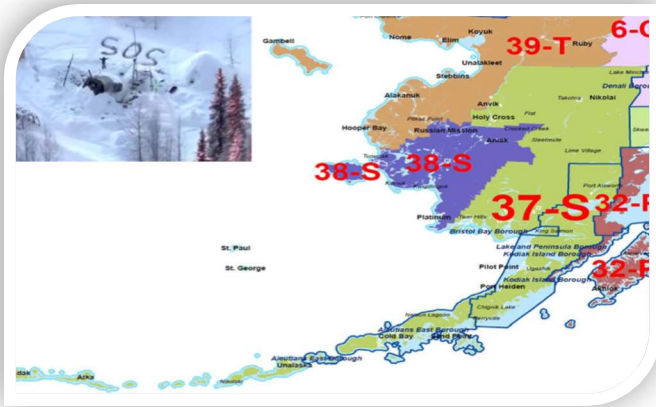
Mission Need:

Integrate UxS across cutter fleet to augment operational capabilities.

Challenge:

- Strategically capitalize on the benefit UxS integration presents to cutter-based mission execution.
- Determine the capacity current cutter classes possess to integrate, deploy, and support UxS.
- Analyze cutter and UxS combinations to optimize operational capabilities.
- Develop UxS integration considerations tailored for USCG assets.
- Identify design efficiencies related to human, mission, system and infrastructure integration.
- Construct force structure models representing integration of available technologies.
- Provide analysis which facilitates the implementation of the USCG UxS Strategy (in development).

Research Question(s):

1. What is the CG cutter class-specific capacity to integrate UxS (operations, logistics, support, personnel)?
2. What are the CONOPs possible when incorporating UxS for each class of CG cutter?
3. What are the requirements that limit integration?
4. What are the future requirements for UxS integration (i.e., engineering design, mission sets, training)?

2023-3: Next Generation Distress Communication Capability for Alaska and the Arctic
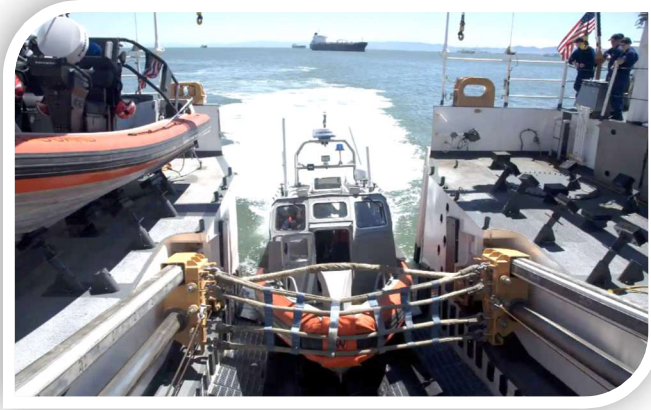
Mission Need:

Modernized and Effective Rescue 21 (R21) for Alaska (AK).

Challenge:

- Map and categorize mobile phone providers in AK based on reliability and throughput.
- Managing availability of technology, i.e., satellite service providers factoring in cost.
- Overcome tyranny of distance through adaptive application of radio, mobile, satellite and Unmanned Aircraft System (UAS) systems.
- Creating an adaptive communication architecture that folds in tribal and regional leaders.
- Development of a comprehensive series of testing opportunities to validate potential solutions for communications and geolocation in summer and winter.
- Recommend a strategy for moving R21 to the cloud like the lower 48 building upon lessons learned from RDC Project 8503 "Radio Frequency Communications in a Cloud Environment."

Research Question(s):

1. What changes could be made to the current R21 Alaska infrastructure to better support coastal communications?
2. How can R21 Alaska be integrated with offshore communications solutions (HF, satellite) to provide a complete communications solution?
3. What capabilities can be employed to provide coverage above 65 degrees north?

NPS-23-E020
2023-15: Study Optionally Manned Surface Vessels for CG Missions

Mission Need:

Increase cutter boat utilization through remote and autonomous control.

Challenge:

- USCG mission requirements often exceed the availability and persistence of deployed assets.
- When inactive, cradled cutter boats provide no mission value.
- Cutter boat platforms are capable of mission durations in excess of available crew resources.
- Risk mitigation opportunities, through the deployment of unmanned surface assets, remain unrealized.
- The functionality and performance characteristics of remote and autonomous vessel control systems require optimization.
- Mission performance impacts, resulting from unmanned vessel operations, have not yet been quantified.

Research Question(s):

1. What is the recommended CONOPs for implementing this solution?
2. What are the command and control, sensor, IT infrastructure, and integration requirements?
3. What are the human-machine teaming alternatives available with this solution?

NPS-23-E021
2023-9: Investigate Modernizing CG Shipboard Interior Communications

Mission Need:

Provide CG vessels updated interior communications systems.

Challenge:

- The CG uses 3 different wireless Shipboard Interior Communications (SIC) systems across their large cutter fleets. These systems have reached end of support by their manufactures. Equipment failures have created unit shortages.
- Support is only provided for SIC systems on the WMSL-418 class of cutters. Support for other classes is borne locally by the ship's crew.
- Cutters with unsupported SIC systems are using varying types of equipment that may not meet safety or security requirements.
- Finding best in class modern SIC solution that can be adapted across multiple Cutter Classes and is CG affordable to include maintenance and replacement costs.

Research Question(s):

1. What interior communications systems are employed by DoD and Industry?
2. What are the recommended alternatives for each class of CG cutter?
3. How can these recommended solutions be integrated into each class of CG cutter?
4. What are the recommended interior communications specifications for new CG cutter acquisitions?

NPS-23-E022

2023-6: Modeled Sustainment of the CG Major Asset Fleets for Improved Decision Making

Mission Need:
Assess the results of deferred maintenance caused by budget shortfalls.

Challenge:
- The CG currently lacks a methodology to determine/understand the long term operational and budgetary impacts of certain operational and maintenance decisions, potentially making short term decisions that are suboptimal on a longer horizon.
- This gap could be addressed by a model that informs budgetary decision making for surface and aviation asset maintenance actions, to include these capabilities:
    - Quantify the impact of maintenance funding shortfalls and the resulting deferments.
    - Evaluate alternative deferment courses of action at different funding levels.
    - Optimize the allocation of maintenance funding within a specified level.

Research Question(s):
1. What are the CG mission-need characteristics of the model?
2. What asset sustainment models are in use by industry and government?
3. What CG data is needed as inputs for an asset sustainment model?
4. Where is this data currently located and who are the data stewards?

NPS-23-E023
2023-16: Alternate Navigation Positioning Sources

Mission Need:

Navigation options in Global Positioning System (GPS)-degraded or -denied environments.

Challenge:

- Jamming and spoofing of the critical GPS signal has been a risk for navigators for several years, particularly in restricted water transits.
- The CG relies heavily on GPS Position, Navigation, and Timing (PNT) and lacks alternative methods of navigation.
- While the Department of Defense has developed several capabilities to identify and mitigate GPS jamming, capabilities are expensive and have had limited operational results.
- The CG has not fully evaluated alternate methods to continue mission operation while under a GPS denial of service attack.

Research Question(s):

1. What PNT solutions are currently employed by DoD and Industry?
2. What are the CG integration and support requirements for possible alternate PNT solutions?

2023-17: Develop Improved Sensor Performance Models for Search and Rescue (SAR)

Mission Need:

Time and cost effective methodology to incorporate sensor capabilities in SAROPS.

Challenge:

- CG assets have access to a variety of sensors that can be employed in the course of a SAR case.
- The potential benefit of many of these sensors is not currently captured within the Search and Rescue Optimal Planning System (SAROPS).
- The traditional approach of developing Lateral Range Curves (LRC), based almost exclusively on empirical data, is not sustainable.
- Modeling solutions to predict sensor effectiveness exist, and have been identified, but must be validated for CG applications prior to implementation.

Research Question(s):

1. Are there alternatives to developing empirical data-driven Lateral Range Curves?
2. What sensor-specific specifications are needed from vendors to build a performance model?
3. What sensor-specific test data should vendors be required to provide to validate their performance specifications?

NPS-23-E024
2022-19: Hazardous Substance Pollution Response Technology Analysis

Mission Need:

Improve hazardous substance release response readiness.

Challenge:

- Identify priority hazardous substance pollution risks in Area Contingency Plans (ACP), from coastal facilities with large quantities of hazardous substances to recurring hazardous-substance vessel transportation.
- ACP architecture is largely focused and based on oil- and petroleum spill response, not hazardous substances.
- Federal On-Scene Coordinator (FOSC) readiness and resiliency requires knowledge about hazardous substance response technologies, capabilities, and resources for adequate response to a chemical release.

Research Question(s):

1. How can hazardous substance pollution risks be cataloged to support FOSCs?
2. How can hazardous substance Material Safety Data Sheets (MSDS) be used to support FOSC readiness and resilience?
3. What hazardous substance response technology is available in the current market?

2023-12: Remote Diagnostic and Monitoring Systems for Technical Support Engineering

Mission Need:

Improve shore-side access to cutter engineering data enabling real-time troubleshooting.

Challenge:

- The CG does not employ a systematic method of transferring data to engineering service centers and product lines, thus hindering the ability to diagnose faults early to prevent failures before they occur.
- Supervisory Control and Data Acquisition (SCADA) technology is mature, however, the USCG requires standardized deployment across cutter classes.
- Targeted Condition-Based Maintenance (CBM), for improved asset availability and reduced life cycle costs, necessitates real-time data transfer and a streamlined shore-side analysis framework.
- Data transfer and analysis systems require design, vetting and certification prior to transition into the afloat community.

Research Question(s):

1. What SCADA technology is available to support this effort?
2. How can SCADA technology be retrofitted on CG cutters?
3. What is the required communications architecture needed to support remote diagnostics and monitoring for each CG cutter class?

NPS-23-E027

2023-14: Machine Learning – Predictive Analytics to Determine Target of Interest Position of Intended Movement

Mission Need:

Increase the likelihood of interdiction when deploying surface and air assets.

Challenge:

- Aligning surface and air assets to interdict Targets of Interest (TOI) is a challenge. These challenges hinder CG operational effectiveness.
- Employing an effective tool to predict the Position of Intended movement will increase TOI detections and can help improve patrol schedules/tactics.
- It may be the case that existing Commercial-Off-The-Shelf (COTS) and Government Off-The-Shelf (GOTS) solutions exist within the Department of Homeland Security (DHS) and/or the Department of Defense, but these have not yet been explored or incorporated into CG/partner operations in this domain.
- Selection of a tool or technology appropriate for this effort will depend on its availability to DHS, whether it can use training data set(s), and if it integrate effectively alongside CG systems.

Research Question(s):

1. What Position of Intended Movement tools are available across DoD and DHS?
2. How can this tool(s) be implemented in the CG?
3. What are the likely CONOPs to use a predictive analysis tool?

2023-4: Maximizing the Potential of a CG Boating Safety Application

Mission Need:
Adaptive mobile application that aggregates impactful maritime information.

Challenge:
- Integration of current best in class maritime applications presently available.
- Requirement for one stop shopping of Code of Federal Regulations and map data.
- Requirement for distress call feature for boater safety.
- Requirement for lean and common display format for application.
- Transition of legacy applications and associated data in a timely manner.
- Combing multiple data formats.
- Identify cyber security concerns and update when necessary, investigate software update challenges from a cybersecurity standpoint.
- Examine existing and future information requirements.
- Evaluate privacy concerns and mitigate Personally Identifiable Information concerns.
- Evaluate reporting timeliness guidelines.
- Designating potential data owner and associated responsibilities.

Research Question(s):
1. What commercial boating applications are available to the public?
2. What are the requirements for a CG Safe Boating application?
3. What are the privacy concerns for a Safe Boating application?
4. How should this application be developed and how should it be supported/maintained?