U.S. Coast Guard Autonomous Systems

Evergreen Pinecone

13-14 September 2023

FINAL REPORT

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NOTE: The information and recommendations contained in this report are derived from the collective knowledge and opinions of the participants in this Pinecone. Their inclusion in this report does not reflect an endorsement of any specific policy or recommendation by the United States Coast Guard.

"In order to meet the challenges of an increasingly dynamic operational environment, we must adapt to the rapid pace of technological development. Unmanned systems (UxS) play a key role and hold great promise to improve Coast Guard mission excellence. UxS can help us find mariners in distress. They can increase our capacity to detect illicit drug and migrant trafficking at sea so we can most effectively allocate finite boats, ships, and aircraft. UxS can be a powerful tool in the monitoring of Illegal, Unreported, and Unregulated (IUU) fishing around the world. In a changing Arctic, UxS can aid in the navigation of icebreakers, tracking of icebergs and increased vessel traffic, and monitor the growth of other commercial activities. Our future will employ UxS in an interconnected spectrum of interoperable systems and enable effective integration of artificial intelligence to deliver actionable data to Coast Guard operators in situations like these and many more. UxS that enable optimal human-machine teaming provide game-changing opportunities for the Coast Guard."

VADM Peter W. Gautier, USCG

USCG Unmanned Systems Strategic Plan (April 2023)

EXECUTIVE SUMMARY

The Office of Emerging Policy and Strategic Foresight (DCO-X) sponsored this Project Evergreen Pinecone workshop in collaboration with the Research and Development Center (RDC) and the U.S. Coast Guard Academy (USCGA). The event brought together a unique and diverse group of federal, academic, and industry participants to explore the state of the industry for autonomy technology and its impact and opportunities for the U.S. Coast Guard (USCG) across plausible futures. The event was held on 13-14 September 2023, at the Army DEVCOM ARL's Robotics Research Collaboration Campus (R2C2). This workshop achieved two main objectives: 1) Produce information to inform USCG strategies, operational approaches, and research efforts towards autonomous systems and 2) Identify future operational and research partners for engagement within the next 10 years to address USCG autonomous capabilities requirements. The workshop focused on framing future USCG strategies, operational approaches, and research areas to address the requirements, possible mission use, and regulation over the "near term" and the "future" out to 2048. The event output will help the Service formulate autonomous strategies, operational and tactical use cases, and focus R&D autonomous initiatives for the coming decades. The event also provided industry an opportunity to offer perspectives that will shape future engagement.

INTRODUCTION

This Evergreen workshop had 72 participants who came from within the Coast Guard as well as federal partner agencies including Space Force, the Air Force Research Laboratory, the Naval Research Laboratory, NASA Jet Propulsion Laboratory, the National Academy of Science, the Connecticut National Guard, the Department of Homeland Security Science and Technology Directorate, the Army Combat Capabilities Development Command, the Army Research Laboratory, the Defense Innovation Unit, the Naval Surface Warfare Center Corona, and the Naval Air Warfare Center China Lake. Other participants came from institutions of higher learning, such as West Point, the Air Force Academy, the Naval Postgraduate School, the University of Arizona, the University of Rhode Island, the Johns Hopkins University Applied Physics Lab, think tanks, and industry. The event featured three significant keynote speakers:

- Vice Admiral Peter Gautier, USCG, Deputy Commandant for Operations
- Brigadier General Stephanie R. Ahern, USA, Director of Concepts, Futures and Concepts Center
- Dr. Patrick Baker, Director, US Combat Capabilities Development Command, Army Research Laboratory

Evergreen Overview: Project Evergreen is the overarching strategic foresight program for the U.S. Coast Guard, designed to identify long-term risks, opportunities, and focus areas across multiple plausible futures over the next 25 years. This Evergreen Pinecone workshop is the third in an annual series of shorter, focused sessions organized by the RDC that bring together key operational, academic, and industry thought leaders for a deep dive on a specific category of organizational strategic risk.

- Each Evergreen Pinecone frames future USCG strategies, operational approaches, and research areas to address impact concerns specific to the topic through 2048.
- The event output helps the Service formulate adaptation, mitigation, resilience strategies and focus R&D initiatives for the coming decades.
- RDC supports Evergreen Pinecone workshops as Science Advisors to the Service.

Autonomous Systems Evergreen Pinecone Workshop Methodology: The participants were divided into three teams, each with a specific focus area and guiding questions. This Evergreen Pinecone allowed for a scan of the state of autonomy in and outside of the federal government. This effort was part gap analysis, part capability assessment, part internal and external and risk discussion. It allowed for the equities and perspectives of multiple stakeholders to be considered. The event further highlighted ongoing and planned activities of other federal and state agencies, organizations, and industry in the autonomy sector. This includes what these organizations have developed within the autonomous space, what they are developing next, what their legal considerations were and how the world community will govern this autonomy space. These issues are critical because autonomous systems are present today and will only grow within the Marine Transportation System (MTS). Autonomous systems offer the promise of being less expensive to operate, having less of an environmental impact and establishing components within the MTS that are safer to operate as goods and services are moved throughout the Maritime Global Commons. We are now in the fourth Industrial Revolution – events like this EVERGREEN will help position the service to address autonomy both within our organization and to our stakeholders.

KEY QUESTIONS FOR EACH TEAM

Team 1: USCG application of autonomy for mission execution and support

Team 1 focused on a strategic view of autonomy, to include physical systems such as uncrewed aerial systems (UAS) and uncrewed maritime systems (UMS) and digital applications such as artificial intelligence systems and synthetic decision making. These systems are increasing in prevalence with the advance of technology. This advance provides clear opportunities for USCG

adoption and incorporation of autonomous technology across its operational missions and support functions.

Team 1 further explored autonomous technologies and areas, missions, and functions within the USCG that could benefit from their adoption, highlighting key areas in need of deeper dives and future research.

Team 2: Analysis of autonomous systems we will regulate as part of the global Marine Transportation System

Team 2's governing assumption was that the USCG serves as the primary regulatory authority for the MTS, including U.S. flagged vessels and foreign vessels operating within U.S. waters. As the maritime industry adopts autonomous technology, the USCG will need to monitor, assess, and regulate its use. Successful regulation will require an understanding and analysis of the technology and its potential risks.

Team 2 further explored this area to help identify areas and specific technologies the USCG should research and investigate as it prepares to regulate autonomous systems within the MTS.

Team 3: Analysis of how to adapt to and counter autonomous technology adoption by nefarious actors

Team 3 explored the adoption of autonomous technologies by organizations outside of the USCG, partners, and the maritime industry. Team 3 also explored how autonomy may be used by adversaries and nefarious actors, how that use will impact the service, and how the service will need to adapt to maintain a competitive edge.

Team 3 further explored these topics to identify areas of research that will help the USCG prepare and adapt to others' adoption of autonomous technology.

Throughout the event, the participants were briefed by three key USCG Program Offices that contributed to the discussion through plenary presentations:

- Captain Thom Remmers, USCG, Program Manager CG UxS Office
- Captain Shannon Pitts, USCG, CG-2AI (Office of Intelligence), Artificial Intelligence
- Captain Mike Nasitka, USCG (Ret), CG-684 (C2/Navigation Program Manager)

The briefs largely centered on Project Minerva, an effort intended to fundamentally transform the future of Coast Guard operations, sharpen our competitive edge in a changing maritime domain, and improve service to the American public. It's focus includes revamping the Coast Guard data ecosystem to enable advanced and autonomous technologies. Data analytics and artificial intelligence, revolutionizing the world around us, are examples of technology enablers that will yield better maritime domain awareness and help us achieve decision advantage using data as our accelerant.

This autonomy EVERGREEN allowed an opportunity to take what the three USCG speakers provided and review them under the lens of the three research questions listed above.

KEY TAKEAWAYS

The USCG Unmanned Systems Strategic Plan: Released in March of 2023, this plan provided a starting foundation for the service regarding use, regulation of, and future engagement with autonomy and autonomous systems. The publicly released document provided a vision and way forward, along with strategic goals – all critical pillars for successful engagement. Its publication was an acknowledgement that a well-reasoned plan was needed because both the external and internal environment regarding UxS had changed. The plan also highlighted autonomous research that was done by the USCG Research and Development Center. By publishing a strategic plan, the uncertainty surrounding autonomy and autonomous systems would start to be addressed, including how to counter their use by nefarious actors.

The UxS Strategic Plan outlines several framing truths: Autonomous vessels are coming, there will be challenges in their regulation, safe operation, and cyber security. The Coast Guard will need to consider how autonomous capability can support a global force and 11 statutory missions. Additionally, the service must address talent management, considering current and projected personnel shortages, and identify missions or activities where autonomous capabilities could support mission execution with little drop in effectiveness (e.g., within the Aids-to-Navigation (ATON) mission, consider starting with UxS verification of aids and then scaling up in complexity to buoy inspection).

Autonomy and Mission/Operational Execution: The possible use of autonomous systems within the Coast Guard's 11 statutory missions was a significant part of the discussion, as was the need to develop integrated systems to counter autonomous threats above, on, and below the surface. From ATON to Ice Operations to Maritime Safety, every facet of Coast Guard operations stands to be affected by autonomous systems. Across all three teams, however, two specific Coast Guard mission use cases were highlighted by the participants: Search and Rescue (SAR) and Law Enforcement (LE).

SAR is part of the Coast Guard's historical legacy, and incorporation of autonomous systems offers great promise towards improving our efficiency and effectiveness in this mission. The teams identified many areas for exploration regarding UxS incorporation in SAR operations: ▪ *What are the most effective and efficient tactics, techniques, and procedures (TTP) for UxS conducting search?* ▪ *What would a hybrid-crewed/uncrewed SAR team look like – could UxS be used to search lower probability areas while crewed assets search the higher probability areas?* ▪ *Could swarm approaches be used to blanket an entire area then move onto the next, changing the current practice of track line searches?* ▪ *What updates are needed to the Coast Guard's Search and Rescue Optimal Planning System (SAROPS), the software used by the service's Search and Rescue Controllers to develop SAR plans for asset deployment?* ▪ *How do we ascertain sensor and search effectiveness for new assets and deployment strategies to retain our ability to calculate optimally effective searches?* ▪ *Could UxS packages be air-dropped in locations to immediately begin search area saturation while crewed assets are being activated?*

▪ *Could lift-capable UxS assets be employed effectively, e.g., air drop assets that could drop a raft, clothing, or supplies to a victim or even hoist/recovery capable UxS?*

One of the academic participants noted that new research from academic institutions such as the University of Melbourne could assist in this area. (The University of Melbourne advertised that they have embarked on a "Collaborative Autonomous Systems for Maritime Search and Rescue Using USVs and UAVs" project as part of their university Partner Project Program.) Peer reviewed publications have multiple articles on autonomy and search and rescue including a publication by Queralta, Raitoharju, Gia, Passalis and Westerlund on multi-UAV response to search and rescue using edge computing. As a final note, participants recognized that a key part of autonomous systems employment in SAR will involve examination of legal requirements. For example, what if a UxS asset causes injury to a victim, or if a survivor is "missed" by a UxS system, have we, in a legal sense, made the situation worse in some way?

The second key mission set discussed was Law Enforcement Operations. Autonomous systems could provide significant MDA capability, including situational awareness updates in real time. These capabilities could be useful in many ways: ▪ *Sensors could provide tip-and-cue detection and notification.* ▪ *They could sustain "sensor custody" or visual contact of a target of interest for a subsequent "hand-off" to an interdiction asset.* ▪ *They could be used to maintain MDA in remote areas where coverage would otherwise be scant or nonexistent.*

In addition, as demonstrated by the USCG Research and Development Center in their South Padre Island autonomy sprint in 2023, an autonomous sensor/MDA capability can detect and track numerous contacts, which allows additional assets a better opportunity to classify, identify, and interdict targets.

In addition to the two highlighted missions, there was significant discussion about how autonomous systems could be used to enhance MDA and logistical support in the polar regions. This could be in the form of additional monitoring capabilities, resupply, and/or logistic support in a contested (or austere) environment.

Regulatory Governance: As the maritime industry adopts autonomous technology, especially in the ATON mission, the USCG needs to comprehensively monitor, assess, and be ready to regulate its safe use including electronic charting and new navigational technology. Several Evergreen participants noted that the Coast Guard is behind in identifying and developing regulatory requirements associated with autonomous systems. Participants noted that USCG regulations should consider that the marine industry does not equate "autonomy" with "uncrewed." There needs to be a focus both within and outside of 12 miles – within the United States Territorial Seas and in the Maritime Global Commons.

As the Coast Guard develops its regulatory framework, vendors may come to the service with proprietary technology, but may not want to show the inner workings. How can this be addressed to the benefit of both the service and the vendor as decisions are made for autonomy governance? This is one place where the Coast Guard Research and Development Center could fulfill its role as science advisors. Conducting limited user evaluations through a rigorous test plan would generate the unbiased, scientific analysis, and regulatory

recommendations that will be needed. Creating new metrics to measure trust levels in the operationalization of emerging technology in the experimental design and/or test & evaluation plans would need to be considered.

When industry participants were asked what would define a trusted system, they made several recommendations: (1) A communications protocol between vessels and pilots that doesn't require a physical transfer, or alternatively, control protocols to make that physical transfer easier; (2) The USCG should develop standards to determine competency of autonomy operations like a driver's test. A potential starting point would be a series of specific simulations first, and then closed course or open water testing. This could be the role for classification organizations and (3) The USCG will need to further develop requirements for the service to deploy "Smart Ship" capable vessels. An example would be a requirement for a fully autonomous ship to dock and unload cargo. The Maritime Professional publication, on October 26, 2022, defines a Smart Ship as:

> "Smart Ships, taking into account the applications of worldwide economic concepts and addressing the maritime sector regulations, aims to supply multi-layer optimization in fuel consumption, CO2 and carbon emissions control, and energy efficiency when full-fledged implementation is completed. It'll capitalize on available COTS technologies and can deliver an ICT & IoT-enabled holistic cloud-based maritime performance & monitoring system, for the whole lifecycle of a vessel, aimed to fully optimize the energy efficiency, emissions reduction, and fuel consumption, with regards to introducing circular economy concepts within the maritime field."

What should policy look like as shippers and ports develop this capability? One specific rule that was mentioned was Chapter V, regulation 24 of the International Convention for the Safety of Life at Sea (SOLAS) 1974 which requires manual control of a vessel's steering be established in "dangerous navigation situations". How is this achieved with an autonomous system? If a system is "remotely monitored" by a human, who can quickly take operational control, and can this meet the requirement?

There are several examples of places where governance is important within a Smart Ship type vessel including: basic controls/steering, obstacle avoidance, and docking. The USCG autopilot regulations/requirements should be extended to uncrewed, semi-autonomous, and optionally manned vehicles on the way to fully autonomous uncrewed vessels.

Several EVERGREEN participants highlighted an article by Katie Dickinson (November 21, 2019) writing in the Michigan Law Journal that stated:

> "Autonomous ships are expected to improve safety, reduce operating costs, increase efficiency, and minimize the effects of shipping on the environment. An increased reliance on autonomy will reduce the chance for human error thereby improving safety. Human error accounts for 75-96% of marine accidents and accounted for $1.6 billion in losses between 2011 and 2016. Operational costs are also expected to decrease as there will be little to no crew on board. Crew costs can constitute up to 42% of a ship's operating costs. If there is no crew then accommodations such as living quarters, air conditioning and cooking facilities can be eliminated. Further, a ship free from crew accommodations and seafarers will make voyages more efficient because the ship will have an alternate design and an increased

> carrying capacity. Lastly, autonomous ships may prove to be better for the environment than current vessels. The ships are expected to operate with alternative fuel sources, zero-emissions technologies, and no ballast."

All the issues proffered by Dickinson need to be part of the service's considerations as autonomy governance is developed.

Analysis of How to Adapt to and Counter Autonomous Technology Adoption by Nefarious Actors

During the EVERGREEN event this team conducted a wide-ranging discussion on the use of autonomy by non-state actors, criminals, and terrorists. Because of the nature and context of this issue the discussions were general. The published work of the Brookings Institution's Sarah Kreps (November 2021) was mentioned. Kreps noted:

> "Advances in artificial intelligence (AI) have lowered the barrier to entry for both its constructive and destructive uses. Just a few years ago, only highly resourced states and state-sponsored groups could develop and deploy AI-empowered drones, cyberattacks, or online information operations. Low-cost, commercial off-the-shelf AI means that a range of nonstate actors can increasingly adopt these technologies."

The consensus from the group was that this issue is appropriate for further analysis by the Coast Guard's Intelligence Community in a secure setting.

RECOMMENDATIONS

While the two-day discussion was a good starting point, the participants provided several specific recommendations to influence operationalization of the UxS Strategic Plan and future service autonomy research and development initiatives:

1) **The USCG needs Autonomy R&D Partnerships:** Although the current research partnerships within the commercial, academic, and intermural spaces are good, there is a need for expansion. The RDC should seek out funded collaborations with other DoD research labs/universities, develop organizational expertise and competency in AI-enabled autonomy, and explore potential public-private partnerships. Some participants recommended starting these efforts on lower risk applications (e.g., buoys) before ramping up to more complex or critical areas (e.g., SAR).
2) **Funding for USCG R&D Autonomy development, operation sustainment for continuous updates, and training**: The USCG (RDC) needs a standing long-term autonomy program (vice individual projects and Coast Guard Headquarters vender technology demonstrations) to develop and ensure service competency, to maintain technological literacy, and to benchmark friendly and adversarial technology progression. This program needs an augmentation staff and funding dedicated to autonomy research which would provide the capability for sustained development and integration testing of autonomous systems including maintenance and training. In addition, the Coast Guard Academy should have dedicated faculty to collaborate with the RDC on autonomy research. This work could include enhanced learning/courses and

decision aids to guide autonomy usage as human/machine interfacing occurs and progresses.

3) **Evaluation of COTS Autonomy Systems for USCG use**: Industry is sprinting ahead in its collective development of air, surface, and subsurface autonomous systems. The Coast Guard needs to develop a rigorous, quantitative way to evaluate each project starting with a clear understanding of what the system needs to do. The system(s) chosen for limited user evaluations need to have reliability, including robustness and redundancy. Examples of autonomous capability that the RDC could investigate include:
   - Research on vessel classification and identification using optical sensors from onboard platforms.
   - Ensuring that autonomous capabilities have all-domain sensor fusion, correlation, and composite track generation.
   - Leveraging work being done in de-centralized dynamic autonomous mission planning by other agencies.
   - Consideration of systems that can predict target location and track forecast latitude/longitude using all-domain sensor data.
   - Embedment of a robust disabling process to prevent a rogue autonomous vessel or aircraft from doing harm to MTS.
4) **MINERVA Linkage**: Autonomous capability offers a multi-dimensional (air/surface/subsurface) opportunity to both provide and leverage data as a catalyst for USCG operational planning and execution. For this reason, it is important to ensure that the lines of effort highlighted within the MINERVA construct are linked with autonomy policy and connected to a future Autonomy Technology Roadmap.
5) **The USCG Should become a Peer Competitor for Autonomy with the Navy**: One industry representative had an out of the box recommendation: The U.S. Navy lacks a "peer competitor" for autonomous training purposes. The Coast Guard's RDC could serve as a funded opposition force to play a "near peer adversary" for Navy exercises. This would require the Navy to provide experimentation funds to the USCG and allow the RDC "opposition force" full latitude to procure and experiment with new autonomous capabilities.
6) **Engagement of Stakeholders**: The USCG needs to engage with both autonomy industry developers, MTS stakeholders (e.g., IMO, America's Waterway Operators, and class societies), and policy makers to ensure all voices are represented in developing policy, regulation, and operations related to autonomous systems in the maritime environment.
7) **Neural Networks and decision-making**: The Coast Guard must ensure that autonomous reasoning combining Deep Neural Networks (DNN) and symbolic reasoning is employed. Part of this effort needs to be the capability to operate in an adversarial environment.
8) **Counter-UxS (C-UxS)**: Adversarial use of autonomous systems is, and will continue to be, a challenge for the USCG. The service needs to update or develop policies, technologies, and practices for use of C-UxS technologies. Some will be enhancements to current technologies and policies, some may be new. Challenges exist across several USCG mission areas including Ports, Waterways, and Coastal Security, and Maritime Interdiction Operations (MIO). Threat vectors include aerial, surface, and subsurface. There have been great strides in C-UAS but the other two threat vectors are equally concerning. The USCG and intelligence partners should continue its monitoring and

analysis of adversarial intent using autonomy. PWCS and MIO operations are just two of many use cases.

9) **Autonomy Post-Graduate Education**: The Department of Homeland Security should create a Post-Graduate Degree opportunity for a Master's in Autonomy and Robotics that could support the needs of components including USCG, ICE, CBP and FEMA. In addition to establishing a graduate opportunity, the Coast Guard could take advantage of currently offered degree programs and see if a selectee would be willing to do their thesis on autonomous capability application in the maritime environment. Potential degree programs could be Operational Research (for modeling or AI work), Mechanical/Electrical Engineering (for systems work), law, or even Maritime/Public Policy (to examine policy and regulation implications).
10) **Incorporate the Maritime Academies and the Merchant Marine Academy in developing training guidelines**: The Coast Guard is not alone in developing a training package for autonomy operations. Partnerships with the United States Merchant Marine Academy and state maritime colleges could be areas of mutual collaboration. These schools have a deep bench strength in MTS operations. Their expertise, perspective, and ability to reach the next generation of MTS operators could be invaluable. The partnership should include maritime autonomous systems education, workforce development, and work on common approaches for introducing autonomous ships into port operations.
11) **Autonomy use in Maintenance and Inspection:** Use Autonomous capabilities with AI/ML to develop condition-based and preventive maintenance programs.
12) **Interagency R&D Opportunities/Engagement**: Industry and academic representatives voiced a strong desire to work with the USCG RDC on developing Cooperative Research and Development Agreements (CRADA) in support of joint Technology Transfer and joint experimentation focused on multiple applications of autonomy. The USCG RDC should continue working closely with Navy Science advisors on experimentation with private industry at the USN numbered fleets and within the Naval Surface Warfare Centers.
13) **Data Management, Use and Infrastructure**: While the issue of data management is being addressed head-on by the Data Management Office and CG-2AI, it was universally discussed in all three Evergreen teams, so its importance needs to be highlighted. Specifically, use of autonomous systems is dependent on the items below, which warrant continued USCG focus and investment:

    - **Data Infrastructure**: Robust data infrastructure is needed to collect, store, and manage diverse data types, including sensor data, satellite imagery, historical records, and real-time information.
    - **Data Quality Assurance**: Data is only truly useful when it is accurate. Data quality through validation, cleaning, and normalization processes is a key enabler.
    - **Data Labeling**: Supervised learning tasks, such as object detection and classification, are reliant on labeled data. Labeling is no small undertaking and must be incorporated as part of a data management plan.
    - **Data storage**: Autonomous data needs to be stored in a manner to allow retrieval and display.

- **Interagency Collaboration**: It is a force multiplier to have so many players working in this space, including collaborations with other maritime agencies, research institutions, and industry partners to access and share data resources and expertise.

Technology Roadmap

Technology Road Maps are useful tools for framing research, development, collaboration, and technology analysis over time. The below notional road map was synthesized from participant input. It will serve as milestone goals for validating research focus today and in outyear USCG R&D Congressional Justifications and research partnerships that will position USCG to unlock the full potential of autonomous systems.

USCG Autonomous Systems Roadmap

		2024 ····· 2034		
		Immediate	**Short-Term**	**Longer-Term**
Autonomous Evergreen 2023	**Autonomous Technology (Coast Guard Research Investment)**	➢ **Develop multi-spectral imagery (AI/ML) partnerships.** • Use available GOCO Systems in demonstrations. • Increase use of space-based SAR Data as an MDA enabler. • Use AI/ML to fill and categorize data into forms. • Focus on understanding how nefarious actors could use these systems in Port Security, IUU, or EZ violation scenarios. • Focus on what industry and academia are working on and doing. ➢ **Develop a software acquisition framework for DHS/CG** ➢ **Review data transport and storage retrieval** • Legal authorities • Cost reduction • Data as a service • LOAC & Authorities Model ➢ **sUAS and USV detect and avoid capability**	➢ **Develop specific value proposition for the use of autonomy within each mission.** • Develop decision aids to support uncrewed systems using autonomous technology. • Implement field systems with capability to protect CG units from autonomous uncrewed systems and to validate the threat. • Conduct a formal Gap Analysis of all 11 missions through the lens of autonomy. ➢ **Man <-> Machine decision-making communication: hand-off, transparencies.** ➢ **FMV edge processing using shared world model.** • Manpower, reduction in PED (Processing, Exploitation, Dissemination). ➢ **Fusion: Intel value of information – optimized orchestration, sense-making.**	➢ **Map USCG activities to locate areas where uncrewed capability can be used.** ➢ **Invest in modular, extendable open architecture platforms – important in supporting missions and transitioning to data centric IT systems. Look to ATON first.** ➢ **Autonomous Refueling** • Ariel mothership with cued offspring to search: ○ Autonomous collaboration among them as environment changes or bad-guys scatter. ○ Automation of adversarial intent warning and indicators forecasting their threat vectors. ○ Risk of vulnerability due to predictability.

	2024 ····· 2034		
	Immediate	**Short-Term**	**Longer-Term**
Research Partnerships	➢ Ensure resilient skills for autonomous systems. ➢ USAF S&T Ecosystem Navy Development OSD CDAO Office ➢ USAF AFRL/RQ & Chief Ethics Office (CDAO) ➢ USAF Research Lab TCO Office or Sensors Directorate ➢ Army DEVCOM ARL R2C2 AI/ML, perception and ground platforms that could supplement what USCG is doing. Consider placing an ARL ground autonomy stack on a USCG platform that could be used in the Arctic to test the bounds of current autonomy, along with providing ARL with a rich data set. ➢ MINERVA Linkage: Autonomous capability offers a multi-dimensional (air/surface/subsurface) opportunity to both provide and leverage data as a catalyst for USCG operational planning and execution. For this reason, it is important to ensure that the lines of effort highlighted within the MINERVA construct are linked with autonomy policy and connected to future Technology Roadmaps. ➢ The USCG RDC should plan a new autonomous sprint that capitalizes on lessons learned from earlier testing. Both strategic and operational input should be used to focus the test plan.	➢ Explain how autonomous capability can be used in logistics support and refine, especially in the Polar Region. ➢ DARPA I20 Office | AFRL /711th HPW | AFOSR Cognitive Computation | LEIDOS, BAE, Raytheon ➢ USAF ACC NASIC (National Air & Space Info Center) ➢ DARPA, OSD R&E | USAF Research Lab – Sensors Directorate ➢ The USCG RDC needs to expand on its integration research between surface systems and both UAS and USS. The work done in 2023 at South Padre Island in which an RDC autonomous craft conducted real work integration with a CASA aircraft could be expanded.	➢ National Guard State Partnership Program: There are over 100 countries partnered with the Guard via security cooperative efforts. May deal with IUU and autonomy. ➢ Focus on assessing autonomous capabilities of hostile actors to predict or forecast their COAs.