FDP Amendment
Number 6

Pass-Through Entity (PTE)	Subrecipient
University of Alaska Anchorage	Entity Name: Monterey Bay Aquarium Research Institute
	Email Address:
Aaron D. Dotson	Principal Investigator: Brett Hobson

Project Title: Centers for Homeland Security

PTE Federal Award No:	Federal Awarding Agency:
17STADA00001-05-01	Department of Homeland Security

Revised Subaward Period of Performance:	Amount Funded This Action:	Subaward No:
Start Date: September 1, 2017 End Date: Mar 31, 2022	$ 90,144.00	UAA P0516972

Total Amount of Federal Funds Obligated to Date:	Cost Share:	Subject to FFATA:	Automatic Carryover:
$ 831,284.00	○ Yes ◉ No	◉ Yes ○ No	○ Yes ◉ No

Amendment(s) to Original Terms and Conditions

This Amendment revises the above-referenced Subaward Agreement as follows:

1. This modification is issued to incorporated any and all of the applicable changes as mandated by the Year 8 Notice of Award received from the Department of Homeland Security (DHS) for the Center of Excellence-Arctic Domain Awareness Center (ADAC) project.

2. Carryforward has been approved by the Department of Homeland Security.

3. This modification is issued to extend the subaward period of performance through March 31, 2022. The subaward period of performance is January 9, 2015 through March 31, 2022.

4. This modification is issued to increase the subaward by $90,144 from $741,140 to $831,284 to fund program year 8 for the period July 1, 2021 through March 31, 2022.

5. This modification is issued to incorporate the following attachments:
* Notice of Award
* Special Terms and Conditions (updated for closeout procedures)
* Year 8 Work Plan as Approved by the Department of Homeland Security
* Year 8 Budget as Approved by the Department of Homeland Security
* Year 7 Carryforward request
* Information Protection Plan (not updated, just reapproved by UAA and DHS)
* Safety Plan (not updated, just reapproved by both by UAA and DHS)

Note:
* Information Protection Plan (not attached was reapproved by UAA and DHS- no changes made)
* Safety Plan (not attached was reapproved by UAA and DHS- no changes made)

For your consideration:
1. An exception to the end date may be made for field testing but UAA needs to be consulted and discuss with DHS prior to field testing extending past Mar. 31, 2022.
2. DHS has notified UAA that this is a closeout year; there will not be any no-cost extensions granted. DHS has notified UAA that all research projects must conclude Mar. 31, 2022. However if funding is needed for students only to continue through the semester, requests need to be made to UAA to vet with DHS with specific additional timeframe and scope of work. Under 2 cfr 200, all subawards will still have the 90 day closeout period that includes final report submission (funds can be used for final report submission but all invoices must be received no later than June 30, 2022).

For clarity: all amounts stated in this amendment are in United States Dollars.

All other terms and conditions of this Subaward Agreement remain in full force and effect.

By an Authorized Official of PTE:	By an Authorized Official of Subrecipient:
_____ _____	_____ September, 27, 2021
Name: Maren O Savage, CRA, GWCCM Date	Name: Basilio Martinez Date
Title: Restricted Funds Management Officer	Title: CFO

1. DATE ISSUED *MM/DD/YYYY*
07/02/2021

1a. SUPERSEDES AWARD NOTICE dated 07/01/2021
except that any additions or restrictions previously imposed remain in effect unless specifically rescinded

2. CFDA NO.
97.061 - Cooperative Agreements

3. ASSISTANCE TYPE Cooperative Agreement

4. GRANT NO. 17STADA00001-05-01
Formerly 2014ST061ML0002

5. TYPE OF AWARD
Research

4a. FAIN 17STADA00001

5a. ACTION TYPE Post Award Amendment

6. PROJECT PERIOD *MM/DD/YYYY*
From 09/01/2017 **Through** *MM/DD/YYYY* 06/30/2022

7. BUDGET PERIOD *MM/DD/YYYY*
From 07/01/2021 **Through** *MM/DD/YYYY* 06/30/2022

8. TITLE OF PROJECT (OR PROGRAM)
Centers for Homeland Security

Department of Homeland Security

DHS Grants and Financial Assistance Division (GFAD)

245 Murray Lane, SW
Mail Stop 0115
Washington, DC 20528

NOTICE OF AWARD

AUTHORIZATION (Legislation/Regulations)
Homeland Security Act of 2002, Public Law 107-296, 6 U.S.C 188

9a. GRANTEE NAME AND ADDRESS
UNIVERSITY OF ALASKA ANCHORAGE
3211 Providence Dr
Anchorage, AK 99508-4614

9b. GRANTEE PROJECT DIRECTOR
Mr. Douglas Causey
3211 PROVIDENCE DR
ANCHORAGE, AK 99508-4645
Phone: 907-786-1021

10a. GRANTEE AUTHORIZING OFFICIAL
Heather Paulsen
3211 Providence Dr
University of Alaska Anchorage
Anchorage, AK 99508-4614

10b. FEDERAL PROJECT OFFICER
Mr. Theo Gemelas
7th and D Street, SW
Washington, DC 20407
Phone: 202-254-6108

ALL AMOUNTS ARE SHOWN IN USD

11. APPROVED BUDGET (Excludes Direct Assistance)

I Financial Assistance from the Federal Awarding Agency Only

II Total project costs including grant funds and all other financial participation — **II**

a.	Salaries and Wages		331,337.00
b.	Fringe Benefits		89,180.00
c.	Total Personnel Costs		420,517.00
d.	Equipment		0.00
e.	Supplies		300.00
f.	Travel		18,820.00
g.	Construction		0.00
h.	Other		431,758.00
i.	Contractual		1,291,515.00
j.	TOTAL DIRECT COSTS	→	2,162,910.00
k.	INDIRECT COSTS		271,973.00
l.	**TOTAL APPROVED BUDGET**		2,434,883.00
m.	Federal Share		2,434,883.00
n.	Non-Federal Share		0.00

12. AWARD COMPUTATION

a. Amount of Federal Financial Assistance (from item 11m)	2,434,883.00
b. Less Unobligated Balance From Prior Budget Periods	1,434,883.00
c. Less Cumulative Prior Award(s) This Budget Period	1,000,000.00
d. **AMOUNT OF FINANCIAL ASSISTANCE THIS ACTION**	0.00
13. Total Federal Funds Awarded to Date for Project Period	21,985,091.00

14. RECOMMENDED FUTURE SUPPORT
(Subject to the availability of funds and satisfactory progress of the project):

YEAR	TOTAL DIRECT COSTS	YEAR	TOTAL DIRECT COSTS
a. 6		d. 9	
b. 7		e. 10	
c. 8		f. 11	

15. PROGRAM INCOME SHALL BE USED IN ACCORD WITH ONE OF THE FOLLOWING ALTERNATIVES:

a. DEDUCTION
b. ADDITIONAL COSTS
c. MATCHING
d. OTHER RESEARCH (Add / Deduct Option)
e. OTHER *(See REMARKS)*

b

16. THIS AWARD IS BASED ON AN APPLICATION SUBMITTED TO, AND AS APPROVED BY, THE FEDERAL AWARDING AGENCY ON THE ABOVE TITLED PROJECT AND IS SUBJECT TO THE TERMS AND CONDITIONS INCORPORATED EITHER DIRECTLY OR BY REFERENCE IN THE FOLLOWING:

a. The grant program legislation
b. The grant program regulations.
c. This award notice including terms and conditions, if any, noted below under REMARKS.
d. Federal administrative requirements, cost principles and audit requirements applicable to this grant.

In the event there are conflicting or otherwise inconsistent policies applicable to the grant, the above order of precedence shall prevail. Acceptance of the grant terms and conditions is acknowledged by the grantee when funds are drawn or otherwise obtained from the grant payment system.

REMARKS (Other Terms and Conditions Attached - ● Yes ○ No)

This modification approves the release of restriction on the Year 8 project named ARCTICE for $60,401 per email dated Friday, July 2. No other funds are approved. Previous terms and conditions remain in effect.

GRANTS MANAGEMENT OFFICIAL:

Jacqueline Greely, Grants Officer
7th And D Street SW
Washington, DC 20407-0001
Phone: (202)447-0724

17.OBJ CLASS 4102	**18a. VENDOR CODE** 92600047	**18b. EIN** 926000147	**19. DUNS** 076664986	**20. CONG. DIST.** 00
FY-ACCOUNT NO.	**DOCUMENT NO.**	**ADMINISTRATIVE CODE**	**AMT ACTION FIN ASST**	**APPROPRIATION**
21. a. U13I70130803	b. RSUP21U31I	c. ADA1	d. $0.00	e.
22. a.	b.	c.	d.	e.
23. a.	b.	c.	d.	e.

Federal Financial Report Cycle			
Reporting Period Start Date	Reporting Period End Date	Reporting Type	Reporting Period Due Date
01/01/2018	12/31/2018	Annual	03/31/2019
01/01/2019	12/31/2019	Annual	01/30/2020
01/01/2020	06/30/2020	Annual	07/30/2020
07/01/2021	06/30/2022	Final	09/28/2022

ADAC Special Terms and Conditions

By signing this Research Subaward Agreement, subrecipient makes the certifications and assurances specified in the Research Terms and Conditions of the Department of Homeland Security Cooperative Agreement. In addition to the terms and conditions, the following also apply effective as of the fully executed Research Subaward Agreement:

1. Subrecipient must adhere to the Information Protection Plan approved by the Department of Homeland Security.

2. Subrecipient must adhere to the Research Safety Plan approved by the Department of Homeland Security.

3. Expanded authority is extended to the subrecipients; any budget deviations within 5% of total approved budget can be moved between categories is allowed following normal federal regulations and rules; budget is to not exceed the approved budget listed on the cover page. Any budget deviations above 5% require prior approval from the University of Alaska Anchorage and requests need to be routed to the Administrative and PI contacts as listed in Attachment 3a.

4. If approved by the University of Alaska Anchorage and subsequently the Department of Homeland Security, a second-tier subaward agreement may be issued. If a second-tier subaward agreement is issued all terms and conditions of the Department of Homeland Security as well as the following special terms and conditions (#1, 2, 6, 11, and 14) found in this subaward agreement.

5. As requested by the Department of Homeland Security, all requests regarding programmatic and budgetary questions and concerns should be routed to the University of Alaska Anchorage Administrative and PI contacts as listed in Attachment 3a and not directly to the Department of Homeland Security.

6. The Department of Homeland Security expects funds to be expended in the appropriate budgetary period; therefore, requests for no cost extensions will not be granted.

7. While the expectation from the Department of Homeland Security is that all funds will be expended, if carryforward of prior year funding is needed, all requests must be submitted to the University of Alaska Anchorage Administrative and PI contacts as listed in Attachment 3a no later than February 28th prior to subsequent incremental funding. No carryforward will be approved in the final year of the Cooperative Agreement.

8. The Department of Homeland Security discourages foreign travel unless the trip is critical to the research. To ensure appropriate approvals, requests for foreign travel must comply with ITAR policies and need to be requested to the University of Alaska Anchorage Administrative and PI as shown in Attachment 3a no later than 90 days prior to the travel.

9. The Department of Homeland Security typically does not allow equipment purchases; however if equipment is necessary please submit a written request to the University of Alaska Anchorage Administrative and PI as shown in Attachment 3a for approval. The University of Alaska Anchorage will seek appropriate approval on your behalf from the Department of Homeland Security.

10. If the research involves Human Subjects or Animals, please submit approved protocols with the executed Research Subaward Agreement.

11. The Department of Homeland Security requires that all publications are reviewed prior to print; therefore, all publications related to this grant are to be submitted 90 days in advance of the publication. Subrecipient grants to the University of Alaska Anchorage an irrevocable, royalty-free, non-transferable, non-exclusive right and license to use, reproduce, make derivative works, display, and perform publicly any copyrights or copyrighted material (including any computer software and its documentation and/or databases) first developed and delivered under this Subaward Agreement solely for the purpose of and only to the extent to meet the obligations to the Federal Government under this award.

12. Subrecipient grants to the University of Alaska Anchorage the right to use data created in the performance of this Subaward Agreement solely for the purpose of and only to the extent required to meet obligations to the Federal Government under its Prime Award.

13. Subrecipient shall report any financial conflict of interest to the University of Alaska Anchorage's Administrative and PI contacts as designated in Attachment 3a. Any financial conflicts of interest identified shall subsequently be reported to the Department of Homeland Security. Such report shall be made before expenditure of funds authorized in this Research Subaward Agreement and within 45 days of any subsequent identified financial conflict of interest.

14. Subrecipient must have a financial conflict of interest policy which by execution of this Subaward Agreement complies with 42 CFR 50. If subrecipient does not have a financial conflict of interest policy that complies with 42 CFR 50 then subrecipient will adhere to the University of Alaska Anchorage Conflict of Interest policy.

15. The parties agree there will be no classified research performed under this Subaward Agreement.

16. Work plans for subsequent funding need to be submitted to the University of Alaska Anchorage no later than January 31st.

17. The University of Alaska Anchorage may issue non-substantive changes to the Period of Performance and Budget bilaterally. Except as expressly set forth in this section, no subsequent amendment, modification or addition to this Subcontract will be binding upon the parties hereto unless reduced to writing and signed by the respective Authorized Official Representatives of each party.

18. Subsequent yearly funding is based on the availability of funds and satisfactory progress as approved by the Department of Homeland Security and the University of Alaska Anchorage. No additional funding is guaranteed.

Reporting Requirements:

Annual Progress Reports. Subrecipient shall submit annual progress reports to the University of Alaska Anchorage Administrative and PI contacts listed in Attachment 3a no later than August 10th of each year of funding. Final Progress report is due no later than thirty (60) days from the end date of the Subaward Agreement. The Progress report should describe accomplishments and significant research findings derived from the work conducted under this agreement.

Property Reports. If property is acquired under this Agreement and property reports are a requirement of the prime award, Subrecipient shall submit a report of equipment purchased to the University of Alaska Anchorage Administrative and PI contacts listed in Attachment 3a within thirty (30) days of the Cooperative Agreement end date.

Invention Reports. If any inventions or discovery is made in connection with this Agreement, Subrecipient shall submit a report of inventions to the University of Alaska Anchorage PI as listed in Attachment 3a stating the nature of the invention and the names of the inventors within thirty (30) days of the Cooperative Agreement end date.

Arctic Domain Awareness Center (ADAC)

A DHS Science and Technology Office of University Programs,

Center for Maritime Research

ADAC work plan for Program Year 8:

1 July 2021 - 30 June 2022
Version 1.3

Submitted by ADAC leadership team to DHS S&T OUP

14 June 2021

Douglas Causey, PhD, Principal Investigator, University of Alaska, Anchorage (UAA)
Nettie Labelle-Hamer, PhD, Research Director, Vice Chancellor of Research at University of Alaska Fairbanks (UAF)
Randy Kee, Maj Gen (Ret.) USAF, MS, Executive Director, UAA and Commissioner, U.S. Arctic Research Commission
Heather Paulsen, MBA, Finance Director, UAA
LuAnn Piccard, MSE, PMP, Project Management Director, UAA
Jason Roe, USCG (Ret), Assistant Director & Senior Research Professional, UAA
Elizabeth Matthews, MS, Education and Administrative Manager, UAA
Connor Keesecker, BA, Research and Communications Associate, UAA

Contents

ARCTIC DOMAIN AWARENESS CENTER (ADAC) YEAR 8 WORK PLAN EXECUTIVE SUMMARY.. 4

CENTER MANAGEMENT PROCESSES 6
Implementation..... 7
Organization and Leadership. 7
ADAC Executive Counselors. 11
ADAC Overall Management Approach and Allocation of Effort. 12
ADAC Review Group and Project Evaluation Process. 14
ADAC Project Evaluation process to assess program activity. 15
ADAC Research Transition Process. 16
ADAC Strategic Communications Plan..... 18
USCG and Key Stakeholder Engagement..... 19

ADAC PROJECT DESCRIPTIONS ALIGNED TO DHS CMR FOA THEMES:..... 21

THEME 1: MARITIME RISK, THREAT ANALYSIS AND RESILIENCE RESEARCH PROJECTS:.... 21
PROJECT: Oil Spill Modeling for Improved Response to Arctic Maritime Spills: The Path Forward..... 21
PROJECT: Arctic Facilities and Infrastructure Environmental Change Risk Index..... 31

THEME 2: MARITIME DOMAIN AWARENESS (MDA) RESEARCH 46
PROJECT: Arctic Ice Conditions Index (ARCTICE)..... 46
PROJECT: Arctic Vessel Monitoring Geofencing/Alert Awareness..... 63
PROJECT: Remote Unmanned Aircraft System (UAS) Inspection and Response Team Development in the Bering Strait Region..... 69
PROJECT: Alaska and Arctic Maritime Communications and Connectivity Analysis (AAMC&CA) 93

THEME 3 – MARITIME TECHNOLOGY RESEARCH:..... 108
PROJECT: Development of Propeller Driven Long Range Autonomous Underwater Vehicle (LRAUV) System for Under-Ice Mapping of Oil Spills and Environmental Hazards..... 108
PROJECT: Arctic Response-related Technologies: Strengthening Partners in Arctic Industry (SPAI) Symposium 128
PROJECT: Arctic Medium- and Long-Term Environment (Arctic MaLTE) Workshop 131

THEME 4: INTEGRATION OF SCIENCE AND ENGINEERING WITH MARITIME SECURITY GOVERNANCE AND POLICY RESEARCH..... 138

THEME 5: END-TO-END (E2E) 138

THEME 6: INTEGRATED EDUCATION..... 138
PROJECT: Minority Serving Institute (MSI) and Significant Minority Enrollment (SME) Workforce Development (WFD) Fellowship Program. 140
PROJECT: ADAC Integrated Minority Serving Institute (MSI) and Significant Minority Enrollment (SME) Arctic Summer Intern Program (ASIP)..... 144

APPENDIX A: ACRONYMS 148

List of Figures

Figure 1 ADAC Center Leadership. 9

Figure 2 ADAC's Executive Counselors 11

Figure 3 Oil spill model inputs and outputs. (a) NOAA's GNOME and other oil transport and weathering models in relation to inputs and outputs for Arctic spills. 26

Figure 4 Ellipse encompasses component of the oil spill models that will be the focus of Year 8 AMSM efforts. 26

Figure 5 AMSM Year 8 Working Group will determine the inputs to the oil transport and weathering models needed for Arctic spills. 27

Figure 6 ARCTICE Visualization Charts providing graphic output of RIO values. 57

Figure 7 Unalakleet, AK. 73

Figure 8 Drone footage taken of a Modern Blanket Toss mission in Shishmaref, Alaska, in April 2014. (Photo courtesy Charlie Parr/Alaska Upward Bound). 75

Figure 9 Unalakleet tank farm. Photo courtesy of Unalakleet Economic Development Plan 2014-2019. 77

List of Tables

Table 1 Tasks and associated metrics for direction and management of established projects 12

Table 2 Tasks and associated metrics for continuation of Year 4, 5, and 6 research initiatives. 13

Table 3 Tasks and associated metrics for conducting outreach, engagement, and communications. 13

Table 4 Tasks and associated metrics for conducting education, outreach, and workforce development efforts. 14

Table 5 Project Tasks and Milestones: 86

Arctic Domain Awareness Center (ADAC) Year 8 Work Plan Executive Summary

The Arctic Domain Awareness Center (ADAC) is a U.S. Department of Homeland Security (DHS) Science and Technology (S&T) Office of University Programs (OUP) Center of Excellence (COE) in Maritime Research.

ADAC supports the U.S. Coast Guard (USCG) and other DHS maritime missions in order to improve capability for Arctic search and rescue, humanitarian assistance, disaster response, and security. This includes efforts to "enable the decision maker" across those mission sets.

In accordance with the DHS S&T OUP Notice of Funding Opportunity (NOFO), ADAC's Program Year 8 is a concluding year of funding under the existing DHS S&T OUP-University of Alaska Anchorage Cooperative Agreement. Following Year 8, ADAC anticipates a transition to an Emeritus Center in relation to DHS S&T OUP.

Accordingly, ADAC looks to the coming program year to ensure full transition of concluded research, advance research to effect suitable transition, complete a final year of innovation of education programs and activities, and publish conducted research. Outside of the work plan, University of Alaska personnel associated with ADAC will continue to seek sponsor diversification.

As core part of the ADAC mission, (even in the concluding year of funded DHS S&T OUP support), is to continue to foster the next generation of scientists and engineers devoted to the discovery, development, and improvement of technologies and applications for Arctic Maritime Domain Awareness, Response, and Resilience. During Program Year 8, ADAC will continue to work with and mentor our student Fellows, presently at different stages in their studies, to ensure their successful transition to the Homeland Security Enterprise workforce once they graduate. ADAC Center leadership will continue to support student transition efforts with enrichment efforts that will enable their success.

ADAC's Year 8 Work Plan management and administrative processes (Section II) highlights the Center's continuing strategy and overarching management plan. This includes ADAC's organization and continued plans for: 1) engagement and strategic communications, 2) research investigation and development (including research calls and operator-driven workshops), 3) current project assessment, evaluation, and management, 4) research transition and/or commercialization, and 5) summary of education management and fiscal accountability.

ADAC's Year 8 Work Plan project descriptions, located in Section III of the document, remains the heart of the Center's mission. This section also describes ADAC's efforts in education and workforce development.

As introduced in ADAC's Year 4 work plan, ADAC's Year 8 Work Plan format aligns research projects to the DHS Funding Opportunity Announcement's (FOA) six overarching themes. These are:

- Maritime Risk, Threat Analysis, and Resilience Research.
- Maritime Domain Awareness (MDA) Research.
- Maritime Technology Research.
- Integration of Science and Engineering with Maritime.
- Integrated Education.

ADAC will conclude specific investigative tasks for the following projects in Program Year 8 in accordance with designated HQ USCG Project Champion and DHS S&T OUP Program Manager (PM) directions in order to effect transition:

- Ice Condition Index for the Arctic (ARCTICE).
- Marine Induced Polarization Methods for the Detection and Mapping of Oil in an Arctic Marine Oil Spill, including investigation of Oil within and under broken ice fields.
- Mitigating the Damage to Arctic Copepods from Surface Oil Spills: When to Apply Dispersants.
- Photo-enhanced toxicity of dispersed and burned crude oil to Arctic mussels.
- Oil Spill Modeling for Improved Response to Arctic Maritime Spills.
- Arctic Vessel Monitoring and Geofencing/Alert Awareness.
- Development of Propeller Driven Long Range Autonomous Underwater Vehicle (LRAUV) System for Under-Ice Mapping of Oil Spills and Environmental Hazards.
- Remote Unmanned Aircraft System (UAS) Inspection and Response Team Development in the Bering Strait Region.
- Alaska and Arctic Maritime Communications and Connectivity Analysis.
- Arctic Facilities and Infrastructure Environmental Change Risk Index.

ADAC also plans to conduct the following exercise or workshops in Program Year 8:

- Arctic-focused Incidents of National Significance Workshop. This Arctic IoNS workshop is re-scheduled from 1-2 April 2020 to fall 2021 because of travel and group meeting bans due to Coronavirus/COVID-19.
- An Arctic focused Medium- and Long-Term Environment (MaLTE) workshops collaborated with U.S. Coast Guard. This event is a follow-up to exercise/workshop from "Arctic Maritime Horizons…an Assessment of the Bering, Chukchi and Beaufort Sea dynamics in safety, commerce and waterways management" event conducted in May 2021. This follow-on activity will analyze what new measures would be helpful to reduce risk in the maritime

transit regions of the U.S. Arctic Extended Economic Zone. This workshop is planned for winter 2022.

As described in detail later in the workplan, in lieu of an ADAC Arctic IoNS 2021 Workshop, the Center is planning to conduct an ADAC "Strengthening Partners in Arctic Industry (SPAI) Symposium" as an aide to commercialization efforts of Center completed research. This symposium is a follow-up to ADAC's similar effort in Program Year 7 that was titled "**Arctic Challenges, Innovations, and Commerce Expo (Arctic CICE)**," conducted 16-17 March 2021 as a virtual event.

ADAC will continue and conclude integrated education and workforce development activities, research internships to specific project investigators, and a summer internship program that provides Arctic research opportunities for students from under-represented demographics.

ADAC will continue to seek and conduct activities in association with DHS S&T and/or USCG projects funded via DHS S&T OUP-ADAC Basic Ordering Agreement.

As a concluding activity under the current DHS S&T OUP-UAA Cooperative Agreement, ADAC plans to complete a report that describes what each of the completed projects accomplished (and any associated shortfalls and gaps these investigations are helping to close). Further, details in how the projects have transitioned, how they are supporting U.S. Coast Guard, pending transition paths, unrealized transition potentials, and recommended follow-on research to increase the utility of each research. This report is envisioned to highlight research value added and serve a performance measurement knowledge product.

Center Management Processes

ADAC Objective and Purpose.

The U.S. Department of Homeland Security, Science and Technology's University Programs (DHS S&T OUP) established ADAC in summer 2014 to research and provide a scientific basis to address the challenges faced by USCG and other DHS maritime missions in the Arctic region. ADAC's principal customer is the USCG. ADAC investigates capability shortfalls and gaps, and orients research activity to support the USCG mission needs. The particular areas that ADAC seeks to assist the USCG are related to missions in support of Arctic search and rescue, humanitarian assistance, disaster response, and security matters. While oriented to the USCG's Arctic mission needs, ADAC support other DHS maritime mission needs in the Arctic.

As U.S. Coast Guard lead U.S. Federal On-scene Coordination (FOSC) in time of maritime crisis, ADAC's research that supports other federal agencies that report to USCG FOSC leadership is also of value. Chief among these other U.S. Federal Agencies is the National Oceanic and Atmospheric Administration (NOAA).

As a university-hosted research venue, ADAC supports student education. Through the Center's Fellows Program, ADAC provisions student research, internships, and entry into the Homeland Security Enterprise. ADAC's approach is to continue and conclude the DHS S&T OUP Cooperative Agreement on schedule by the end of Program Year 8.

Outside of the current DHS S&T OUP-University of Alaska Anchorage OUP Cooperative Agreement, ADAC seeks to transition to alternative programmatic means to continue providing value to the nation in research, convening and educational endeavors.

As in prior year work plans, research and development conducted by ADAC will not only serve USCG and other DHS maritime missions, but also benefit an array of ADAC partners and collaborators and support the public good.
ADAC's corresponding *vision, mission and strategy* remains unchanged:

Vision: The DHS Center of Excellence providing networked and mission-focused support to the USCG Operator in the High North. ADAC strives to become a National Center of Arctic maritime research.

Mission: ADAC's mission is to develop and transition technology solutions, innovative products, and educational programs to improve situational awareness and crisis response capabilities related to maritime challenges posed by the dynamic Arctic environment. ADAC seeks to accomplish this mission through an inclusive approach.

Strategy: ADAC will conduct a parallel effort over five lines of major collaboration with DHS S&T OUP and USCG in order to:

- Execute approved research work plans that are appropriately detailed and resourced.
- Successfully integrate university student Fellows into the Homeland Security Enterprise workforce.
- Transition sufficiently mature research to meet customer acquisition needs and commercialize as appropriate.
- Adapt Center activities, management, and communications to continue to learn and collaborate with an array of Center partners and continue to suitably expand the reach of ADAC across U.S. and Canada to include Arctic government, military and security operators, researchers, and industry partners.

Implementation.
In order to implement the Year 8 strategy, ADAC will continue to improve established management processes, continue existing communications practices, execute approved work plans, seek commercialization opportunities, and continue to innovate in education and workforce development. This includes continuing management processes established in ADAC's Program Year 6 as well as further development on ADAC's cutting edge communications practices.

Organization and Leadership.
DHS S&T OUP awarded ADAC's cooperative grant to University of Alaska, Anchorage, with the Center's first program getting underway in January 2015. Since re-organizing in January 2016, ADAC has created and continues to refine a unified approach to leading the Center for the University of Alaska through close partnership with the University of Alaska Fairbanks. ADAC reports to the DHS S&T OUP program manager in accordance with protocols established via the DHS S&T OUP cooperative grant. ADAC's Principal Investigator and Executive Director jointly report through

University of Alaska Anchorage Vice Chancellor for Research to the UAA Chancellor, and the University of Alaska System President for academic institutional support requirements.

ADAC leadership consists of the following team of both full and less than full time members. The overall leadership is maintained by a collaborative arrangement via the ADAC Principal Investigator, Research Director and Executive Director.

Full time Center members: Executive Director, Associate Director and Senior Research Professional, Education & Administrative Manager and Communications & Research Associate.

Less than full time members: Principal Investigator, Research Director, Finance Director, and Project Manager.

In program Year 8, ADAC will continue communications support from UAA resources at the Business Enterprise Institute.

ADAC has established an extensive research partnership and collaboration network across Arctic-minded universities and industries throughout the U.S. and Canada. ADAC also gains multi-faceted counsel through an external advisory board and has established an effective student Fellows program.

ADAC maintains committed collaboration with fellow DHS S&T OUP Centers of Excellence. ADAC comprehensively engages with U.S. Federal, State of Alaska, and local Arctic authorities on Arctic research matters. Internationally, ADAC principally engages with Canada as well as other Arctic partners, including Denmark, Finland, and Norway. In Program Year 8, these engagement activities will continue. In accordance with the DHS award, the senior leadership for the center is as follows: The University of Alaska Anchorage hosts the Principal Investigator and Executive Director. The ADAC Research Director is located at the University of Alaska Fairbanks campus, while also serving as the Vice Chancellor for Research at the University of Alaska Fairbanks.

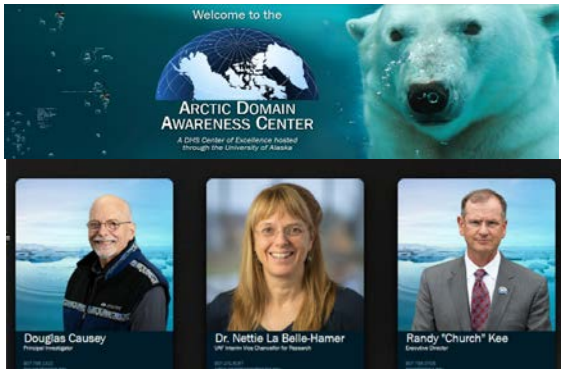

Figure 1 ADAC Center Leadership.

In sum, the ADAC team comprises a diverse blend of Arctic science and technology academics, Arctic-related strategy and policy expertise, and strong organizational and fiscal leadership credentials. The following is the leadership lineup for ADAC:

- *Principal Investigator (PI),* ***Douglas Causey****, PhD, University of Alaska*. The ADAC PI is responsible for close collaboration with the Executive Director and the Research Director to achieve ADAC mission goals. The ADAC PI will seek to connect ADAC with partners and opportunities. In coordination with the Executive Director, the ADAC PI is responsible for reporting to the University of Alaska System Leadership and DHS program sponsors on a regular basis. The DHS S&T – UAA ADAC Cooperative Agreement remains credited to the ADAC PI as the associated lead University faculty member.

- *Executive Director (ED),* ***Randy Kee,*** *Maj Gen, USAF (Ret.), MS, University of Alaska, and Commissioner, U.S. Arctic Research Commission.* The ADAC ED provides direction of all Center activities to meet COE goals, achieve milestones, develop technology, communicate with customers, and engage the broader Arctic community across the U.S. and Canada. The ED will organize site visits for demonstrations, interface with the end-users, and will work with ADAC leadership to ensure the Center complies with federal regulations and reporting. Together with the ADAC PI, the ED will regularly meet with DHS staff at DHS headquarters and represent the program at meetings required to support the needs of DHS management and the greater DHS enterprise. The ADAC ED works closely with USCG stakeholders to ensure the Center meets USCG expectations. Finally, the ED will ensure ADAC appropriately conducts internal processes, in particular assessment meetings, engagement forums, and DHS sponsored workshops.

- *Research Director (RD),* ***Nettie Labelle-Hamer****, PhD, Vice Chancellor, University of Alaska Fairbanks****.*** The ADAC RD provides leadership for the center in establishing research concepts and follow-on proposals. The RD also provides leadership to support research concept generation, individual project leaders, and research teams. ADAC's RD is responsible for addressing and guiding scientific quality for the individual projects and the overall program.

The ADAC RD, where suitable, interacts with DHS and stakeholders and interfaces with other DHS COEs and research centers to identify and formulate additional research projects. The ADAC RD is a key leader for the Center to identify when research projects are ready to transition to the next Technology Readiness Level (TRL) and whether they are suitable for transition from research to development.

- *Finance Director (FD),* ***Heather Paulsen****, MBA, University of Alaska Anchorage.* The ADAC FD is responsible for management and oversight of administrative operations of the COE and its group of associated subcontracts. The ADAC FD will provide program/project planning, budgeting, and implement operational policies and processes to support the COE. Further, the FD will work in close collaboration with the ED and the Project Management Director to develop budgets aligned to program and project planning objectives and to manage expenditures as aligned with the research mission of the Center.
- *Project Manager (PM),* ***LuAnn Piccard****, MSE, PMP, University of Alaska Anchorage.* In partnership with ADAC ED, Finance Director, and Project PIs the PMD will support efforts to integrate project plans into a cohesive program with phased solution and technology deliverables aligned with ADAC's strategic mission and ADAC's research-to-development process.
- *Associate Director and Senior Research Professional (AD/SRP),* ***Jason Roe****, USCG Ret, University of Alaska Anchorage****.*** ADAC's Associate Director and Senior Research Professional provides technical coordination with the USCG, to include investigating feasibility and applicability of ADAC research integration to USCG decision support systems. The ADAC AD/SRP leads Center operations in the absence of the ADAC ED. The AD/SRP supports transition activities and research diversification. The ADAC AD/SRP will support commercialization research and assist ADAC ED in representing the Center at technical exchanges, with DHS, USCG and industry. Lastly, the ADAC AD/SRP is the investigative lead for the Center in gaining insights and identifying challenges and describing solutions/solution pathways to address USCG technology shortfalls and gaps, to include challenges uniquely suited to the Arctic and the directly associated with "enabling the decision maker" at USCG command centers.
- *Education and Administrative Manager (EAM),* ***Elizabeth Matthews****, MS, University of Alaska Anchorage.* ADAC's Education and Administration Manager oversees ADAC's student development program. This includes DHS Career Development Grant Scholarships and student research interns. ADAC's EAM will oversee and support the Center's student, summer internship program for ADAC Fellows and under-represented students from Minority Serving Institutions (MSI), Federal Tribal Designations (FTD), and Significant Minority Enrollment (SME) universities or colleges. ADAC's EAM will lead efforts to recruit, enroll, and monitor student performance and to graduate entry into the Homeland Security Enterprise. The ADAC EAM leads administrative management functions and supports communications outreach.

- *Research Communications and Associate (CRA)* ***Connor Keesecker****, BA, University of Alaska Anchorage.* ADAC's CRA supports developments of Center written reports (such as Program Year Workplans and Annual Reports), conducting directed research tasks, developing

products to support workshops oriented to USCG mission needs and supporting media development for ADAC events such as the Center's Annual meeting.

- *Research Associate (RA)* ***Kelsey Frazier,*** *MS, University of Alaska Anchorage.* ADAC's RA is focused in supporting the development and transition of ADAC's Arctic Ice Conditions Index and associated engineering research.

- ***Note,*** in ADAC Program Year 8, ADAC will also incorporate research support from ***Shawn Butler****, PhD, UAA College of Engineering* to assist ADAC leadership in transition activities of all concluding ADAC projects. This will be in addition to her investigative tasks associated with ARCTICE and Geofencing/Vessel Alert Awareness projects.

ADAC Executive Counselors.

The Executive Counselors (EC) are ADAC's external advisory board and are highly qualified senior leaders and/or research professionals. The EC provide counsel pro-bono. The EC principally provide strategic advice on Center management focus, critical commentary on current project work, and insights to future opportunities. In Program Year 8, ADAC will continue to meet individually with these Executive Counselors periodically, while also conducting three Strategic meetings with the Counselors via a dedicated forum (one associated an ADAC Program Quarterly Review).

ADAC's Executive Counselors are:

- ***Tom Barrett, VADM (Ret),*** USCG, Former President, Alyeska Corporation**,** Anchorage, Alaska. Admiral Barrett is a former USCG Vice Commandant and District 17 Commander.
- ***Paul Hubbard, PhD,*** Canada Department of National Defense, Ottawa, Canada.
- ***John Farrell, PhD,*** Executive Director, U.S. Arctic Research Commission, Washington, D.C.
- ***Heather Quilenderino, CDR, USN,*** Director, National Ice Center, Suitland, Maryland.
- ***Michael Duxbury, Former Deputy Commissioner,*** State of Alaska Department of Public Safety, on assignment to Washington D.C.
- ***Tom Case, Lt Gen (Ret),*** USAF, Chancellor Emeritus, UAA, Anchorage AK.
- ***Rudy Peschel, RADM (Ret),*** USCG, Ocean City MD.
- ***Gail Schubert, JD,*** President and CEO, Bering Straits Native Corporation, Nome AK

Figure 2 ADAC's Executive Counselors

ADAC Overall Management Approach and Allocation of Effort.

The USCG and other DHS maritime Arctic operators are the key end-users driving research for ADAC. The Center will conduct fundamental and applied research in MDA and maritime technology. Strategically, ADAC will:

- Complete planned Arctic domain awareness research areas to advance the science of knowledge and understanding in order to improve USCG Arctic operator coordination, control, and decision- making.
- Conduct and conclude research in maritime technology to provide needed capability to support and effect increased domain awareness.
- Transition sufficiently mature or completed research. Transition outcomes are project specific.
- Pursue commercialization options as suitable for concluding or completed research. This includes accomplishing a follow-up technology and commercialization expo in ADAC Year 8, similar to what was accomplished in Year 7.
- Advance and submit patents, trademarks, and other measures to protect developed intellectual property.
- Support center student research programs, including student Fellow participation within research projects and their participation in cross-Center activities.

ADAC's leadership apportions the execution of the Program Year 8 Work Plan accordingly:

- Direct and manage the research of established projects, which includes extensive research transition coordination between Project teams, USCG Project Champions, HQ USCG Acquisition and DHS S&T OUP. This entails 60% of the ADAC management focus. Specific tasks and associated measurements include:

Table 1 Tasks and associated metrics for direction and management of established projects

Task	*Associated Metric*
Conduct weekly teleconferences with ADAC Project leads and research teams.	Informed ADAC leadership and research team.
Participate in weekly teleconference with DHS S&T OUP Program Manager.	Informed DHS S&T OUP Program Manager.
Conduct monthly project invoice review.	Fiscal understanding of each project performance on monthly basis.
Conduct a Quarterly Review with ADAC Project Leads and research teams for DHS S&T OUP Approved workplans that includes specific project transition planning.	Comprehensive review of project performance by ADAC leadership team, enabling oversight on a scheduled basis.
Conduct one Quarterly Review with ADAC Project Leads and research teams, with the Executive Counselors.	Comprehensive review as with regular reviews, with added recommendations from ADAC's Executive Counselors.
Conclude research activities by 31 Mar 2022.	Research activities completed on schedule.
Subrecipient monitoring via ADAC leadership in-person visits at each subrecipient of the DHS S&T	Successfully concluded subrecipient monitoring. ADAC leadership plans to

OUP Cooperative Grant location (university or business).	conduct a minimum of one subrecipient monitoring visit at each location at least once per two-year program period.
Prepare Annual Report reporting on Center activities and Project Research	Approved report by DHS S&T OUP PM.
Participate in detailed effort for project transition, including collaboration with HQ USCG CG-9 ADAC point of contact and USCG Project Champions.	Established transition pathway for ADAC research to meet USCG acquisition needs.
Seek commercial opportunities for research transition, including patent and licensing.	Approved patents and/or licensing from submitted proposals.

- Continue research development Initiative started in Program Year 4 and extended through Year 7. This entails 10% of ADAC leadership focus. This effort entails collaborating with DHS S&T OUP and USCG for workshops that generate research questions, conducting and processing calls for research. Specific tasks and associated measurements include:

Table 2 Tasks and associated metrics for continuation of Year 4, 5, 6 & 7 research initiatives.

Task	*Associated Metric*
Plan and conduct Arctic Strengthening Industry Partnerships Symposium (planned as a virtual event)	Successfully concluded Arctic Strengthening Industry Partnerships Symposium. Advanced ADAC research transition pathways and generated commercial interest in ADAC research projects.
Coordinate and conduct Arctic Medium and Long-Term Environment (Arctic MaLTE) workshop analyzing risk for waterways management and safety aspects for the Bering, Chukchi and Beaufort Sea regions in support to HQ USCG requirements.	Conducted workshop addressing HQ USCG security and safety concerns.

- Conduct outreach, engagement and communications with customers, partners and collaborators, to inform of center initiatives and research project details, while continuing to support ADAC's research networks. This encompasses 10% of ADAC leadership focus. Specific tasks and associated measurements include:

Table 3 Tasks and associated metrics for conducting outreach, engagement, and communications.

Task	*Associated Metric*
Prepare and conduct Annual meeting, if safety permits, meeting will be held in Washington D.C. otherwise, meeting will be virtual	Successfully presented meeting, informing DHS, USCG and invited participants of ADAC research and transition planning.
Conduct approximately quarterly Customers and Partners Roundtables via teleconference/webinar.	Successful completion of roundtables and publishing of associated minutes.
Participate in Alaska Marine Science Symposium (January 2022).	ADAC completing a planned presentation.

Develop center and project motion graphics presentations in support of outreach.	Completed and posted motion graphics that describe ADAC efforts.
Prepare and release quarterly newsletters.	Published newsletters to established ADAC mailing list and posted to Center website.
Prepare brief noteworthy activities and project vignettes for DHS S&T OUP communications staff.	Providing DHS S&T OUP, communications needed information of ADAC activities and project research.
Update ADAC website, Facebook and Twitter of Center activities and noteworthy events.	Informing public of ADAC activities and research.
Publish specific ADAC events and activities to Interagency Arctic Research Policy Committee (IARPC) and U.S. Arctic Research Commission.	Informing community of Arctic researchers about ADAC activities.

- Continue conducting education, outreach, and workforce development efforts consisting of a variety of activities that include both ADAC Fellows and minority students. ADAC anticipates this effort requires 10% of Center leadership focus.

Table 4 Tasks and associated metrics for conducting education, outreach, and workforce development efforts.

Task	*Associated Metric*
Recruit student interns (ADAC Fellows) for available research.	Achieve 100% fill for ADAC Fellow available slots.
Assign projects and develop workplans to ADAC Fellows.	Students fully assigned to projects with associated workplans.
Conduct monthly ADAC Fellows meetings.	Accomplish planned meeting schedule.
Conduct an ADAC Student research Symposium.	Completed symposium highlighting student research efforts.
Support ADAC Fellows entry into suitable summer internship oriented to the constraints of Year 8;	All ADAC Fellows conclude Year 8 planned internship.
Support post-graduate student placement with Homeland Security Enterprise (HSE).	All graduated ADAC Fellows complete one-year minimum service in an HSE related position or alternatives as described in the DHS OUP Terms and Conditions.

ADAC Information Protection Plan.

ADAC has reviewed the Center's Information Protection Plan established in Program Year 1. ADAC will continue to execute this plan that is already on file with DHS.

ADAC Research Safety Plan.

ADAC has carefully reviewed Center's Research Safety Plan established in Program Year 1. ADAC will continue to execute this plan that is already on file with DHS.

ADAC Review Group and Project Evaluation Process.

ADAC Review Group. Central to ADAC's evaluation plan is establishing a comprehensive review of the Center's work on a quarterly basis. Therefore, ADAC will schedule the convening of the ADAC Review Group to govern ADAC Quarterly Reviews. The ADAC Review Group will also review ADAC's comprehensive approach to investigate and develop new research for DHS S&T OUP and USCG consideration. This process has remained consistent for the Center from ADAC Program Year 3 to date.

ADAC's Executive Director will Chair the ADAC Review Group at Center Quarterly Reviews, closely supported by the ADAC AD/SRP. Principal Investigator, Research Director will participate and consult in review group sessions. The remaining ADAC leadership (Finance Director, Education and Administration Manager, Project Manager) will support ADAC Review Group sessions. ADAC ED will consider inviting additional subject matter experts to assist the ADAC Review Group in executing an overall "end to end" approach for the Center and for project examination. ADAC ED will consult with the ADAC Executive Counselors Board for appropriate participation to provide their assessments of program and project utility and performance.

ADAC Project Evaluation process to assess program activity.

ADAC will use the following process to evaluate Center projects during Center quarterly reviews by the ADAC Review Group. As needed, ADAC leadership will conduct specific reviews on research projects outside of the quarterly review cycle.

1. Evaluate the science and technology advances. The ADAC Review Group will assess the progress made by each individual project compared to the utility of the research for ADAC's goals and objectives and make onward recommendations for proposed action.

2. Assess project resourcing versus project execution. The ADAC Review Group will determine the appropriate alignment between project plans and resources. If a project's importance, priority, and performance measures warrant additional resourcing during "in-year execution," ADAC's leadership will seek to address or mitigate the need by coordinating cross-funding from projects that are under-executing (according to project planned schedule and milestones) in resource expenditure. Any movement of resources between projects will comply with the terms and conditions of the DHS S&T - ADAC cooperative agreement protocols.

3. Assess each project's ability to communicate current findings and projected research trajectory. The ADAC Review Group will determine if project discoveries or developments warrant the pursuit of publication in the appropriate media, particularly scientific journals. The ADAC Review Group stresses the importance of publishing ADAC funded research.

4. Assess project TRLs. The ADAC Review Group will determine if the actual TRLs versus the planned TRLs at given milestones for each project indicate that research is progressing as planned. Additionally, assessment will seek to determine if research indicates planned TRLs are on a trajectory to produce a useful capability for the Arctic operator.

5. Review Project Transition Plan. The ADAC Review Group will review and consult with the project team and Project Champion for discoveries in new intellectual property, commercialization opportunities, and alignment that meet end-user acquisition needs.

6. Determine actual program execution versus planned in terms of schedules, milestones, and metrics. The ADAC Review Group will assess how well each project is progressing according to their work plan submitted by ADAC to DHS OUP for the project year. If the project is substantially off schedule, the project team will develop a "Get Well Plan" to re-establish adherence to the prior approved project schedule, milestones, and metrics.

7. Assess project team overall performance. For projects that are significantly under-performing, the ADAC Review Group will determine if the project lead is able to present an acceptable approach to Center leadership. If necessary, ADAC leadership will consult with the DHS S&T OUP Program Manager to restructure the project's leadership, team, and/or project plan in accordance with DHS S&T OUP - ADAC grant terms and conditions. If a project is unable to proceed accordingly, ADAC leadership will consult with DHS S&T OUP PM to discontinue the project. Following such a decision, ADAC leadership will conduct documentation and provide reprogramming recommendations.

8. Specific process for Education Program Management: ADAC's Education and Administration Manager will present assessments of the education program during quarterly reviews or during periods between quarterly reviews as needed. Following each quarterly education assessment, the ADAC Review Group will:
    a. Examine the effectiveness of student participation in individual projects.
    b. Evaluate Center performance for recruitment of under-represented students in both the ADAC Fellows program and for the summer internship program.
    c. Assess individual ADAC Fellow performance in meeting their work plan objectives.
    d. Evaluate the Education Outreach and Workforce Development Program by assessing schedules, milestones, and planned metrics for the overall program.
    e. Assess recommendations by the Education and Administration Manager to address any deficient areas of performance.

9. Subrecipient monitoring visits by ADAC leadership. Independent of the ADAC quarterly review cycle but instrumental in the overall management of project work for the Center, ADAC leadership will conduct subrecipient monitoring visits. ADAC leadership has developed a subrecipient checklist to guide awardees in preparing and presenting their project's compliance with the cooperative grant terms and conditions. ADAC's Executive Director and Finance Director normally conduct these subrecipient monitoring visits. If/as Coronavirus/COVID-19 travel restrictions remain in place, ADAC is prepared to conduct these via remote means.

ADAC Research Transition Process.

As a DHS S&T OUP Center of Maritime Research (CMR), ADAC's priority is to transition research that is sufficiently mature to DHS acquisition processes. In pursuit of acquisition, ADAC seeks to connect sufficiently mature research to industry, HQ USCG CG-7 (Assistant Commandant for Capabilities), and HQ USCG CG-9 (Assistant Commandant for Acquisitions). In addition to working with HQ USCG CG-7 and CG-9, ADAC will conduct appropriate coordination with USCG Research and Development Center (RDC) for operational testing of research in advance of formal USCG acquisition of ADAC maturing

research. While principally oriented to the USCG, ADAC also seeks to support other DHS maritime mission needs in the Arctic.

Complete, transition and commercialize is principal focus of ADAC Year 8. All ADAC's projects included in Year 8 plan include transition as an integral part of their work plans. Center leadership evaluates project progress on schedules and milestones and advancement to overall transition planning during quarterly reviews via the ADAC Review Group. This review is one way to discern the pathway of transition planning needed to support end-user *ADAC's "Research-to-Capability Process" (RTCP).* ADAC's RTCP remains the Center's approach for finalizing the transition of research to end-users. ADAC will continue to recruit the support of the University of Alaska Business Enterprise Institute and UAA Office of Sponsored Programs to support transition activities. **ADAC will also leverage the assistance of DHS S&T's Industry Partnerships in developing an overall transition strategy early in the program year and executed throughout.**

This task team approach includes careful handling of transfer for appropriate documentation and patent initiation. ADAC's Principal Investigator, Research Director, and Executive Director will determine the task organization needed to migrate research to receiving development and acquisition professionals. ADAC's Executive Director will lead with Center's Project Management Director and/or Assistant Director and Senior Research Professional in serving as deputy lead for the task-organized team. This team will include project investigators, PI(s), Center support personnel, and supporting institutions.

Note, a new add for ADAC Program Year 8 is the incorporation of Dr. Shawn Butler, UAA College of Engineering to support project transition tasks of each active investigation at the Center.

The task-organized team will prepare the transfer of research materials, associated physical hardware, software, and intellectual property. Transfer preparation will include a review of financial documentation, DHS S&T OUP-ADAC grant terms and conditions, onward disclosure notifications to DHS S&T OUP Program Manager, and appropriate public announcements.

The Project PI(s) will complete documentation. This will include fully describing the research, completed milestones, objectives, and project research conclusions while also initiating science review and preparing journal submissions. The Project PI(s) team, in coordination with ADAC leadership, will initiate patent application with University of Alaska as appropriate.

Following internal center preparations, ADAC's Executive Director and Project Management Director will lead the task-organized team in correspondence and meetings with the receiving agency or organization to conclude transfer.

A continued focus in Year 8 is on commercialization activities of completed/completing research. If a research project is not able to discern a primary pathway to DHS and other end users, ADAC's next approach is seeking transition for commercial application. ADAC believes the following categories are the most feasible for commercial application of ADAC research:

- *Oil and mineral extraction.*
- *Coastal and port security.*
- *Destination adventure cruises.*

- *Arctic region maritime shipping.*
- *Education materials.*

In support of ADAC's efforts to advance commercialization of completed and concluding research, Center leadership seeks the following commercial activities in Program Year 8:

- Conduct a Center led commercialization market study between Center leaders and project investigative teams at the onset of ADAC's Program Year 8 and align outcomes to inform ADAC partnering, and presentation activities as outlined in the following conferences, workshops and symposiums:
    - Coordinate participation in Alaska Ocean Cluster WebEx's to present ADAC's research to commercial partners oriented to maritime development. See: https://Alaskaoceancluster.com
    - Planning, marketing and conducting a follow-up to ADAC's commercialization and research expo as conducted in Spring 2021 for Winter 2022 specifically targeting research suitable for commercialization.
    - Soliciting and then presenting ADAC research suitable for commercialization at a monthly meeting of "Commonwealth North." See: https://commonwealthnorth.org.
    - Soliciting and then presenting at the World Trade Center Anchorage "Arctic Ambitions 2022" forum billed as Alaska's Premier Arctic Business Event Focused on Trade, Commerce, and Investment in the Region, planned for early January 2022 (note, COVID19 complications caused the closure of the January 2021 event. See: https://www.akbizmag.com/event/arctic-ambitions/
    - Continue ADAC's planned participation at Canada's Maritime and Arctic Safety and Security (MASS) Conference for November 2021 at St John's Newfoundland, oriented to commercialization of completed/completing research. See: https://arcticmaritimesecurity.ca
    - Participate in the industry forum associated/aligned with the Arctic Encounter Symposium (AES) 2022 (note, COVID19 complications caused the closure of the 2021 event). See: https://www.arcticencounter.com/

Lastly, ADAC will seek to connect completed research with those in the community of Arctic maritime research who will benefit the most. In all cases, ADAC will continue to strive to ensure research outcomes benefit the public good.

ADAC Strategic Communications Plan.

Effective communications are essential for ADAC research success. ADAC will continue to advance cutting edge communications advances made in program Year 6, particularly with the Center's greatly advanced Internet website. The ADAC Year 8 communication plan is both a chance to publicize Center and project activities and accomplishments, and to receive input from stakeholders. The below reflects both mediums and audiences targeted for communications.

ADAC's plan will communicate progress on research projects and Center activities as well as announcements of workshops and research opportunities. The Center will engage with the community of Arctic researchers (particularly in the U.S. and Canada) to inform and be informed of S&T advances and research associated with Arctic Domain Awareness. ADAC plans to continue a comprehensive approach in various mediums to communicate to customers, partners, and

collaborators. Therefore, ADAC plans to utilize the internet, social media, workshops, roundtables, and direct engagement with USCG entities and other key stakeholders to remain informed.

Correspondingly, in Program Year 8, ADAC will accomplish the following tasks to advance Strategic Communications:

- As part of ADAC's Quarterly Review process, ADAC leadership will review communications activities. This includes review of ADAC's internet website, quarterly newsletters, and proposed project journal articles. During the Quarterly Review, Center leadership will benchmark ADAC communications products based on a summary review of other DHS S&T OUP COEs and U.S. university research centers. Following the review, ADAC communications team will implement changes.
    - Center newsletters will include focused project reviews and ADAC Fellow's written contributions.
- Continue to use Facebook, LinkedIn, and Twitter social media when suitable.
- Continue ADAC outreach through utilizing the resources and venues of the University of Alaska, the Arctic Research Consortium of the U.S., the Interagency Arctic Research Policy Committee, and the U.S. Arctic Research Commission communications media.
- Engage fellow DHS S&T OUP Centers of Excellence for collaboration opportunities.
- Collaborate with fellow University of Alaska research entities.
- Continue to improve engagement activities as discussed under USCG and Key Stakeholder Engagement. This includes providing a survey via Customers and Partners Roundtables to solicit feedback of all ADAC engagement. ADAC leadership will address surveys at ADAC Quarterly Reviews.
- Bolster communications oriented to attract the attention of the Alaska, Arctic and Northern commercial sector to note and coordinate with ADAC for transitioning Center completed and concluding research suitable for application to industry.
    - This communication approach will be to advance market ADAC completed and concluding research prior to the industry forums via ADAC's list serve, Center newsletter (with the Center planning the Fall 2021 Quarter Newsletter specifically oriented to commercialization) and the network of Alaska and Arctic commercial sectors associated with the conferences listed previously.
    - ADAC continued participation in Commonwealth North's new initiative to refresh the prior publication "Why the Arctic Matters" provides a unique opportunity to showcase Center research to a diverse new audience.

USCG and Key Stakeholder Engagement.

In Program Year 8, ADAC will build upon successful prior engagement with USCG, which encompasses Headquarters, Area Commands and District levels in the Arctic and Great Lakes regions. ADAC will also advance partnering activities which has particularly strengthened at the local level between USCG District 17 Sector Anchorage and Anchorage based ADAC team members.

ADAC will also advance efforts with other U.S. Federal departments and agencies, particularly those agencies that also seek to support USCG missions in the Arctic. Current or planned collaborations with U.S. Federal agencies include National Oceanic and Atmospheric Administration (NOAA), National Aeronautics and Space Administration (NASA), U.S. National Ice Center (USNIC), National Geospatial Intelligence Agency (NGA) and National Maritime Intelligence-Integration Office (NMIO).

In Program Years 1-7, ADAC has focused engagement on USCG and other members of Federal government, state and local officials (to include Alaska Native and other Arctic Indigenous leaders) and with International Arctic research leaders. Engagement with industry has been focused to learn current baselines to study shortfalls and gaps.

In Program Year 8, ADAC will dedicate energies discern and market research suitable for commercialization.

ADAC will work to advance partnerships and investigate potential for joint or sponsored research with these and other Federal agencies that are oriented toward USCG mission needs in the Arctic. ADAC's leadership will conduct teleconferences and webinars with these key agencies, participate in their workshops and conferences when invited, and provide invitations for these agencies to participate in ADAC or University of Alaska hosted venues.

ADAC's "*Customers and Partner's Roundtable*" will continue to be an important research synchronization forum, that will be conducted on a quarterly basis in Program Year 8. This forum has proven itself as a useful venue to inform research and provide customers and partners alike, the opportunity to ask specific questions, and stay connected to ADAC's research projects and Center activities. As a focused supplement to the open nature of Customers and Partner's Roundtable, there will be a semi-annual USCG "Principal Customers" teleconference, which include HQ USCG Project Champions. The Project Champions' teleconference provides the chance for extended conversations on Center activities and research, within a USCG-oriented format, for ADAC's principal customers in the USCG.

Due to their reach across the network of Arctic research, additional key partners for engagement include the U.S. Arctic Research Commission, Arctic Research Consortium of the U.S., the Alaska Arctic Policy Commission (a State of Alaska agency), and the U.S. Interagency Arctic Research Policy Committee. Advancing efforts in Program Year 8 for committed outreach include:

- Commonwealth North.
- Arctic Today.
- World Trade Center Anchorage.
- Alaska Ocean Cluster.
- UAA's Business Enterprise Institute (for Commercialization activities).

ADAC leadership and project leads will continue to routinely interact with HQ USCG Project Champions and key HQ USCG staff leadership, and engage with USCG Pacific Area, USCG Districts 9 and 17, and USCG RDC. ADAC will also continue interaction with DHS S&T Homeland Security Advanced Research Projects Agency (HSARPA). In addition to routine engagement with USCG Project Champions and project advocates, ADAC will conduct the following calendar driven engagement approach for program Year 8 as previously described.

ADAC Project Descriptions Aligned to DHS CMR FOA Themes:

THEME 1: Maritime Risk, Threat Analysis and Resilience Research Projects:

1. Oil Spill Modeling for Improved Response to Arctic Maritime Spills: The Path Forward.
2. Arctic Facilities and Infrastructure Environmental Change Risk Index.

PROJECT: Oil Spill Modeling for Improved Response to Arctic Maritime Spills: The Path Forward
Project Investigator: Dr. Nancy E. Kinner.

Project supporting investigators:

Megan Verfaillie
Jessica Manning

Lead Institution: University of New Hampshire Coastal Response Research Center (CRRC), Center for Spills and Environmental Hazards (CSE).

Project Champion: CAPT Kirsten Trego (HQ USCG MER).

Project Description:

Abstract.
This project provides a structured approach to solicit expert advice to develop such a strategy as driven by USCG FOSC core needs in an Arctic oil spill response. The project commenced with forming a project "Core Team" (membership consists of ADAC center representative, University of New Hampshire Coastal Response Research Center, Center for Spills in the Environment, Headquarters USCG Maritime Environmental Response (HQ USCG MER), USCG Pacific Area (PACAREA) USCG District 17 (USCG D17), Alaska Department of Environmental Conservation (ADEC) and NOAA OR&R). This Core Team developed a list of needs/questions that Arctic response models should address. These serve as guideposts to focus all of the project's efforts. The team has conducted a major workshop and established 4 expert post-workshop Working Groups to produce stakeholder consensus on approaches to Arctic response modeling that yield more accurate results with clear uncertainty bounds in response timeframes. The second workshop and the subsequent two stakeholder working sessions synthesized the findings of the individual working groups to create final recommendations. These recommendations include: (1) new components/sub-models to characterize Arctic maritime oil spill trajectories, (2) a new method to present information on uncertainty associated with model inputs and outputs, (3) delineation of sampling techniques and technologies to improve quality and spread of input and validation data, and (4) suggestions on how best to coordinate further modeling efforts to aid a government-led response in an Arctic maritime environment. Preparation of the final Knowledge Product and a workshop to present its contents is the focus of activities during the latter part of Year 7.

For the final part of Year 7 and carrying on into Year 8, AMSM investigators will facilitate of an expert working group, starting immediately after the Knowledge Product is completed, to determine the exact data feeds from the existing ice forecasting models and services that will be input into existing

U.S. oil spill models (e.g., NOAA's GNOME) to predict the trajectory of oil in ice. Once these feeds are determined, coding will be undertaken and validated to get the necessary data from existing ice models/services in the correct format to ingest into oil spill models, particularly GNOME. Finally, a tabletop exercise will be conducted to test the speed and seamlessness by which the ice inputs are fed into the spill models and the veracity of the subsequent oil trajectory outputs.

Objective/Purpose.

This project is creating and publishing a Knowledge Product (a comprehensive report) that will detail: (1) specific needs and questions that must be addressed by Arctic oil spill response models; (2) the current state-of-the-art Arctic oil spill models available; (3) the state-of-the-art in Arctic ice forecasting/modeling; and (4) components from recent research efforts (e.g., Gulf of Mexico Research Initiative (GOMRI) useful for incorporation in order to improve current Arctic spill response models. In addition, the Knowledge Product will clearly delineate the characteristics of oil spill response that make some models inappropriate for the timescales required to inform daily response planning and decision making. The Knowledge Product will also recommend what specific new components/sub-models should be developed and validated so that Arctic maritime spill response models may better inform an FOSC's crisis decision-making. It is likely that such model development will need to consider the special requirements of the U.S. Federal incident command system where the USCG FOSC receives scientific support from NOAA's Office of Response and Restoration (OR&R).

Subsequent to the completion of the Knowledge Product in Year 7 and into Year 8, the project will: (1) determine the exact ice model/service data feeds that are needed by the Arctic oil spill models; (2) create, implement and test the code necessary to ensure that those data can be ingested directly by the oil models during a spill in a timely and accurate manner; and (3) conduct a small tabletop exercise to validate that the linkages will lead to an oil in ice spill model trajectory which will enhance information to aid FOSC in decision making.

Baseline.

ADAC and the AMSM investigators note it is imperative that effective models be available for use during Arctic oil spills. Oil spill response modeling may be used as the basis to respond to numerous questions that an FOSC may need answers for during a spill response. For example, the modeling outputs may be used to predict the trajectory, or path and future location, of the oil slick. This information is also valuable in determining whether there are habitats or species that may be at risk from oil exposure or contamination and the extent to which habitats or species can/must be protected. Modeling during response may also be used to estimate oil weathering - the physical changes that result when oil is released into the environment. Decision makers may use response modeling to inform stakeholders and the public about the location of the oil slick. Further, response modeling is useful to predict/evaluate the performance/success of various response alternatives (i.e., mechanical equipment, *in situ* burning, dispersant application). Understanding response needs, particularly those of the FOSC and associated response Unified Command, balancing evolving technologies with realistic response capabilities, ensuring data access and integrating forecasts and analysis into operations are all areas for consideration in spill response modeling (CRRC, 2008). Effective response modeling must consider availability and standards for data access, needed time/length scales of meteorological/ocean data, and non-transport modeling needs (i.e., wave or water level forecasts for salvage operations). In addition, the model must consider biological

metadata in order to integrate consideration of natural resources with fate and transport forecasts (CRRC, 2008).

Spill response modeling has been a focus of UNH's CRRC and its sister center the Center for Spills and Environmental Hazards (CSE) since 2006 when this team facilitated a workshop for NOAA OR&R on "Innovative Coastal Modeling for Decision Support: Integrating Physical, Biological and Toxicological Models. [See *https://crrc.unh.edu* for more information on CRRC/CSE.]

CRRC and NOAA OR&R facilitated a Spill Modeling Summit in June 2007 that concluded a Working Group was needed to move ahead. From 2008 to 2011, the Oil Spill Modeling Working Group (OSMWG), consisted of 30 modelers, responders and scientists who had the common goal of developing new 3D algorithms. OSMWG subgroups created associated working documents on topics such as spreading, water in oil emulsification, time-length scales, as well as a matrix of existing models that included dispersants, skimming, *in situ* burning and booming. The matrix included the inputs and outputs on fate, transport and biology, and the gaps in the models with respect to these processes.

Several global ocean and ice models (e.g., NWS, EUROGOOS) and oil spill trajectory and weathering models (e.g., GNOME, ADIOS, Oilmap, OWM) exist that can be applied to spills in the Arctic. A few of these are actually coupled trajectory and weathering models. Among existing models, the Oil Spill Contingency Response (OSCAR) program developed by SINTEF is an advanced software tool used to predict the fate and transport of spilled oil in ice-covered waters. In addition, the Russian State Oceanographic Institute model "Spill Mod" predicts spreading of oil in between fixed ice floes (Afenyo, Veitch, & Khan, 2016). Canada is developing its own oil spill model, COSMOS, which is coupled to the ice model CICE.

An in-depth review of fate and transport models in open and ice-covered water by Afenyo et al. (2016) expanded reviews done by Spaulding (1988), Reed et al. (1999) and Fingas and Hollebone (2003). Afenyo et al. (2016) identified multiple investigative needs specific to ice-covered waters to improve oil spill trajectory and fate models. Wilkinson et al. (2017) suggested models be parameterized with values specific to ice-covered waters such that model output uncertainty is greatly reduced. Arctic oil spill response models must also quantify the uncertainty of their outputs to better guide decision-making. Furthermore, in a crisis response, modeling must be done in the relatively short time scale, aligned to rapid decision-making windows that are dictated by emergency oil spill response, while addressing the unique complications of ice, adverse weather, international waters, and lack of response equipment.

AMSM investigators have comprehensively sought to identify: current state-of-the-art Arctic maritime oil spill response modeling, potential integration of these models with sources of information on ice conditions (e.g., ice forecasting models, ice observations), and specific needs to be addressed to obtain models that will be functional and effective in the response temporal and spatial scales to advance the FOSC's decision making during an incident and improve the experience gained from exercises and drills.

During the first year of the project (ADAC Project year 5), the investigators established a Core Team of multi-disciplined experts who examined the limitations of current spill modeling for the Arctic and

structured a workshop to establish a set of working groups to improve understanding of specific response model components/criteria needed for future modeling. Subsequently, through the Core Team, Working Groups and Workshops, the investigators have collaborated with the Arctic-oriented maritime spill response and ice modeling communities and incorporated responder perspectives from both the USCG and Alaska Department of Environmental Conservation. Potential Arctic spill scenarios (well blowout under ice, pipeline spill under shore fast ice, and a large vessel spill of combinations of oil in the shoulder season) were explored and questions were answered related to: responder needs that can be addressed by oil modeling, limitations to use of ice data in response modeling, gaps in environmental observations, and updates needed for existing algorithms as well as creation of new ones. Over a 7-month period, the Working Groups had detailed discussions to understand: oil-in-ice interactions at the sub-grid (meter) and grid (km+) scales, the usefulness of new and existing technologies for filling data gaps, and how to improve visualization and uncertainty when communicating model results to the FOSC.

Methodology.

The objective of the AMSM project is to identify the: current state-of-the-art Arctic maritime oil spill response modeling, potential integration of these models, and specific needs to be addressed to obtain models that will be functional and effective in the response time scale to advance the FOSC's decision making during an incident and improve the experience gained from exercises and drills. The focus is on making models that consider the complications unique to the Arctic (e.g., ice, adverse weather) that make response modeling particularly challenging. Accordingly, the project was originally divided into six phases. The last two have comprised the second half of ADAC Program Year 7: numerous working group sessions culminating in a virtual workshop to review Working Group drafts and integrate feedback, and the completion of the final Knowledge Product.

The goal of the originally planned in-person workshop was to present the findings of the working groups. Due to the COVID-19 pandemic, the workshop and subsequent working group sessions were held virtually on three consecutive Mondays in November 2020. The investigators leveraged past deliberations from the first workshop and the follow-on Working Group activities to stimulate collaboration and consensus on a path forward for Arctic oil spill response modeling, including acceptance of standards, assumptions and approaches to solve a variety of issues. The key was initiation and broadening of an open channel of communication among responders, scientists and modelers. The second workshop and working sessions were essential to ensure that the final Knowledge Product is consistent and cohesive, particularly because multiple groups have been working on the topics. The workshop consisted of report outs from the Working Groups and feedback from the stakeholders (e.g., NOAA ORR, USCG, Core Team, and Project Champion). The subsequent working sessions allowed cross-fertilization with other groups and delineated a path forward for activities (i.e., another working group, tabletop exercise, research needs). The project investigators will subsequently conduct report writing and coordination of the Working Group products into the final Knowledge Product.

The Project PI and ADAC fellow, Megan Verfaillie is drafting the final knowledge product: *Oil Spill Modeling for Improved Response to Arctic Maritime Spills: The Path Forward* as a comprehensive report, providing reviews and conclusions. Detailed recommendations, conclusions and general scopes of work on needed modeling research to fill gaps will be included. They will develop the

content and outline of the final Knowledge Product with reviews and coordination by the Core Team and Project Champion, CAPT Trego. Following coordination of/concurrence with the overall outline, the investigators will draft the associated final Knowledge Product, and complete it on or before May 2021. Once drafted, the Project PI will forward it to the Project Champion, Core Team, Organizing Committee and Working Group co-leads for their edits. Once this level of coordination is accomplished, the Project PI will send it to ADAC for coordination. Within one month of receiving ADAC's comments/edits, the Project PI will submit the final Knowledge Product to ADAC, the Core Team and Project Champion CAPT Trego. Once the report is submitted and promulgated, the Project PI and ADAC will coordinate a corresponding peer-review journal article.

For Project Year 8, the Project PI will work with the Project Champion CAPT Trego and the Core Team to establish a Working Group comprised of U.S. and Canadian Arctic oil spill modelers (i.e., NOAA OR&R GNOME modelers Drs. Amy MacFadyen and Chris Barker; RPS OILMAP modeler Dr. Debbie French-McCay; Environment and Climate Change Canada (ECCC) COSMoS modeler Dr. Guillaume Marcotte and others) and ice forecaster/modelers (e.g., Alaska Sea Ice Program, U.S. National Ice Center, HIOMAS, U.S. Naval Research Laboratory (CICE), neXtSIM). The specific goals of the Working Group will be:

1. Determine the exact ice data/parameters needed for the oil spill model (e.g., % ice coverage/concentration, ice velocity and direction), and the types of temporal and spatial scales that can be accommodated (Figure 1).
2. Determine what data feeds from which sources can produce the necessary inputs to the oil spill models.
3. Ensure the ice model/service parameters, outputs and data are all accessible and available and who will be able to provide them on short notice when a spill occurs.
4. Create and validate the code necessary to get the inputs into GNOME in the correct format efficiently.
5. Test and debug the code, as needed.
6. Conduct a small tabletop exercise with an Arctic oil spill scenario that includes the ice data providers, NOAA SSC, USCF FOSC and GNOME modelers and practices the notification of the ice data providers, transfer of information into GNOME and presentation of the predicted oil trajectory.
    a. The scenario and planning for the tabletop will be coordinated with the Alaska RRT, USCG D17 and NOAA OR&R, along with the AMSM Core Team.
7. Conduct a "hot wash" and write a Lessons Learned/Path Forward report as a follow-up to the tabletop exercise.
8. Include the Year 8 activities in an addendum to the AMSM Knowledge Product published in Year 7. Publish a peer-reviewed journal article on the Year 8 activities.

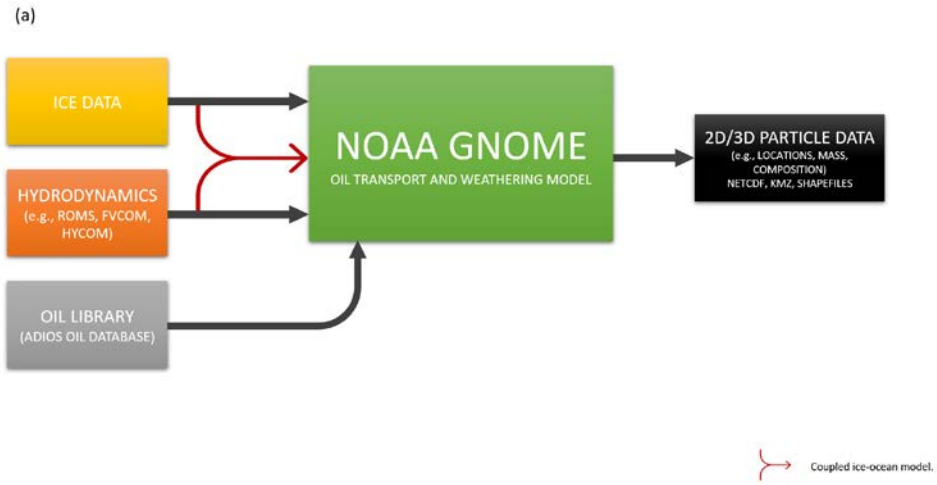

Figure 3 Oil spill model inputs and outputs. (a) NOAA's GNOME and other oil transport and weathering models in relation to inputs and outputs for Arctic spills.

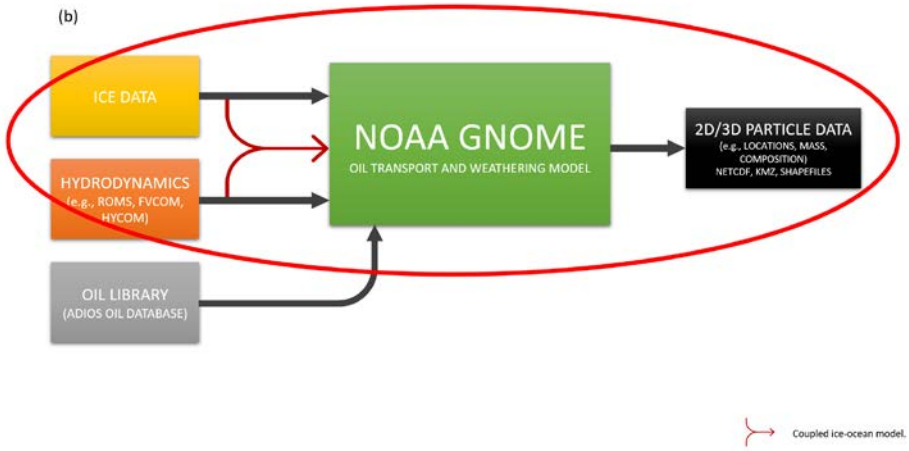

Figure 4 Ellipse encompasses component of the oil spill models that will be the focus of Year 8 AMSM efforts.

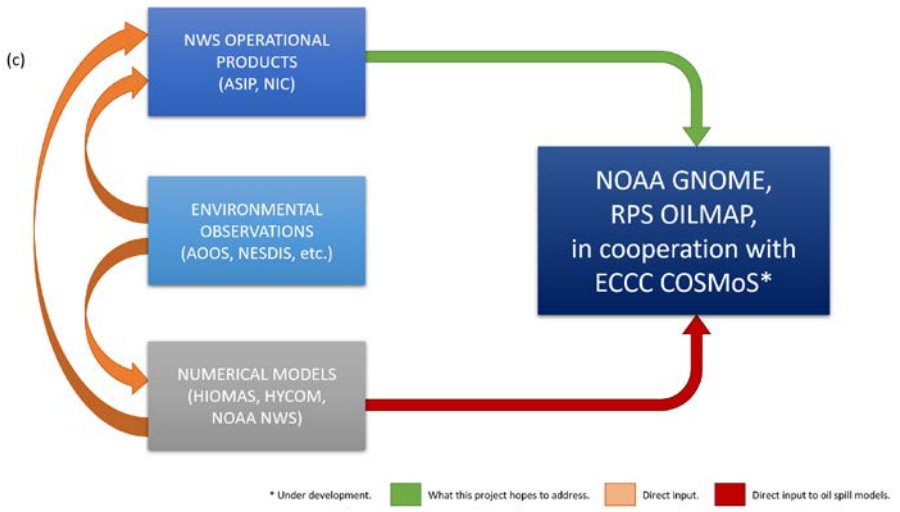

Figure 5 AMSM Year 8 Working Group will determine the inputs to the oil transport and weathering models needed for Arctic spills.

Key Milestones.

The following provides a review of the project principal milestones in Program Year 8.

- Project PI will facilitate monthly meetings with the Project Champion and Core Team.
- Project PI and Core Team will solidify the Working Group objectives and invite responders, modelers, and other experts to participate.
- Project PI facilitates tri-weekly meetings of the Working Group over 5 months to establish ice inputs that will be used by oil spill models, particularly GNOME.
- Project PI coordinates coding activity and validation.
- Project PI works with Core Team and other stakeholders to plan and execute the tabletop exercise using the % cover and ice velocity and direction data in GNOME to produce an oil spill trajectory that will be presented by NOAA OR&R to an FOSC.
- Project PI writes an addendum to the AMSM Knowledge Product regarding Year 8 activities that is vetted by the Project Champion and Core Team.
- Project PI and ADAC collaborate to draft and submit a peer-review journal article.

Key Stakeholder Engagement Plan.

The Project PI will continue to participate and be featured in the planned ADAC "Customers and Partners" Roundtable, in order to inform and receive feedback on project progress. The stakeholders including USCG PACAREA and D17, NOAA OR&R and other federal agencies, and representatives of the Arctic spill response community delineated above have been actively recruited for this project. This has occurred for academics, industry, NGO, and state, local and indigenous representatives, including students (ADAC Fellows assigned to the project at UNH CRRC/CSE). An ADAC undergraduate fellow assigned to Year 8 of the project will also attend all working group meetings and tabletop exercise.

The Project PI will work with the Project Champion, the Core Team, in particular NOAA OR&R, and other stakeholders in the project (e.g., RPS and ECCC spill modelers; NOAA NWS Alaska Sea Ice Program, U.S. National Ice Center, HIOMAS, neXtSIM, CICE) throughout the project to ensure the outcome is a clear understanding of the state-of-the-art in oil spill modeling as it applies to the Arctic.

The Project PI will work closely with Project Champion, CAPT Trego, who is the USCG Deputy Director of Emergency Management. CAPT Trego's knowledge of interagency and international oil spill response will be very helpful in guiding the project team to focus and coordinate spill modeling efforts in the U.S. Arctic and beyond, especially for large transboundary incidents. CAPT Trego chairs the Core Team for the project and in that role will ensure that input from NOAA OR&R, USCG PACAREA, USCG D17 and its affiliate members and Alaska DEC will be at the forefront of the project.

The Project PI will engage CAPT Trego and the Core Team at a minimum on a monthly basis for a pre-scheduled conference call meeting. ADAC leadership will be informed of all of these meetings and included on all conference call meeting invitations. There will also be meetings with the NOAA OR&R modeling team.

The Project PI will plan for the project representation at the following ADAC events:

1. Monthly Core Team meetings with the Project Champion, Core Team members and ADAC leadership.
2. Weekly All Hands meeting/teleconference (typically Thursdays, 1130-1230 Alaska Time).
3. Quarterly Reviews and Quarterly Customer's and Partner's Roundtable.
4. Annual meeting at HQ USCG, Washington D.C. or virtually.

Student Participation.

Throughout the project, the PI has focused on workforce development with one undergraduate and one graduate level student from the University of New Hampshire's Civil and Environmental Engineering Department assisting in all activities including taking notes during conference calls and at the workshop and Working Group meetings. Jessica Manning completed her undergraduate ADAC Fellowship in December 2020. Her senior honor's thesis will describe the various ice models and ice services that are available for Arctic modeling, as explored by the AMSM Working Groups. The Excel spreadsheet she developed as the basis of this product will be included in the final Knowledge Product and has helped determine the possible ice models/service feeds that will be considered by the Phase 8 Working group. Megan Verfaillie will complete her master's thesis research as well as her ADAC Fellowship in May 2021. Her thesis will be the basis of the AMSM Knowledge Product. Jessica will be continuing at UNH, pursuing an M.S. in Environmental Engineering working with the Project PI on the stripping velocities of oil under ice. Megan will be pursuing a Ph.D. at UNH focusing on remote sensing, a topic she became interested in during her work with the AMSM New and Existing Technologies Working Group.

Student fellows are governed and supported in accordance with the DHS S&T OUP-ADAC Cooperative Grant Terms and Conditions. The student fellows help write the progress reports and the final products. They support the Project PI in administering project tasks, to include the on-going modeling literature review, and maintain the project database. Through conference call and workshop participation and attendance, notetaking, database maintenance and report writing, the students

meet key people in the field of oil spill response, assessment, restoration and research as well as modelers. This includes meeting with USCG experts and operators. The students learned the foundational principles in the field, the state of the current science, and the new and emerging topics. In accordance with the well-established processes in ADAC's Education Program, the Center will work with all ADAC fellows upon graduation for entry into the Homeland Security Enterprise.

Performance Metrics.

1. Is the project on time, based on the schedule set forth in the detailed work plan established between ADAC, the Core Team and Project PI?
2. Are resources (e.g., references, working group participants) being gathered/recruited in sufficient numbers for the project tasks?
3. Is the scope of the project adequate or does it need to change to meet unforeseen components that arise in the response modeling?
4. Is the quality of the project products acceptable to the Project Champion/Core Team/ADAC? (N.B., the Project Champion/Core Team/ADAC will judge the acceptability of the project products based on the answers to the following two questions.) Are the products useful to responders and decision makers in exercises and spills? Are they advancing the ability to model Arctic oil spills and inform decision making by an FOSC?
5. What actions need to be taken to continue the project/maintain quality/or improve quality?

Outcomes/Output.

The greatest outcome of the project will be a stakeholder consensus on the approaches to, and solutions for, improving response modeling in support of decision making for the USCG FOSC during maritime oil spills in the Arctic. The long-term goal is to establish a credible and useable response model framework for response model(s). If such a model framework can be available for use by government entities such as NOAA OR&R, it can be useful for defining research projects that must be funded to enhance oil spill transport and weathering models in the Arctic as well as framing exercises/drills to test newly developed feeds of ice data into oil spill models. The project will focus the energies of the stakeholders on moving Arctic response modeling in order to produce more accurate results with clear uncertainty bounds that the FOSC can understand and factor into response decisions. The overall project is anticipated to meet at least TRL-3 threshold requirements.

The final knowledge product will be a comprehensive report containing:

- A list of the needs/questions related to oil spill modeling that must be addressed to support the USCG FOSC in decision-making during an Arctic response.
- A review of the current state-of-the-art on oil spill response modeling for Arctic maritime oil spills and ice modeling/data services.
- Delineation of model output uncertainty and how to express it in a format that can be easily interpreted by an FOSC.

- Outline of new and existing technologies that are available to locate and determine the characteristics of oil in the Arctic, notation of their usefulness in anticipated Arctic spill scenarios.
- Suggestions for incorporating local and indigenous knowledge into oil spill trajectory forecasts.
- Detailed recommendations/scopes of work on modeling research needed to fill gaps identified during the project.

In addition to the final knowledge product, the Project PI and ADAC will coordinate a corresponding peer-review journal article. The team has recently had a journal article accepted into the *Journal of Marine Science and Engineering*.

The Year 8 efforts will result in code that allows GNOME to ingest necessary information on %ice cover/concentration, ice velocity and direction with the temporal and spatial needed for the FOSC's decision making during an oil spill response in the Arctic. It will also provide experience for modelers and responders with the modeling and its outputs during the tabletop exercise. Finally, it will provide a refined template for the path forward in the addendum to the Year7 Knowledge Product.

UNH CRRC/CSE will also host/maintain, for a minimum of 5 years, a section of its website dedicated to this project entitled "Arctic Oil Spill Modeling." ADAC will correspondingly plan to cross-link this information to the ADAC website at: https://arcticdomainawarenesscenter.org/. The UNH CRRC/CSE website will contain all of the information for each of the project phases. A complete bibliography will be maintained as a part of the project in a database that will be searchable.

Transition Plan.

The Comprehensive Research Report and corresponding peer-review journal article will be promulgated across USCG, Interagency Coordinating Committee on Oil Pollution Research (ICCOPR), and NOAA and via ADAC and CRRC/CSE networks. The knowledge gained from this project will be directly transferable to HQ USCG Maritime Environmental Response, NOAA OR&R and its Emergency Response Division (ERD) team, which is represented on the Core Team. This is important because NOAA OR&R is responsible for providing scientific support to USCG during maritime incidents, so its oil spill modeling must be fully adapted to the varying and unique conditions in the Arctic. ADAC will also inquire as to suitability of completed knowledge product to potentially support Arctic oriented commercial Oil Spill Response Organizations (ORSOs) as part of the Center's efforts to connect research activities and outcomes to commercial entities.

This includes meetings with industry as described in the overall center management activities. The Project PI also anticipates that much of the knowledge gained and consensus reached will be used by the private sector and other government agencies within and outside of the U.S., hence, the inclusion of RPS OILMAP in the Working Group. Many proprietary models exist (e.g., OILMAP) for use in the Arctic during spills, it is likely that they will also benefit from the consensus approach to modify their oil spill response modeling products, as needed. There will also be coordination with the ECCC which is currently in advanced stages of development of its COSMoS Arctic Oil Spill Model.

Potential programmatic risks to completion.

The project team assesses overall risk to project completion as low. The project team is very familiar with the project methodology and is well acquainted with both the USCG Maritime Environmental Response (MER) community, the oil spill preparedness and response community within the U.S. Federal government, industry and academic disciplines, all of whom are planned as prime contributors and coordinators within the planned project. The product produced from the research is a knowledge document, which is a relatively simple approach to successfully conclude the research endeavor. The team also assesses the risk associated with Year 8 activities as low because the ice and oil spill modelers have been working closely during Phases 4, 5, and 6. They wholeheartedly support the planned integration of ice data into GNOME and OILMAP and testing the efficiency of the linkages in a tabletop exercise.

PROJECT: Arctic Facilities and Infrastructure Environmental Change Risk Index.

Project Investigators: Dr. Craig Tweedie, University of Texas El Paso, El Paso TX, and Dr. Matthew Calhoun, College of Engineering, University of Alaska Anchorage (UAA), Anchorage AK

Lead Institutions: University of Alaska Anchorage UAA and University of Texas El Paso

Project Supporting Researchers:

Dr. Ben Jones, Institute of Northern Engineering, University of Alaska Fairbanks, Fairbanks AK.

Ms. Kelsey Frazier, ADAC Research Associate, UAA.

Mr. Jeff Libby, Director, Applied Environmental Research Center (AERC), UAA

Dr. Molly Grear, Pacific NW National Laboratories, Richland WA.

Mr. Nagruk Harcharek, Ukpeaġvik Iñupiat Corporation, Utqiaġvik, AK.

Project Advisors:

Tom Douglas, Cold Regions Research and Engineering Laboratory, Ft Wainwright AK.

Givey Kochanowski, Alaska Senior Advisor for the U.S. Department of Energy (DOE) Office of Indian Energy, Anchorage, AK.

Project Evaluators: 1

Dr. Nancy Kinner University of New Hampshire, Durham NH, and two additional evaluators who are experts in Coastal engineering and/or permafrost degradation or risk assessment.

Project Champions:

[1] Project require subject matter experts to monitor and evaluate scientific progress based in part on the project evaluation criteria for objectivity and quality.

Ms. Galia Kaplan and MSTC Douglas Furman, Office of Port and Facility Compliance CG-FAC, Headquarters (HQ)U.S. Coast Guard (USCG), Washington D.C.

Project Stakeholders:

Mr. Dan Lawrence, CG-OES, HQ USCG Washington D.C.

CDR Wes James, Office of Marine Environmental Response CG-MER, HQ USCG Washington D.C.

Mr. Shannon Jenkins, Senior Arctic Policy Advisor, CG 5PW, HQ USCG Washington D.C.

Dr. Phil McGillivary, Science Advisor USCG Pac Area, Alameda CA

Mr. Phil Thorne, Arctic Planner, USCG District 17, Juneau, AK.

Mr. Mark Everett, USCG District 17, Juneau, AK.

LCDR Jereme Altendorf, USCG District 17 Sector Anchorage, AK.

Project Description

Abstract.
As the Arctic region is exposed to the impacts of climate change, increased coastal erosion, and more frequent precipitation, structures once protected by shore-fast ice and securely anchored in permafrost are now exposed to an increasingly dynamic and adverse environment. The imminent threat of infrastructure failure has the potential to cause significant environmental harm and disrupt socioeconomic stability and food security of U.S. Arctic residents. Recognizing that) the Arctic is experiencing the most dramatic impacts from climate change on the planet; ii) there is a prevalence of ageing oil and other infrastructure constructed upon increasingly unstable permafrost coastlines and riverine landscapes; and iii) there has been multiple small to large scale infrastructure failures documented in the Arctic over the past decade.

This project responds these concerns as expressed by U.S. Coast Guard (USCG) District 17 to provide an environmental risk index oriented to Arctic coastal regions as a decision support tool to assess environmental impacts to coastal facilities and infrastructure that are under the purview of USCG inspections. This research will focus on conducting a coastal facilities and infrastructure engineering risk analysis along western and northern Alaska. The study will draw experts from a range of disciplines and utilize a collaborative set of workshops and smaller standing working groups to solicit expert opinion that will be used to derive data to apply to models, and test, and deliver an "Arctic facilities and infrastructure environmental change" risk index. The project team will actively seek to coordinate with relevant international Arctic scientists, engineers, and other stakeholders to share and co-develop approaches that are mutually beneficial to those similarly challenged by Arctic environmental change.

The project will primarily focus on bulk oil/fuel containers and pipelines, and piers, docks, and platforms in permafrost coastal and riverine landscapes of the Bering, Chukchi and Beaufort Seas. . Analysis will use appropriate qualitative and quantitative approaches for the data being used and questions posed with attention to uncertainty. Products will inform responders and inspectors of the current and predicted future structural integrity of those facilities, and the bearing capacity, stability, and susceptibility to erosion of the surrounding/ supporting landscape. The research effort will produce three products: a comprehensive Arctic facilities and infrastructure environmental change

knowledge product, an operationally relevant Arctic facilities and infrastructure environmental change risk index, and an Arctic inspector and responder structural environmental impacts training guide.

Objective/Purpose.
This project will address direct concerns regarding structural risks of facilities and infrastructure in Arctic Alaska due to cumulative effects of environmental change.
Based upon analyzing these concerns, this research will address two principal questions:

1. What are the risks and severity to USCG monitored facilities along the Arctic coastal regions of the Bering, Chukchi and Beaufort Seas?
2. What are the risk weightings related to the USCG monitored facilities along the Arctic coastal regions?

In order to address these questions, three primary objectives will be conducted, and each objective contains a series of underlying questions and/or sub-objectives and supports the generation of one of the three project outcomes for the research:

1. Synthesize published literature, existing data from available sources,[2] USCG infrastructure and incident reporting, and consolidate expert opinion to establish a baseline knowledge project in support of USCG Project Champion and USCG Project stakeholders. This information will guide and inform the project's interdisciplinary workshops and focused working groups.
    a. Core supporting questions:
        i. What environmental phenomenon, and/or structural engineering, and other factors are associated with infrastructural degradation or inspection failure?
        ii. How are environmental phenomenon associated with infrastructure degradation or inspection failure changing?
        iii. How adept are past and present engineering and inspection practices suited to the changing environment?
    b. Associated product/deliverable(s):
        i. Research team developed knowledge product, which provides USCG Project Champion a report of investigations accomplished, associated Literature Review, annexes of acquired data and research findings. The research knowledge product provides Stakeholders a source document, potentially useful for additional applications/follow-on research, beyond the scope of the investigations.

[2] Examples provided: Alaska District U.S. Army Corps of Engineers, State of Alaska Department of Environmental Conservation, Denali Commission, University of Alaska Fairbanks Institute of Northern Engineering, Associated State of Alaska Boroughs, Ports and Villages associated with USCG designated infrastructure and facilities of concern and others as determined by the research team and established project research groups.

2. Drawing from the knowledge product to be established in Objective one, develop an "Arctic facilities and infrastructure environmental change" risk index, as a USCG decision support tool.

    a. Core supporting questions/ sub-objectives:

        i. What key engineering and or environmental factors, conditional states, and thresholds best predict infrastructure or inspection failure in the US Arctic?

        ii. Can a risk index model for infrastructure failure adequately predict known infrastructure failure events?

        iii. Using a validated risk index of infrastructure failure, what are the forecast spatiotemporal patterns for infrastructure failure in the US Arctic?

        iv. How can facilities and infrastructure inspection and monitoring be modified to improve the early detection of infrastructure failure?

        v. What are the key uncertainties, priorities for risk reduction, and future research priorities that arises from this project?

    b. Associated product/deliverable(s):

        i. Integrated environmental, infrastructural data set drawn from published literature, data archives, change analyses, inspection and incident reports, and associated environmental characterization models[3].

        ii. Validated risk index and associated analysis of uncertainty.

        iii. Tangible and rationalized review of USCG inspection and structural monitoring approaches.

3. Transition products from Objectives one and two into products that can be promulgated to the USCG, stakeholders, and the broader scientific and engineering community.

    a. Core supporting questions/ sub-objectives:

        i. Develop an optimized and operationally relevant transition plan and guidelines for improved infrastructure inspection and monitoring.

        ii. Share findings with project stakeholders.

        iii. Share findings with the broader scientific and engineering community.

    b. Associated product/deliverable(s):

[3] As examples, the Barrow Area Information Database, which monitors coastline for permafrost degradation and coastal erosion along Beaufort and Chukchi Seas, developed by Project Investigator Dr. Tweedie, and ADAC Storm surge and coastal flooding model project for Western Alaska.

i. Deliver products as well as provide supplemental briefings to inform USCG Project Champion and USCG Project Stakeholders.

Definitions: The focus of the research is to study environmental change on infrastructure and facilities built on permafrost coastal and riverine landscapes in the U.S. Arctic. Project team focus our interests on infrastructure and facilities that are of prime interest to the USCG, even if the jurisdiction of these facilities and infrastructure are not owned or operated by the USCG or the Department of Homeland Security.

For the point of research definitions, the term "***facilities***" for this project is principally oriented to bulk oil/fuel facilities and/or piers, platforms, pipelines and loading docks near coastal regions or nearby/adjacent waterways. Facilities may be horizontal or vertically constructed. **Specifically,** for research associated with this project, the investigators will focus on bulk oil facilities regulated under 33CFR154. U.S. Coast Guard D17 will provide a list of those facilities to the project team.

The term "***infrastructure***" is associated with buildings that have foundations anchored in permafrost landscapes, are principally vertically constructed, and are permanent in nature near or adjacent to ports, waterfront or adjacent to waterways in the U.S. Arctic. **Specifically,** for the research associated with this project the investigators will focus on USCG Forward Operating Base Kotzebue, port facilities at Nome, and the pier and surrounding uplands in Dutch Harbor where USCG has a use agreement with the City of Unalaska.[i]

This project will create and publish three knowledge products (supporting Arctic facilities and infrastructure environmental change knowledge product, operationally relevant Arctic facilities and infrastructure environmental change risk index, and Arctic inspector and responder structural environmental impacts training guide) that collectively will detail:

1. Existing environmental models useful for predicting vulnerability to coastal erosion and permafrost degradation in Alaskan Arctic Coastal communities. Note, the research team may discover, identify and recommend adaptations to existing models that support/inform the overall environmental risk index.
2. Identify Arctic coastal facilities (i.e.: tanks, platforms) and design components (i.e.: risers, above or below ground pipelines) that are most at risk of significant structural impairment from erosion and permafrost degradation.
3. Identify specific signs and symptoms of infrastructure degradation and structural stress which can serve as accurate indicators of high risk of near-term structural failure. A follow-on activity of modeling indications may prove useful and feasible (beyond the scope of the research).
4. Identify or establish needed technologies, methodologies, and practices for identifying structurally stressed or high-risk facilities.
5. Correlate specific environmental changes and infrastructure engineering design typologies to create an operationally relevant Arctic facilities and infrastructure environmental change risk index and validate these against independent inspection and incident reports.

6. Describe critical observational data collection procedures, structural change documentation procedures, and on-site risk analysis methodology in an Arctic inspector and responder structural environmental impacts training guide.
7. Address how these Arctic-specific datasets can inform responses in other regions.
8. While principally focused on the needs of the U.S. Coast Guard and their operations in the United States, the project team will actively seek to coordinate with relevant international Arctic scientists, engineers, and other stakeholders to share and co-develop technologies that are mutually beneficial to all those similarly challenged by Arctic environmental change.
9. Note: While these knowledge products will be oriented to support U.S. Coast Guard decision makers, the products and associated research outcomes will also benefit the community of Arctic science and engineering, in accordance with ADAC's efforts to support the public good.

Baseline.

Characterizing Arctic region environmental change is an important and growing researched topic. Understanding larger scale impacts of environmental change in coastal Arctic Alaska has a number of existing studies conducted by University of Alaska Anchorage, (specifically, the UAA College of Engineering), the University of Alaska Fairbanks (specifically the UAF College of Engineering and Mines and the Institute of Northern Engineering), the Alaska District of the U.S. Army Corps of Engineers, the Denali Commission, State of Alaska Department of Environmental Conservation, and the Barrow Area Information Data Base (BAID) coastal monitoring project supporting the State of Alaska's North Slope Borough, principally developed by the University of Texas El Paso.

Existing research and modeling efforts have characterized and modelled regional coastal erosion and vulnerability to storm surge and associated flooding from storms, oriented to several low-lying regions in Western and North Slope Alaska (Yukon-Kuskokwim River delta, Norton Sound and the region around Utqiagvik and Barter Island Alaska).

Review of existing published research has not determined any associated suitable, fine scale characterization of environmental risk to Arctic coastal region bulk storage facilities or infrastructure in coastal areas that may be at risk to degradation of coastal erosion or permafrost thaw.

Due the extraordinary logistics and associated costs of travel to remote/off road system rural Alaska facilities and the short summer season to safely conduct inspections, USCG regulated facility inspectors are challenged with completing necessary critical inspections of potentially hazardous coastal facilities (such as fuel storage tanks) on an annual basis. Other operational and response personnel are routinely challenged with evaluating and mitigating the additional risk associated with a rapidly eroding and increasingly unstable coastal landscape across the U.S. Arctic.

As a generalization, most of Alaska's Arctic Coastal regions contain soils that are vulnerable to erosion. Until recently, permafrost was frozen hard and solid year-round and provided a sturdy and stable substrate for building facilities, infrastructure, and coastal communities. As Alaska, and in particular, the Alaskan Arctic are now increasingly subjected to rapid and dynamic change, those changes are having sustained, significant, and increasingly detrimental impacts upon tundra, underlying permafrost, and coastal areas. As Permafrost degradation and coastal erosion continue, the bearing capacity and load stability of the ground surface will continue to substantially decrease.

These rapid changes cause increasingly larger shifts in the ground surface that destabilize foundations, thereby negatively impacting their structural integrity.

The Arctic Domain Awareness Center has conducted prior research in storm surge and coastal flooding in Western Alaska, completing fine scale models oriented to the Yukon Kuskokwim River delta and Norton Sound. These models highlight the vulnerabilities of the Bering Sea coastal regions impacted by a diminishing ice environment, in which increasing storm severity and associated surge and wave impacts are increasing inundation and coastal region erosion.

Current facilities inspection guides highlight security, secondary containment, transfer equipment, and safety protocols as major lines of effort in reducing the likelihood of pollutants entering nearby waterways.

There is a need to increase the fidelity of operational planning and risk mitigation strategies by supporting existing area familiarization and local knowledge with an increased technical understanding of key environmental processes contributing to rapid change and instability, providing operators with greater detail of expected on scene conditions and a clearer picture of associated risks. Due to the transportation challenges in accessing the remote coastal regions of the U.S. Arctic for routine facilities inspection, there is need for increased technical understanding of the rapidly changing Arctic coastal environmental conditions as it relates to coastal erosion, permafrost degradation, and associated infrastructure instability. Advancing knowledge products and providing risk indexes to inform inspections and response operations, should help U.S. Coast Guard inspectors identify more vulnerable facilities reducing risk of catastrophic failure, while also providing USCG disaster response operators increased understanding for corresponding environmental mitigation activities.

As the dynamic Arctic environment exerts a multitude of forces upon remote infrastructure, it is advantageous for safe and efficient operations to understand, calculate, and predict those forces and forecast their associated impacts upon the structural integrity of effected facilities. Developing a comprehensive guide outlining associated precursors of an incident, methods for failing structure identification and triage, and methods for closely monitoring change will greatly assist the triage and scheduling of the most at-risk facilities. More frequent inspections of only the most at-risk facilities/structures and less-frequent, periodic inspections of lower risk locations will maximize USCG resources and reduce unnecessary risks to inspection teams, and in light of on-going concerns from the Coronavirus, such efforts will also reduce risk of exposure of indigenous communities to communicable diseases.

As a University of Alaska (UA) hosted, and U.S. Department of Homeland Security (DHS) Science and Technology (S&T) Office of University Programs (OUP) sponsored Center of Excellence (COE) in maritime research, ADAC is uniquely positioned to convene the government, industry, and research communities together in strategically designed forums to closely examine capability gaps, as well as both available and needed solutions. Accordingly, As ADAC's mission is to seek solutions that "enable the decision-maker" in advancing Arctic domain awareness, this project is proposing to apply an effective and well-practiced ADAC research method in order to address a known and high priority problem for the USCG.

Methodology.

The research approach for the project is to utilize a multidisciplined team of Arctic scientist and engineer to study the environmental changes in U.S. Arctic coastal regions to assess overall soil degradation and their impacts to infrastructure and facilities, in order to derive an associated risk index. The research team will organize and conduct expert workshops, acquire related data via the participants to the workshops and follow-on activities and establish a core and additional functionally aligned teams to develop an environmental risk index to assess and prioritize risk to USCG designated facilities and infrastructure in Arctic Coastal Alaska.

These combined impacts include such factors as permafrost thaw, reduction of protective persistent shore fast ice, and associated coastal region erosion. From, studying available data and reports, accessing known models, and by soliciting input from a number of additional expert analysis via working groups, investigators will create an Arctic coastal region environmental risk index that incorporates investigative review of associated effects to key infrastructure and facilities, focused on the particular locations identified by USCG. The research is intended to provide decision makers an overall environmental risk index by assessing specific locations of interest.

The investigative team is comprised of Arctic engineering experts who will lead focused studies of environmental change caused degradation of Arctic coastal regions, expanding their expertise via establishing working groups to provide multidisciplined analysis of fine scale changes of Arctic climate change to analyze deterioration of structural stability of infrastructure and facilities.

The overall approach designed for this project is conceptualized in Figure 1.

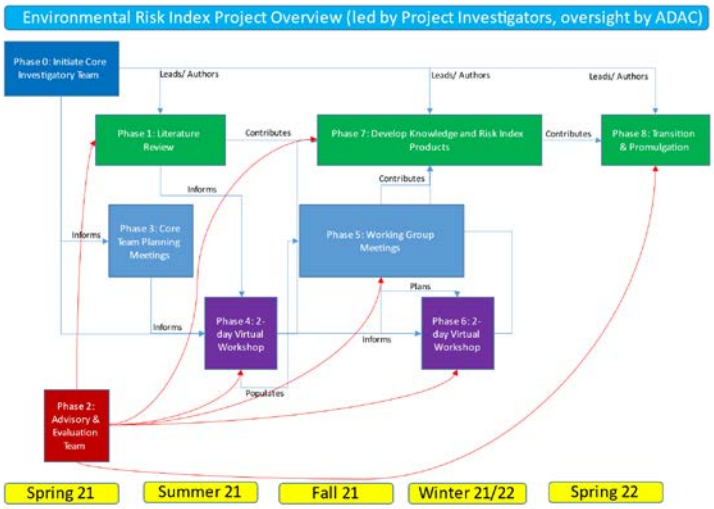

Figure 6: ERI Project Overview

The Investigatory (Phase 0), and the Advisory and Evaluation Teams (Phase 2) will be initiated in Spring 2021. The Investigatory team will author the primary products arising from the project (Phases 1, 7, 8 ~ green boxes), and inform both the planning (Phase 3) and working group meetings (Phase 5; light blue boxes) and virtual workshops (Phases 4, 6 ~ purple boxes). The Advisory and Evaluation Teams will advise/evaluate product development and working group activities

and virtual workshops (red arrows). The Literature Review (Phase 1) will contribute to the generation of other products and inform the workshops (Phases 4, 6) and working group activities (Phase 5).

Data to be collected for this research will be associated with qualitative and quantifiable attributes of environmental changes of Arctic coastal regions, principally oriented to USCG focused areas of interest. This includes such factors as coastal erosion and permafrost thaw, and available survey and engineering reports associated with the facilities and infrastructure identified by USCG D17[4]. Data of environmental changes/associated structure changes/risk factors to specific USCG identified facilities and infrastructure will be sought. As identified in the literature review, existing data from sources of coastal erosion and monitoring data (such as the Barrow Area Information Database) will be leveraged. Modeled data (such as that associated with prior ADAC Western Alaska Storm Surge and Coastal Flooding project) that helps characterize changing conditions of coastal structural stability will also be accessed.

Implementation of the methodology will include a sequenced set of coordinated and collaborative virtual meetings and Working Groups to facilitate the convergence of multiple scientific disciplines and the formulation of a knowledge product (or series of knowledge products) useful and relevant to USCG management of both risks to operational personnel and of a future regulated facility incident.

ADAC Program Year 8 project phases include the following:

- *Phase 0*: Initiate investigative team led studies that forms the core of the knowledge product**.**
- *Phase 5*: Establishing virtual Working Groups and conducting meetings.
- *Phase 6*: Conducting a Two-Day Workshop to Review Working Group Drafts and Integrate Feedback into Knowledge Product.
- *Phase 7*: Completion of comprehensive Arctic facilities and infrastructure environmental change knowledge product.
- *Phase 8:* Transition: promulgation of completed knowledge product across USCG community of interest (specifically, as designated by USCC Project Champion and USCG Project Stakeholders) and onward manuscript development and submission to peer review professional journals.

Details describing each phase of the project are as follows:
Phase 0: Initiate investigative team led studies that forms the core of the knowledge product. Co-investigators and funded research team, informed by prior research analysis and modeling in storm

[4] Project team will inquire with Alaska District U.S. Army Corps of Engineers, State of Alaska Department of Environmental Conservation, Denali Commission and associated village and port authorities to gain access to survey and engineering reports associated with USCG D17 identified facilities and infrastructure**.**

surge, coastal inundation and erosion in Western and North Slope Alaska establish qualitative and quantitative baselines of regional and localized effects of Arctic climate change in deteriorations to existing infrastructure and facilities. In particular, research team will seek via existing engineering analysis to characterize degradation of facilities and infrastructure risks to USCG determined assets in order to ascertain initial estimates of structural stability. These studies will continue throughout the tenure of the project. The investigatory team will lead the development of the core knowledge product, guide development of the risk index and lead. Co-investigators and funded research team, informed by prior research analysis and modeling in storm surge, coastal inundation and erosion in Western and North Slope Alaska establish qualitative and quantitative baselines of regional and localized effects of Arctic climate change in deteriorations to existing infrastructure and facilities.

Phase 1, 2, 3 and 4: Accomplished in ADAC Program Year 7.

Phase 5: Establishing and executing working groups *(1 July 2021 – 30 Nov 2021).* Project team will accomplish this task early in ADAC Program Year 8. Following the 2-day virtual event, the Project PI will convene and facilitate working groups. The Project PI will designate a co-group lead for each Working Group. The Project PI will coordinate subject matter experts for each working group while also establishing a co-lead from among USCG Stakeholders. The Co-Working Group Leads will work with the Project PI prior to each group's meetings to set each working group meeting agenda.

> *Task 5.1* Establishing Working Groups. The Project PI will solicit Group members during the Two day virtual and finalize membership in coordination with Project Champion (TBD) and the overall Project Core Team. The Working Groups will meet every three weeks via web-meeting conference calls. The Project PI will provide administrative coordination for all Working Groups, to include maintaining records and files for documents and relevant materials.
>
> *Task 5.2* Conduct Working Group meetings. The Working Groups will meet 8 times for 1-1 ½ hour each. The Project PI and Co-Working Group Leads will coordinate and document group outcomes in a spreadsheet and a five-page white paper summarizing the group's findings, their relevance to response modeling, resolution of issues and detailed research needs.

Phase 6: Conducting a Two-Day Workshop to Review Working Group Drafts and Integrate Feedback into Knowledge Product. *(1 Jan 2022 – 30 Jan 2022). Project team will accomplish this task in ADAC Program Year 8.*

> *Task 6.1*: *Conducting a two-day Workshop to Review Working Group Drafts and Integrate Feedback into a Knowledge Product.* The principal activity of this phase is to plan and conduct an Alaskan and U.S. Arctic Maritime Connectivity Team Knowledge Product Development Workshop. The goal of the Workshop is to advance and refine the Environmental Risk Index and establish and frame a final knowledge product, which should be a comprehensive project report summarizing the findings of the Working Groups.

Phase 7: Completion of Arctic facilities and infrastructure environmental change knowledge product *(30 Mar 2022). Project team will accomplish this task in ADAC Program Year 8.*

> *Task 7.1*: *Create USCG-focused Knowledge Products*. Research team will conduct needed analysis by reviewing accomplishments of research and development of corresponding protocols

and associated data to create a useful knowledge product for the USCG Project Champion and USCG other department/agency advisors as determined by the Project Champion.

This Knowledge Product will be used by the Project team as baseline of knowledge to conduct onward information dissemination and will address the following:

1. Environmental models useful for prediction of coastal erosion and permafrost degradation in Alaskan Arctic Coastal communities.
2. Identify Arctic coastal facilities (i.e.: tanks, platforms) and design components (i.e.: risers, above or below ground pipelines) are most at risk of significant structural impairment from erosion and permafrost degradation.
3. Identify specific signs and symptoms of infrastructure degradation and structural stress which can serve as accurate indicators of high risk of near-term structural failure. Such indications may prove both useful and feasible for engineering modeling.
4. Identify or establish needed technologies, methodologies, and practices for identifying structurally stressed or high-risk facilities. Again, modeling may prove useful and feasible.
5. Correlate specific geophysical changes and bearing capacity loss models/calculations with specific infrastructure and facilities design typologies to create an operationally relevant Arctic facilities and infrastructure environmental change risk index.
6. Describe critical observational data collection procedures, structural change documentation procedures, and on-site risk analysis methodology in an Arctic inspector and responder structural environmental impacts training guide.
7. Address how these Arctic-specific datasets can inform responses in other regions.
8. While principally focused on the needs of the U.S. Coast Guard and their operations in the United States, the project team will actively seek to coordinate with relevant international Arctic scientists, engineers, and other stakeholders to share and co-develop technologies that are mutually beneficial to all those similarly challenged by Arctic environmental change.

Phase 8: Transition: promulgation of completed knowledge product across USCG community of interest (specifically, as designated by USCC Project Champion and USCG Project Stakeholders) and onward manuscript development and submission to peer review professional journals. Following the completion of the USCG Arctic Region Environmental Risk Index Knowledge Product, the project team will host a primary and back-up webinar in coordination and consultation with USCG Project Champion to describe the Knowledge Product and provide demonstrations in applying the product to inform USCG stakeholders and community of interest. The Knowledge Product and associated instructional materials will be provided to the USCG Project Champion in accordance with the desires of the Project Champion for posting to USCG information/knowledge portals. In accordance with ADAC management and communications practices, the Knowledge Product will also be posted to the associated ADAC Project Page (see: https://arcticdomainawarenesscenter.org/Projects). Following delivery of Knowledge Product, research team will complete and submit associated manuscript for peer review journal publication.

Key Milestones.

Phase 0: Initiate investigative team led engineering analysis that forms the core of the knowledge product. *(1 Apr 2021-15 May 2022).*

Phase 1, 2, 3, 4: Completed in Program Year 7.

Phase 5: Establishing virtual Working Groups and conducting meetings. (1 Jul 2021 – 30 Nov 2021)

Milestone 5.1: Project PI leads formation of Working Groups following the Phase 4 event.

Milestone 5.2: Working Group Co-lead selection (one of the Co-leads from each group will be from USCG/governmental agency).

Milestone 5.3: Project PI facilitates meetings of the Working Groups at 3-week intervals.

Milestone 5.4: Project PI facilitates cross-coordination meetings of Core Team and Working Group co-leads at 3-week intervals.

Milestone 5.5: Project PI conducts scheduled cross-team Working Group meetings.

Milestone 5.6: Project PI coordinates drafting of Working Group reports with onward edits provided by Co-leads, reviewed and approved by Working Group members.

Phase 6: Conducting a Two-Day Workshop to Review Working Group Drafts and Integrate Feedback into Knowledge Product. *(1 Jan 2022 – 30 Jan 2022)*

Milestone 6.1: Project PI leads event Organizing Committee (OC) in coordination with Core Team.

Milestone 6.2: Project PI convenes OC and provides charge to its members.

Milestone 6.3: Project PI conducts meetings to solidify event objectives and agenda, including speakers and breakout groups, and participants.

Milestone 6.4: Project PI leads execution of final event in Jan 2022.

Milestone 6.5: Project PI completes report from event and incorporates into knowledge product.

Phase 7: Completion of an Arctic facilities and infrastructure environmental change knowledge product**.** *(30 Mar 2022)*

Milestone 7.1: Research team will review accomplishments of research, development of corresponding protocols, and associated data.

Milestone 7.2: Project PI and Core Team will facilitate the creation of a written knowledge product for the USCG Project Champion and USCG other department/agency advisors as determined by the Project Champion.

Milestone 7.3: Knowledge product delivered to USCG Project Champion by 30 Mar 2022.

Phase 8: Transition: promulgation of completed knowledge product across USCG community of interest. *(1 Apr-1 Jun 2022).*

Key Stakeholder engagement.

The Project Team will participate and be featured in the ADAC "Customers and Partners" Roundtable, in order to inform and receive feedback on project progress. The stakeholders including USCG PACAREA and D17, USCG Sector Anchorage, and other Arctic facilities stakeholders. This project will also seek collaboration from academics, industry, NGO, and state, local and indigenous representatives, including ADAC student fellows. Students of participating academics will also be invited to attend the virtual events.
The Project PIs will work with the Project Champion, the Core Team, in particular USCG D17, and Sector Anchorage throughout the project to ensure the outcome is a clear understanding of the impacts of rapid environmental change upon coastal facilities stability and structural integrity. Through initial engagement of the USCG D17 and Sector Anchorage, the Project PI will determine what questions must be answered in advance of facilities inspection operations. This set of specific questions will be vetted by the Core Team and once accepted will serve as guideposts for the rest of the project. These guideposts will be used in all engagement with the virtual event OC and participants, and the Working Groups. They will help to ensure that the driving force behind all of the Project Team's efforts are addressing these needs and answering these questions – not to be confused with those questions that are solely research-focused (e.g., to increase understanding of the entire Arctic ecosystem).

The Project PIs will work closely with Project Champion and Project Stakeholders as confirmed by HQ USCG. The Project Champion will serve as the principal advisor to the Core Team for the project and in that role will ensure that input from USCG PACAREA, USCG D17, USCG Sector Anchorage, and associated facilities inspectors will be at the forefront of the Project Team's consideration.

The Project PIs will engage the Project Champion at a minimum on a monthly basis for a pre-scheduled conference call meeting. Subsequent to these meetings each month, The Project PIs will meet with the Core Team via conference call. ADAC Center leadership will be informed of all of these meetings and included on all conference call meeting invitations. The Project PIs or designated representative will participate in ADAC's Quarterly Review, quarterly ADAC Customers and Partners Roundtable, the ADAC Annual meeting in Washington D.C. as well as on all Core Team calls. In addition, the Project PI or designee will participate in the weekly ADAC "all hands" team meetings.

The project researchers plan for the representation of the project team at the following ADAC/ADAC supported events:

1. Designated meetings with HQ USCG Designated Project Champion and any Project Champion Directed USCG and/or other Agency/Department Advisors.
2. Weekly All Hands meeting (Normally Thursdays, 1130-1230 Alaska Time via teleconference).
3. Quarterly Reviews and Quarterly Customer's and Partner's Roundtable.
4. Annual ADAC meeting at HQ USCG, Washington D.C.
5. Meetings coordinated by ADAC with industry, such as conferences and symposia.

Student Participation.
ADAC and project team will investigate opportunities for one existing Center Fellow to participate in the research project, jointly managed via ADAC Education and Administrative Manager and the research investigators at UAA.

Performance Metrics.

The Core Team, chaired by the Project Champion, on a quarterly basis will evaluate the project's management progress and assess project performance on Scientific and Technical metrics. A parallel review will be conducted by ADAC and the Project PI, in accordance with ADAC's Annual management plan. These metrics will include:

1. Project Management and Progress Metrics:
    a. Is the project on time, based on the schedule set forth in the detailed work plan established between ADAC, the Core Team and Project Investigator? [**Assessment**: conformity with project GANTT schedule]
    b. Is the project at, or under, cost based on the workplan budget established by ADAC and the Project Investigator? [**Assessment**: budget analysis of expenses and obligated funds]
    c. Are resources (e.g., references, workshop/working group participants) being gathered/recruited in sufficient numbers for the project tasks? [**Assessment**: comparison of actual vs. time & effort by participants]
    d. Is the scope of the project adequate or does it need to change to meet unforeseen components that arise in environmental modeling? [**Assessment**: comparison of attainment of actual vs. project goals]

2. Scientific and Technical Metrics:

    a. Does the literature review highlight unanticipated technical advances that may benefit Alaskan and U.S. Arctic Federal, State and local facilities inspection and management communities? [**Assessment**: comparison of documented literature review with the results of online resources (e.g., Web of Science, Google Scholar, PubMed, etc.) review using same search terms]
    b. Does engagement of project stakeholders and community provide unanticipated discoveries in how infrastructure and facilities managers reduce their operational risk as related to changing environmental conditions? [**Assessment**: comparison of actual vs. novel findings or realities by brief, targeted, and web-based survey instruments]
    c. Evaluation of methods for literature review and information gathering:
        I. Has an appropriate search strategy been developed and executed to identify unpublished or "gray-literature" source documents, artifacts, and individuals to consult in the course of this study? [**Assessment**: assessment of attainment of actual vs. project goals]
        II. Have the data gathered during the course of the study been interpreted and organized using a systematic taxonomy, data fields or framework? [**Assessment**: assessment of attainment of actual vs. project goals]
    d. Validation of data and recommendations:
        I. How complete is the set of documents, artifacts and individuals that were consulted in the study? [**Assessment**: comparison of known vs newly acquired resources through broadscale publishing among project participants]
        II. Is the data gathered in the study accurate, as assessed by the third-party independent reviewers, or by consulting additional sources? [**Assessment**:

comparison and evaluation of data and results using standard criteria in the subject matter field of study]

III. Are the recommendations' objective, and supported by the data gathered in the study? [**Assessment**: evaluation by SME using standard field of study criteria]

Outcomes/Outputs.

The principal outcome of the project will be a comprehensive assessment and public document on the approaches to, and solutions for, improving risk mitigation and operational decision-making for USCG facilities inspections and response operations. The long-term goal is to establish a credible and useable framework for categorizing Arctic infrastructure and facility status and calculating risk of future failure based on the various erosion, permafrost, and facilities engineering conditions that routinely occur in the Arctic. If such a risk framework can be available for use by government entities such as USCG, it will be useful scheduling the frequency of facilities inspections, and identifying the most at-risk locations. The development of an Environmental Risk Index is planned as fundamental research activity, particularly, as this project is less than 15 months in overall length. Accordingly, the final project is anticipated to meet at least TRL-3 threshold requirements. If/as USCG was interested in advancing the Environmental Risk Index to higher level of technology readiness, ADAC and the research team are at the ready to support additional investigations via ADAC's Basic Ordering Agreement (BOA).

The final knowledge products will contain:

- A completed Arctic Infrastructure and Facility Environmental Risk Index that is at least at TRL-3, oriented to address USCG D17 designated Infrastructure and Facilities in Arctic Alaska. This a core deliverable from the research.
- An associated product containing an Arctic operator and Facility Inspector's Arctic environmental factors training guide. This is a companion document to implement the Environmental Risk Index. A supporting knowledge product that includes the following:
    - A summary of all associated meetings, workshops, with key findings, data, reports and associated information.
    - A list of the key parameters related to coastal erosion, permafrost degradation, and facilities structural decline that are the best predictors of increased operational risk and near-term structural failure in the rapidly changing Arctic environment.
    - A review of the current state-of-the-art on permafrost and coastal erosion modeling for Arctic coastal areas that identifies gaps and weaknesses in current capabilities.
    - Recommendations for addition of modules on response technologies that assist with identifying and categorizing coastal Arctic changes.
    - Recommendations on incorporation of additional natural processes into models.
    - Detailed recommendations/scopes of work on potential research needed to fill gaps identified during the project.

- The Project Investigators will draft a corresponding peer-review journal article following the conclusion of the research.
- In consultation with the Project Champion, ADAC will correspondingly post all information related to this research to the ADAC website at: https://arcticdomainawarenesscenter.org/.

Transition Plan.
As discussed in Project Phase 8, the Comprehensive Research Report and corresponding peer-review journal article will be promulgated across USCG and ADAC networks. The knowledge gained from this project will be directly transferable to USCG Facilities Inspections and Maritime Environmental Response, which are to be represented on the Core Team. The Project development team anticipates that much of the knowledge gained and consensus reached will be used to manage facilities inspections schedules, inform inspectors as to the severity of observed environmental changes, and predict expected future condition of USCG supporting infrastructure and Regulated Facilities.

Potential programmatic risks to completion.
The project team assesses overall risks to project completion as low. The project team is very familiar with the project methodology and is well acquainted with the USCG Facilities Inspections, Environmental Response (MER), and Search and Rescue communities. In addition, the oil spill preparedness and response community within the U.S. Federal government, industry, and academic disciplines are also planned as prime contributors and coordinators within the project. The Environmental Risk Index product produced from the research is a knowledge document, which when applied with the companion training guide, produces a relatively simple decision support tool. The additional products produced from the research, provide the USCG Project Champion a useful set of accumulated reports, workshops, data and background to add professional details to successfully conclude the research endeavor.

THEME 2: Maritime Domain Awareness (MDA) Research

1. Arctic Ice Conditions Index (ARCTICE).
2. Arctic Vessel Monitoring Geofencing/Alert Awareness.
3. Alaskan and Arctic Maritime Communications and Connectivity Analysis (PMC&CA)

PROJECT: Arctic Ice Conditions Index (ARCTICE)

Commented [GT1]: NOT APPROVED

Project Investigators: Dr. Jifeng Peng, University of Alaska Anchorage.

Project supporting investigators:

Dr. Shawn Butler, University of Alaska Anchorage.
Dr. Jinlun Zhang, University of Washington.
Kelsey Frazier, University of Alaska Anchorage.

Lead Institution: University of Alaska Anchorage.

Project Champion: CDR Christopher B. Tuckey, HQ U.S. Coast Guard CG-WWM.

Project Description:

Abstract.

In collaboration with USCG and other government agencies, the ADAC team is refining and adding operational utility to the Arctic Ice Condition Index (ARCTICE), which is focused on the ice laden waters of the Bering, Chukchi and Beaufort Seas (corresponding to the U.S. Arctic Extended Economic Zone (EEZ). The first two years of this project produced an easy-to-understand numeral to communicate ice conditions that are relevant to the capabilities of an individual vessel. This visualized decision support product, a numeric index that combines marine vessel size, gross tonnage and hull strength polar classification to contrast against current and forecast ice of the planned route of sail, is available for current and future ice conditions. ARCTICE provides forecasts from 72 hours up to 1 month in advance. ARCTICE transition activities led to publicly available, ready access to this information through the data management organization, Axiom Data Science. This information produced by the ARCTICE algorithm supports USCG and shipmasters in route planning and in determining associated risk with traveling through a particular region in the Arctic Waters, thus increasing the safety of sailing in Arctic ice laden waters.

The ARCTICE team is guided by a USCG-led "council of experts" which provides operationally relevant expertise and perspective in the design, functionality, and utility of the algorithm's output. Input from the council of experts indicates further work, beyond the scope of the year 6 and 7 workplans, is necessary to increase data integration abilities for USCG operators. Further, live testing of the algorithm, which was delayed due to Covid-19 restrictions, is integrated in the workplan for year 8. End-of-term transition of the ARCTICE products and an operational home for the algorithm is still under development, with potential homes at the U.S. National Ice Center (USNIC) or the Alaska Ocean Observation System. Finally, adaptation of the ARCTICE algorithm beyond its current domain is a key element in the proposed scope of work. This extension is inclusive of investigation as to applicability of the algorithm to D1 needs, and utility of the hind and forecast capabilities to predict future Arctic port demand and utility.

Accordingly, project researchers plan to integrate end user feedback and perform extension research through workshops and seminars (using distant technologies as appropriate) in coordination with USCG D17 to collaborate with ice and maritime transportation experts. These experts are from a range of organizations including (but not exclusive to): NOAA, the U.S. National Ice Center, the US Army Corps of Engineers Cold Regions Research and Engineering Laboratory (CRREL), USCG RDC, USCG D17, Transport Canada, the Canadian Ice Service, the Finish Meteorological Institute, and the University of Alaska. Transitioned ARCTICE is planned to publish to U.S. National Ice Center and will be readily to USCG D17 and Arctic mariners.

~~In collaboration with USCG and other government agencies, the ADAC team is developing an Arctic Ice Condition Index (ARCTICE). In this project, the team is focused on the ice laden waters of the Bering, Chukchi and Beaufort Seas (corresponding to the U.S. Arctic Extended Economic Zone (EEZ). The first two years of this project produced an easy-to-understand numeral to communicate ice conditions that are relevant to the capabilities of an individual vessel. This index is available for~~

~~current and future ice conditions, providing forecasts from 72 hours up to 1 month in advance. Based on completed and transitioned Great Lakes ICECON investigations, proposed research will result in providing marine operators a transition destination ready access to this information, in particular the U.S. National Ice Center (USNIC) and the Alaska Ocean Observation System supporting vessel captains and officers in route planning and in determining associated risk with traveling through a particular region in the Arctic Waters.~~

~~Similar to the completed project creating ICECON for the Great Lakes region, ARCTICE research, guided by the USCG led "council of experts" has produced a visualized decision support product, a numeric index that combines marine vessel size, gross tonnage and hull strength polar classification to contrast against current and forecast ice of the planned route of sail, to provide USCG and shipmasters improved safe passage insight in Arctic ice laden waters. In order to achieve improved usefulness and utility, ARCTICE research will include an inclusive and iterative process principally with meteorological, marine traffic, and safety experts.~~

~~In order to provide vessel masters environmental data to create an ARCTICE decision support tool, the decision support will leverage existing (and will be able to select between) available sea ice characterization models. It is important these factors include and model (forecast) available Arctic region ocean current, sea ice presence, thickness, movement and ridging factors.~~
~~Accordingly, project researchers plan workshops and seminars (using distant technologies as appropriate) in coordination with USCG D17 to collaborate with ice and maritime transportation experts. These experts are from a range of organizations including (but not exclusive to): NOAA, the U.S. National Ice Center, the US Army Corps of Engineers Cold Regions Research and Engineering Laboratory (CRREL), USCG RDC, USCG D17, Transport Canada, the Canadian Ice Service, the Finish Meteorological Institute, and the University of Alaska. Transitioned ARCTICE is planned to publish to U.S. National Ice Center and will be readily to USCG D17 and Arctic mariners.~~

Objective/Purpose.

The research team will continue the transition efforts for their ARCTICE algorithm and investigate extended capabilities beyond the U.S. Arctic EEZ. This algorithm was designed specifically for use by vessels operating in the U.S. EEZ, focused on the Bering, Chukchi, and Beaufort Sea regions, and secondarily operating in the waters of the North American Arctic. This planned research investigation is a continuation of year 7 efforts to transition the operational model into federal ownership, with new research proposed in testing and validation of the output charts, and new research into extended applications. The research team will further continue to develop an Apple iOS-based app for the ICECON data collection efforts, as requested by USCG D9. This investigation will leverage guidance from a USCG led Council of Experts and will deliver the mariner support tool to operational destinations as determined and coordinated via the planned USCG led, Council of Experts.

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Baseline.

Year to year and decade-to-decade, marine vessel traffic in the Arctic regions of the Bering, Chukchi and Beaufort Seas is increasing. The rise in vessel traffic is highest in summer months but is also increasing in the summer "shoulder seasons" of spring and fall, and there is even a rise in winter related traffic, due in part from the establishment of Liquefied Natural Gas (LNG) in Arctic Russia, transiting the Chukchi and Bering Sea regions year-round. Commercial interests are now exploring the feasibility of an Alaska North Slope LNG operation to carry LNG via ship to markets in lower latitudes. Marine vessels operating in the ice-laden waters within the U.S. Exclusive Economic Zone (EEZ) of the Bering, Chukchi and Beaufort Seas in the Arctic face a number of challenges.

These challenges include long distances between ports of call, communication shortfalls, increasingly difficult to predict weather, limited infrastructure, limited U.S. Coast Guard and other search and rescue forces, and a unique safety challenge to assess how to navigate complex sea ice. Currently, there are limited planning tools to support mariner route and decision-making in sea ice conditions. A real-world example was the USCG D17 rescue of the 36 ft. "*Altan Girl*" inadvertently locked in Chukchi Sea ice in July 2014. Specifically, there is no method to communicate to vessels underway or planning a navigation route the relative risk due to sea ice conditions and related to their specific vessel capabilities.

The ARCTICE project leans on the research methods developed in the Great Lakes ICECON project. Great Lakes ICECON is a decision support tool combining vessel class with nowcast and forecast, lake ice conditions. In order to ensure the safety and security of Arctic vessels, personnel, and the environment, the development of a high resolution, Arctic Ice Condition Index (ARCTICE) is warranted to support Arctic mariners in operational decision making.

There are numerous methods for communicating sea ice conditions and each Arctic nation has their own system. Russia and Canada, for example, both have systems to take ice conditions and translate those conditions into the relevant risk of transit based on a vessels' particular class. Translating between Russian and Canadian systems can be challenging as each nation uses a different ice condition scale and a different vessel classification method. Following the adoption of the International Maritime Organization's "POLARIS amendment" to the IMO Polar Code, those communication tools are starting to migrate to a uniform methodology. While the IMO has no existing or planned international enforcement privileges, the IMO Polar Code is seen as a "best practices" guide, many nations require that vessels comply with the code as it reduces the potential risks of death, environmental contamination, and excessive search and rescue support.

The POLARIS amendment to the IMO Polar Code is based on vetted ice condition processes from the Canadian AIRSS system, the Russian Ice Certificate concept, and additional inputs from other coastal administrators. The IMO offers a Polar Certificate to crews that train on, and comply with, the Polar Code. Therefore, crews on vessels traveling on Arctic routes will most likely have a Polar Certificate and will be familiar with the ice condition communication regime outlined in POLARIS. Based on the successful completion of Great Lakes ICECON, researchers proposed an Arctic version of ICECON. Arctic ICECON, called ARCTICE, focuses on those Arctic regions that are most relevant to USCG mission and their waterway management concerns: the Bering, Chukchi and Beaufort Sea

areas within the U.S. EEZ. The ADAC team researched the subject and completed a report describing the feasibility of ARCTICE (submitted to USCG on 20 July 2019) based on the available science and information gained from the Great Lakes ICECON project. The study assessed the properties and associated differences between sea and lake ice. As this project is the transition from the Great Lakes to the Arctic Ocean, references were reviewed to establish baseline knowledge of the new challenges ARCTICE would need to address. Sea ice strength is relative to its thickness, stage, and temperature. Brine channels play a key role in the relative strength as well. Operators need to understand how these elements will affect their ability to navigate through water with sea ice.

This research also helped the team better understand both U.S. and international sea ice models. There are many operational and experimental Arctic Sea Ice models, including U.S. Navy Global Ocean Forecast System (GOFS), NOAA Global Real-Time Ocean Forecast System (RTOFS), NOAA-ESRL Coupled Arctic Forecast System (CAFS), Canadian Global Ice Ocean Prediction System (GIOPS), and High-resolution Ice-Ocean Modeling and Assimilation System (HIOMAS), which was developed at Arctic Domain Awareness Center. After careful consideration of each of these models, the project team intends to use HIOMAS for its higher resolution (2-km, pan-Arctic).

Included in the feasibility study was a review of the relevant guidelines from the International Maritime Organization for Arctic operators. In the current Polar Code, vessels are required to adhere to a narrow set of standards in order to obtain an internationally recognized "Polar Certificate." This certificate is required by many foreign nations if vessels wish to operate within their waters where sea ice is present. Vessel operators learn to plan routes through sea ice using the guidelines therein and will look likely seek similar data sources when traversing U.S. waters.

The ARCTICE study evaluated the Polar Operational Limit Assessment Risk Indexing System (POLARIS) amendment as a suggested methodology to adopt for clearly communicating the operational risk related to ice. Within the POLARIS guidelines, there is a clear preference for communicating ice conditions with the CIS/WMO standards. These conditions are then used to calculate risk of maritime navigation. This addendum to the Polar Code is based on the Canadian AIRSS methodology, but also includes some additional features such as icebreaker escort.

Having received approval for the ARCTICE project for year 6 of the Center, the project team developed an initial algorithm using the index method outlined in POLARIS. This work included confirming the relationship between Polar vessel classes and vessel classifications typical for US carriers, an investigation of other national models and methods for communicating sea ice risk to vessels, developing suitable environmental factors, determining how information would be accessed, and testing initial output. Year 7 for the Center saw further development of the algorithm, including the production of output visualizations, automation of the system, ARCTICE validation, and transition to its current operational destination.

~~Year to year and decade to decade, marine vessel traffic in the Arctic regions of the Bering, Chukchi and Beaufort Seas is increasing. The rise in vessel traffic is highest in summer months but is also increasing in the summer "shoulder seasons" of spring and fall, and there is even a rise in winter related traffic, due in part from the establishment of Liquefied Natural Gas (LNG) in Arctic Russia, transiting the Chukchi and Bering Sea regions year round. Commercial interests are now exploring the feasibility of an Alaska North Slope LNG operation to carry LNG via ship to markets in lower~~

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The ARCTICE project leans on the research methods developed in the Great Lakes ICECON project. Great Lakes ICECON is a decision support tool combining vessel class with nowcast and forecast, lake ice conditions. Great Lakes ICECON forecasts up to 120 hours into the future and uses circulation and ice models developed by NOAA's Great Lakes Environmental Research Laboratory (GLERL). Great Lakes ICECON accounts for icebreaker activity and its impact via nowcasts and forecasts. In parallel with the development of Great Lakes ICECON, the research identified and adopted a vessel classification system to define a number of vessel classes and the ice capability of ships in those classes (in terms of ICECON). The ICECON system supports USCG to provide guidance and appropriate decision support to Great Lakes marine vessels (for a given class) planning a given transit. ADAC researchers have previously delivered a Beta version of Great Lakes ICECON for integration to USNIC and are currently in progress in adapting prior feedback and the current winter season, lake ice associated environmental data to refine and deliver the finalized version.

In order to ensure the safety and security of Arctic vessels, personnel, and the environment, the development of a high resolution, Arctic Ice Condition Index (ARCTICE) is warranted to support Arctic mariners in operational decision making.

There are numerous methods for communicating sea ice conditions and each Arctic nation has their own system. Russia and Canada, for example, both have systems to take ice conditions and translate those conditions into the relevant risk of transit based on a vessels' particular class. Translating between Russian and Canadian systems can be challenging as each nation uses a different ice condition scale and a different vessel classification method. Following the adoption of the International Maritime Organization's "POLARIS amendment" to the IMO Polar Code, those communication tools are starting to migrate to a uniform methodology. While the IMO has no existing or planned international enforcement privileges, the IMO Polar Code is seen as a "best practices" guide, many nations require that vessels comply with the code as it reduces the potential risks of death, environmental contamination, and excessive search and rescue support.

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Having received approval for the ARCTICE project for year 6 of the Center, the project team developed an initial algorithm using the index method outlined in POLARIS. The POLARIS amendment outlines the relationship between input environmental parameters and the output ice condition numeral as a function of ice class, season of operation, and vessel operational state (i.e., independent operation or icebreaker escort). This method may appear similar to the Transport Canada AIRSS method, but the POLARIS method considers vessel speed/escort operations, as well as seasonal ice decay and ice strength. While escort operations are not currently planned for the US EEZ, the influence of ice decay and strength is an important factor.

The ARCTICE program also accomplished the following items:

1. *Provide and confirm the ARCTICE vessel classification index.*

   The Polar Code uses the International Association of Classification Society (IACS) Polar Class Unified Requirements and the Finnish Swedish Ice Class Rules (Baltic Ice Class). The project team has identified the correlation between the Polar Class/Baltic Ice Class and the ABS Ice Class. Researchers also compared the differences in Arctic vessel classification systems

established by Polar Code and by American Bureau of Shipping (ABS). Both the Polar code and POLARIS use a Polar Class classification system (PC 1 to PC 7) from the International Association of Classification Societies (IACS). ABS uses Arctic class (A5 to A1); and Baltic ice class (A0 to E0).

The ARCTICE team also surveyed the AIS data available in the Bering, Beaufort, and Chukchi seas. Unique MMSI IDs were pulled for vessel information, allowing the team to better understand the current state of Arctic and sub-Arctic shipping. Looking specifically at July and September of 2017, the team found an overwhelming majority of the vessel traffic had been freight and towing vessels. Curiously, there were multiple instances of Russian and Chinese icebreakers passing through the Chukchi.

2. *Investigate other national models (in particular, Canadian programs).*

The project team has investigated the Arctic Ice Regime Shipping System (AIRSS) as a regulatory standard for ice condition used by the Canadian authority. It is the basis of the POLARIS in the Polar Code and very similar to POLARIS. The research team also did a review of other national ice charts as they were related to vessel navigation through ice. Output from these nations follows the IMO's guidance in the Polaris amendment of the POLAR code. The team was satisfied that following the Polaris amendment would offer a high degree of interoperability for Arctic mariners and that this was a prudent path to follow in the development of ARCTICE.

3. *Determine suitable environmental factors*

Based on other Arctic nation's models, and the guidance from the Polaris amendment, suitable environmental parameters were determined. Polaris quantifies the ice condition numeral by a "Risk Index Outcome" method, or RIO. POLARIS quantifies the ice condition numeral by a "Risk Index Outcome" method (RIO). The RIO is calculated using the following equation:

$$RIO = C_1RV_1 + C_2RV_2 + \cdots + C_nRV_n$$

Where $C_1, C_2, \ldots, C_n$ are the concentrations of ice types in tenths of percent over the total region in study, and $RV_1, RV_2, \ldots, RV_n$ are the risk values corresponding to each ice type per vessel classification. Positive RIO values correspond to low risk routes, while negative RIO values correspond to high risk routes.

The research team, having established which environmental factors are necessary for the ARCTICE algorithm, investigated available environmental models from which to collect the necessary inputs. These models included the High resolution Ice Ocean Modeling and Assimilation System (HIOMAS), the Global Navy Coastal Ocean Model (NCOM), the CICE4 model developed at Los Alamos National Laboratory, and the Pressurized Ice Model by the National Research Council Canada. Due to access restrictions the NRC model was excluded from selection. Further, due to the necessity of sea ice partial concentrations from a potential model, and the desire for a high resolution of 1km, HIOMAS was selected as the best option.

4. *Investigate suitable access*

~~Researchers spent time discussing the type and size of files accessible when vessels are underway. Based on anecdotal evidence from the district experts, there are significant connectivity challenges for commercial entities above 65 degrees N, where satellite communications start to diminish. Above 70 degrees N, data sources are extremely limited. Very few commercial communications satellites are available in the Arctic. It was suggested that if a vessel had a satellite link, there would be the possibility of receiving ARCTICE output if the file size were very small. When the vessel was at port, size of file is less of a concern.~~

~~Therefore, the research team has determined that the ARCTICE output will come in two formats. Namely, .png files to accommodate low bandwidth access users, which will offer low resolution data, enough for vessels to identify whether significant changes to the ice pack have occurred, and whether they need to adjust course.~~

~~For vessels with a higher bandwidth availability, geotiff output files will be provided for integration with ArcGIS and other software. The team is currently discussing the transition of ARCTICE. They identified the need for a partner who could publish the RIO charts, and offer a subscription service. Currently, the team believes Axiom Data Science will be the best home for ARCTICE.~~

~~5. *Create, and then optimize a forecasted, numeric Arctic ice condition index for Arctic waters*~~

~~At the onset of the project, the team included the idea that the forecast would need to be optimized to marry observable ice conditions with the modeled conditions. This was an important learning from the Great Lakes ICECON project. As the team discovered, optimization is not a necessary component. This is due to the methodology employed by the project team. Using the Polaris amendment meant that the process by which the RIO is calculated was vetted by international experts in the area of Arctic vessel/ice interactions. Therefore, the team feels optimization is not a necessary component for this project. Further, the team feels that Year 8 tasks, namely the validation of the project output, will prove that the model is accurate and effective in their claims.~~

~~After careful investigation, the research team created an operational ARCTICE algorithm using Python. The algorithm pulls environmental data, as defined above, from HIOMAS, calculates the RIO for a region, and generates the color maps illustrating RIO values for a given vessel polar class.~~

~~While the creation of ARCTICE visualizations is a Year 8 task, the team felt it necessary to graphically output the RIO values. Examples of the output charts can be seen below for vessels with polar classes PC 1, PC 5, and PC 7. These charts were created in 2020.~~

Methodology.

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The core ARCTICE algorithm is based on internationally standardized, vetted methodology to ensure clear communication of risk and accurate measures of sea ice related risk to vessels. With a functional algorithm in place, the specialized team of engineers, sea-ice geophysics, sea ice modelers and computer architecture experts, guided by a USCG-led council of experts, will increase functionality and utility of the output through the following series of research tasks in ADAC Program

Year 8:

1. *Finalize the validation efforts for the ARCTICE algorithm.*
   Unlike the Great Lakes project, direct observations of ice by marine operators are generally unavailable. Further, other Arctic nations have yet to make a publicly available product using the POLARIS methodologies, so direct comparison is not possible. However, the USCGC Healey will sail the Arctic Northwest Passage during the summer of 2022 and cruise organizers have indicated their willingness to test the output onboard. The research team will coordinate in year 8 with the cruise organizers, including planned onboard researchers from USNIC and ADAC, to facilitate a live test of the system. Challenges to tackle include communications, data collection and delivery, and aligning observed ice conditions with modeled conditions, which will be much of the focus of the research team to ensure a successful test in the future.

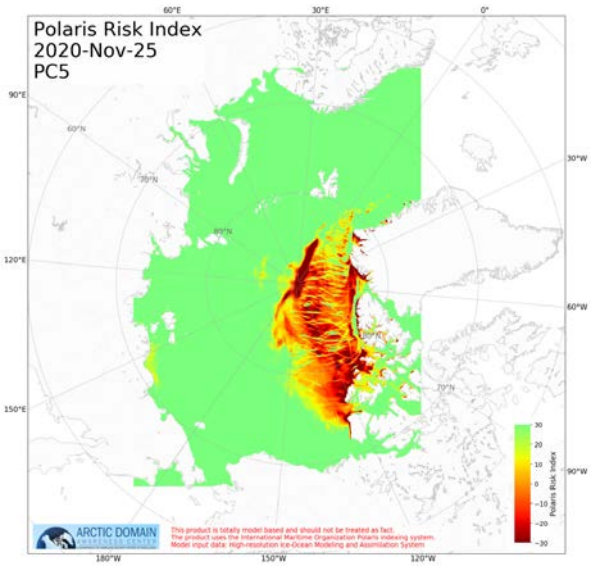
2. *Increase the accessibility of ARCTICE products.*
   The team will collaborate with Axiom Data Science to continue transitions efforts for ARCTICE. Currently, the algorithm produces individual RIO charts that, while accurate, are somewhat challenging to navigate online. The research team, alongside Axiom employees, are investigating ease of access and are considering building a front-facing website with thumbnails of the products aimed for on-board and mobile device usage. Another value-added element proposed is the inclusion and offering of ArcGIS capable data sets allowing onshore use such as route planning.

3. *Transition the ARCTICE to a Federally owned operational destination*
   The ADAC team will also pursue agreements to provide agencies such as USNIC, AK NWS, and Alaska Ocean Observing System based in Anchorage, for automated index generation of the POLARIS-based output charts. This work will also include the creation of a user guide, posted to the website and shared with USCG, for operating the algorithm and accessing the RIO charts.

4. *Investigate enhanced ARCTICE output for USCG D1.*
   Currently, ARCTICE covers the entire Arctic Ocean and provides a POLARIS index for all sailing routes within this region. The area of operation covered by USCG D1 on the east coast is outside the current region of ARCTICE. However, ARCTICE provides a suitable framework onto which additional informational layers might be added. The current environmental model for ARCTICE, another Center project called HIOMAS, is not operational on the east coast, so additional work into identifying a suitable data source is necessary. Further, the research team needs to coordinate with experts from D1 to identify district needs and appropriate methods for applying an ARCTICE-type algorithm to their region. Depending on their feedback, this might include a proposal to add SAR information about surface conditions and converging factors, to include the “hidden structures” work D1 has already tested off Martha’s Vineyard. This additional layer of information would use existing environmental data and provide enhanced capabilities for USCG D1 and D17 in SAR activities. The information collected by the research team will constitute a feasibility study with actionable items USCG

may use moving forward.

5. *Investigate application of ARCTICE RIO charts to forecast Bering Strait traffic bound for a future Arctic Port in Nome, AK.*
   In response to Congressional approval for the Consolidate Appropriations Act of 2021, in which a deep draft port in Nome Alaska was approved, the ARCTICE team plans to support USCG D17 by investigating the future sea ice conditions vessels can expect to encounter in the Bering Strait that might impact operations near the proposed Arctic Port in Nome. ARCTICE, in conjunction with another Center project, the environmental model HIOMAS, will be used to forecast sea ice conditions through the strait, informing USCG on relevant risks and conditions that might impact operations in the area. Guiding information could include, but is not limited to, (a) the Polar classification of vessels that will be able to transit the Strait, thus likely to utilize port facilities, on a year-round basis, (b) which classes will be limited to seasonal use and transit, and (c) given the retreat of the sea ice, when models predict less capable Polar class vessels will be able to access the port on a year-round, or nearly year round basis. This work, guided by D17 experts, will take the form of a summary report that would inform USCG on the possible timeframe in which they may see increases in necessary patrols, search and rescue responses, and general increased activity in the area.



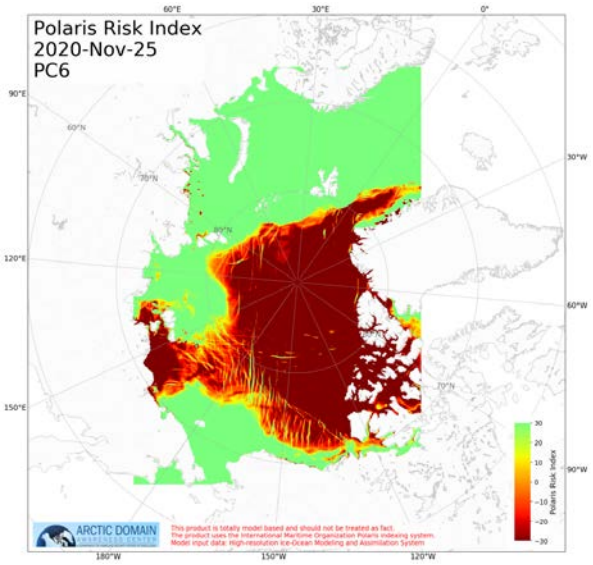


Figure 7 ARCTICE Visualization Charts providing graphic output of RIO values.

~~***Methodology***~~.

~~ARCTICE is adapting research associated with Great Lakes ICECON to the Arctic Ocean environment. A specialized team of engineers, sea ice geophysics, sea ice modelers and computer architecture experts, guided by a USCG led council of experts to accomplish a series of research tasks (a) to continue to conduct validation of ARCTICE output charts, (b) transition the ARCTICE to an operational destination, leveraged by Arctic mariners for route planning and decision making, (c) provide documentation for the independent operation of the algorithm by its operational host, and (d) explore extended functionality and suitability of the algorithm in the northern Atlantic region.~~

~~ARCTICE creates a mariner decision- support tool oriented to vessel categorization principally focused, but not constrained to existing U.S. EEZ of the Bering Chukchi and Beaufort Sea regions. ARCTICE seeks to leverage Arctic vessel automated information systems (AIS) data from existing ADAC research, gain guidance from a USCG led Council of Experts and utilize sources of ocean current, sea ice presence, movement, thickness and ridging environmental model. ARCTICE plans to deliver the mariner support tool to operational destinations as determined and coordinated via the planned USCG led, Council of Experts.~~

~~In creating an ice conditions index for Arctic Mariners, (oriented principally to the Bering, Chukchi and Beaufort Seas), researchers seek to develop and transition readily accessible Arctic Ice Condition Index as a decision support tool for Arctic marine operators, useful to ships Captains, first mates and navigation officers. Arctic ICECON is distinct from Great Lakes ICECON in the following:~~

~~1. Little to no available "local" ice observations.~~

2. Research team has higher resolution environmental inputs than available in the Great Lakes region due to completed ADAC project, HIOMAS.

3. Sea ice is inherently different than lake ice.

4. There are new international standards for communicating ice conditions.

5. USCG District 17 has operational challenges quite distinct in its region of responsibility compared to the operational environment faced by USCG District 9.

While there are significant differences between creating an Ice Conditions Index for the Great Lakes region and an Ice Conditions Index for the ocean regions of the U.S. Arctic EEZ, overall research methodologies are similar and experiences in creating Great Lakes ICECON are useful and complementary. Accordingly, ARCTICE investigations suitably leverage prior research associated with creating an Ice Conditions Index for the Great Lakes region.

The research team will accomplish the following research tasks in ADAC Program Year 8:

1. *Finalize the Integration of the index to a visualization tool as an aid to vessel mariner planning and underway activities.*

   This research task takes the calculated ARCTICE to display for operator reference. While the numeric is a useful decision support aide, without suitable visualization, mariners are not able to suitably apply and benefit from ARCTICE to determine route of steam or adapt in underway circumstances (if the vessel can connect suitably to derive underway ARCTICE numeric).

   Despite the limited bandwidth, operators will benefit from a visualization of the ice conditions on a graphical chart. This chart would be similar to the ArcGIS map produced by USNIC in connection to the Great Lakes ICECON project. The recommendation from the experts at USCG D17 and HQ USCG is to offer a broad area/low resolution chart, augmented by a limited area/high resolution chart. Options to overlay or do a side by side comparison with hindcast data will also be included. Further, ARCTICE charts should be accessible by both desktop and mobile web browsers, offering the widest access possible.

   Unlike ICECON, ARCTICE in the nearer term, will have little access to mariner observations and therefore cannot use this method for developing relationships between ice conditions and an index numeral. Instead, researcher will use the construct that ships with Polar Certificates will programmatically be assigned an ice class based on IMO adopted standards. Those ice classes are based on regulated design practices across the ship building industry to determine ice capabilities, or lack thereof. For each vessel ice class, there is a specific, weighted value for a given ice condition.

2. *Automate a forecast numeric Arctic ice condition index for Arctic waters.*

   After establishing the numeric ice condition index for Arctic waters based on the POLARIS index from the Polar Code, the ADAC team will collaborate with Axiom Data Science to develop computer scripts to automate the process of calculating the ARCTICE index. The scripts will automatically obtain input source data from HIOMAS, run the ARCTICE script, generate POLARIS index plots, and publish the plot on a server.

3. ~~*Conduct ARCTICE validation.*~~

   ~~ADAC researchers believe validation of the ARCTICE product is challenging, but achievable. Based on current levels of traffic, and unlike the Great Lakes project, direct observations of ice by marine operators remain unavailable. Further, other Arctic nations have yet to make a publicly available product using the POLARIS methodologies, so direct comparison is not yet possible. However, the team believes that factual representation can be illustrated using other available products to ensure accuracy between modeled output and observed conditions. As an additional, supporting validation, the team will investigate via coordination to the Project Champion to evaluate RIO charts on the CGC Healy during its next Arctic cruise (planned for late FY2021).~~

4. ~~*Transition the ARCTICE to an operational destination.*~~

   ~~Overall, the ARCTICE transition is taking a similar approach as for Great Lakes ICECON. After the ADAC team established the ICECON automation, the team collaborated with Axiom Data Science to transition it to operation. Axiom data science host the computer scripts to automatically obtain input source data, run the script, generate POLARIS plots, and publish the plot at a server. The research team will continue and finalize with Axiom Data Science to transitions efforts for ARCTICE. Same as for Great Lakes ICECON, Axiom data science will host the computer scripts to automatically obtain input source data, run the script, generate POLARIS plots, and publish the plot at a server. The team will compare the new output to regional ice data sources to ensure accuracy of the RIO plots. The ADAC team will also finalize agreements with USNIC, and Alaska Ocean Observing System & Axiom Data Sciences based in Anchorage for their hosting of ARCTICE & the POLARIS based output charts.~~

5. ~~*Explore enhanced ARCTICE output for USCG D1.*~~

   ~~Currently ARCTICE covers the entire Arctic Ocean and will provide POLARIS index for all sailing routers within the Arctic Ocean. The understood area of operation covered by USCG D1 on the east coast, is outside the current region of ARCTICE. However, ARCTICE provides a suitable framework onto which additional informational layers might be added. This could realistically include SAR information about surface conditions and converging factors, to include the "hidden structures" work D1 has already tested off Martha's Vineyard. This additional layer would use existing environmental data and provide enhanced capabilities for USCG D1 and D17 in SAR activities.~~

Key Milestones.

1. *Finalize the validation efforts for the ARCTICE algorithm.* The research team will coordinate to continue validation efforts on the USCGC Healey with the cruise organizers, including planned onboard researchers from USNIC and ADAC, to facilitate a live test of the system. Validation coordination will be completed by 31 March 2022.

2. *Increase the accessibility of ARCTICE products.* The research team will work with Axiom Data Science to increase the usability and accessibility of the RIO charts by making a front facing website with additional file types by 31 December 2021.

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3. *Transition the ARCTICE to a Federally owned operational destination*. Researchers will plan to transition ARCTICE to Axiom Data Science, with a user guide, for automated index generation to USNIC and NWS Anchorage ice desk by 30 June 2022.

4. *Investigate enhanced ARCTICE output for USCG D1.*
   Project team will coordinate with D1 to identify their needs in an ARCTICE-type model, to include appropriate environmental data, a needs summary of work that would be necessary to accomplish this task and proposed timeline to completion by 31 March 2022. Note, this also includes providing D1 access to the ARCTICE output for their use (as it does have pan-Arctic coverage that includes the Northern portions of the North Atlantic, Greenland, Norwegian and Barents Seas).

5. *Provide USCG an ARCTICE users guide.*
   Project team will provide USCG an ARCTICE users guide for ready use at Sector and District levels by 30 June 2022.

~~1. *Finalize the Integration of the index to a visualization tool as an aid to vessel mariner planning and underway activities.* Project team will continue to conduct ARCTICE integration efforts started in Program Year 7 to complete integration to a visualization tool by 15 October 2021.~~

~~2. *Automate a forecast numeric Arctic ice condition index for Arctic waters.* Project team will continue to advance automation development initiated in Year 7 to complete automation by 15 December 2021.~~

~~3. *Conduct validation.* Project team will continue to conduct ARCTICE validation, leveraging research methods established Great Lakes ICECON, which will include collaboration with Canadian Ice Services and coordination with both USNIC and National Weather Service (NWS) Anchorage ice desk, and potential live validation methods. Validation will be completed by 15 December 2021.~~

~~4. *Transition the ARCTICE to an operational destination*. Researchers will plan to transition ARCTICE to Axiom Data Science by 31 March 2022 for automated index generation to USNIC and NWS Anchorage ice desk.~~

~~5. *Explore enhanced ARCTICE output for USCG D1.* Researchers plan to engage with USCG D1 in seeking to inform the District of ARCTICE and through collaboration via conference calls, determine suitability of ARCTICE framework to USCG D1 concerns. This is a separate, parallel effort to finalizing and transition of ARCTICE as a vessel master support tool. This collaboration will be complete by 31 March 2022.~~

~~***Key Stakeholder Engagement:***~~

Key Stakeholder Engagement:

The Project team will continue to engage Project Champion CDR Christopher B. Tuckey (CG-WWM)/his designated POC on a frequency basis as determined by CDR Tuckey, but as a minimum the team will seek to conduct monthly teleconferences. Critical coordination is planned with all team members, the PI, and project champion. Project advocates include HQ CG-926, San Cheung, USCG

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RDC, the U.S. National Ice Center, and USCG D17. As with the Great Lakes ICECON project, ARCTICE researchers will be in frequent contact with project champion, key project support at USCG RDC, USCG D17, USCG D1 and USCG-led Council of Experts. Project team and ADAC leadership will seek to establish a Council of Experts who are Arctic oriented experts from USCG Pacific Area, District 17, NOAA/NWS, and others as agreed by USCG, such as Arctic shipping company representatives, the American Bureau of Shipping, subject matter experts from the Alaskan Native community, and Arctic Ocean specialists from the Canadian Ice Service. As part of the Center's Year 8 effort towards commercialization, ADAC will also inquire as to suitability of completed research to potentially support Arctic oriented commercial shipping and tourism industries.

In addition to dedicated efforts to establish and transition ARCTICE in the same manner as ICECON, research findings will be disseminated throughout the academic/research community through oral presentations and by production of knowledge products.

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Investigators plan for the representation of our team at the following ADAC events:

- Meetings with Project Champion CDR Tuckey.
- Weekly All Hands meeting (Normally Thursdays, 1130-1230 Alaska Time via teleconference).
- Quarterly Reviews and Quarterly Customer's and Partner's Roundtable.
- Annual meeting at HQ USCG, Washington D.C.

Student Participation.
The research team plans for at least one participating student fellow on ARCTICE. Student participation will include assisting with the development of the ARCTICE algorithm and support advancement of validation methodology.

Performance Metrics.
Researchers will evaluate their investigations according to the following metrics:

- The ARCTICE algorithms enable accurate Arctic ice condition predictions a minimum of 65% of the time.
- ARCTICE algorithms provide comparable Bering, Chukchi and Beaufort Sea ice-conditions index accuracy to known accuracy of Canadian ice services within Canadian waters.

Outcomes/Outputs.

- A finalized set of ARCTICE algorithms for U.S. waters in the Bering, Chukchi and Beaufort Sea.
- A finalized vessel classification system U.S. waters in the Bering, Chukchi and Beaufort Sea.
- USNIC & or National Weather Service hosting POLARIS index from ARCTICE for U.S. waters in the Bering, Chukchi and Beaufort Sea.
- Final product development anticipated to conclude at TRL ~~7~~/8.

Transition Plan.

Overall, the ARCTICE transition seeks to replicate the transition planning used for Great Lakes ICECON from research to an operationally relevant tool. For the Great Lakes ICECON, the ADAC team established the ICECON algorithm and collaborated with Axiom Data Science to automatically obtain input source data, run the script, generate ICECON plots, and publish the plot at a server. USCG is able to download the ICECON plots direct from the server. In addition, through an agreement with USNIC, the ICECON plots are also transferred to USNIC to add to USNIC's USCG D9 support data folder. This approach of using a third-party to run the script to generate ICECON plots and to only host the generated plots at USNIC is recommended by USNIC.

For ARCTICE, while noting the USCG Project Champion will direct the transition focus and overall destination, the research team notes that a similar approach is desired as achieved by Great Lakes ICECON. The ADAC team will continue to work with Axiom Data Science to establish the operation for ARCTICE script and pursue an agreement with USNIC to host the generated ARCTICE data. In addition to directions and guidance received from USCG D17 and other Council of Expert members, transition planning will need to account and gain input/product feedback from Alaska-based mariners who comprise the bulk of the maritime traffic in the U.S. Arctic waters. The research team has also discussed this topic with USCG D17 during the project feasibility study last year and was recommend by D17 to develop a mobile app for ship-based ice observation data collection on CGC Healy (similar to the mobile app for and the data-collection practice of D9 in the GL ICECON project). This practice of data collection does not require separate missions by USCGS Healy, simply an opportunity to collect data incidental to USCG planned missions.

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Potential programmatic risks to completion.

The project team assesses overall risks to ARCTICE project completion as low-medium. Generating a suitable environmental data feed to generate ARCTICE is a programmatic risk. Auto generation of Great Lakes ICECON proved very successful. Same as ICECON, ARCTICE is intended to also be an "auto-generated" decision support tool. If environmental data is not available to support the auto generation, a useful ARCTICE will not be produced. Researchers have reduced risk by seeking to leverage ADAC's successful sea ice modeling protocol, the High-resolution Ice-Ocean Modeling and Assimilation System (HIOMAS) via transition destination at Axiom Data Sciences (the Alaska Ocean Observation System, a NOAA affiliate), which as an "on-demand" and approximately bi-weekly computational cycle to provide modeled data to a multiple sea ice user. In addition to HIOMAS, researchers can also potentially leverage Navy Research Lab's similar Research team believes such data will prove invaluable to ARCTICE.

PROJECT: Arctic Vessel Monitoring Geofencing/Alert Awareness
Project Investigators: Dr. Shawn Butler

Supporting Team:

Rob Bochenek, Axiom Data Sciences

Lead Institution: University of Alaska Anchorage (UAA)

Project Champion: LT Evan Richter, HQ USCG CG-761 and Mr. James "Dan" Blackman, C5I Systems & Capabilities Management Division (CG-681)

Project Description:

Abstract.

The original goal of the project sought to extend the Arctic Vessel Monitoring Geofencing/Alert Awareness project, initially funded in ADAC Program Year 5, by providing enhanced command and control features that improve on the original goals of monitoring and alert awareness developed for the unclassified Marine Exchange PACTRACS system (which is a commercial mariner application). As CG OneView 3.0, is USCG's determined common operating picture, which now displays both terrestrial and satellite AIS data, there is a need for a geofencing/alert awareness application that

supports Coast Guard planning and command & control decision making tasks which easily integrates into CG OneView.

ADAC Program Year 7 focused on development of a geofence application software architecture that would not only be compatible with CG One View's software architecture but could easily integrate with CG One View. In addition, new geofencing capabilities could be implemented with the research outcomes developed in the Arctic Domain Awareness Center's project *Arctic All-Hazards GIS Platform*. Therefore, the Geofencing/Alert Awareness project, oriented to USCG CG OneView in ADAC Program Year 7, focused on the development and implementation of a CG OneView compatible software architecture and to initiate a development integration process.

ADAC Program Year 8 will result in a geofence prototype that includes USCG Anchorage Sector's specific geofence operation center's requirements identified during Program Year 6 and a fully developed into CG One View integration process. The final deliverable will be able to integrate into the current (as of the end of Program Year 8) CG One View version/edition, which will allow users to ability to create, display, share, and manage static and dynamic geofences. In addition, planners and operators will receive alerts via the CG One View display. Operators will have the ability to define and display geofences and receive notifications via the CG One View console, either visually or textually.

The objectives of this project are to use the CG OneView application architecture and leverage the previous year's Marine Exchange implementation to explore the human computer interface (HCI) features that facilitate efficient geofence creation, re-use, modification, deletion, and alert notification, which can be especially challenging in an information overloaded environment. Although this project will focus on Arctic maritime operations, the results should enhance geofencing capabilities in CG OneView and USCG mission command and control in general.

Objective/Purpose.
The objective of this project is to develop a geofence prototype that meets the needs of operators and planner's using CG OneView and can be relatively easy to integrate into the U.S. Coast Guard's command and control application, (again, CG OneView). The prototype will be a functional and capable software innovation for integration into CG OneView either by USCG directly, or if/as desired, by the established contract CG OneView vendors to USCG.

USCG watch-standers across Coast Guard command centers, (using CG OneView) are the principal users of geofences. These watch-standers will over time, create a number of geofences in support of various planning and operational needs. Accordingly, these USCG users will need a mechanism to find existing geofences, perhaps modify some of the geofence attributes, and reuse or create altered copies. In addition, they will likely need to cull no longer needed geofences. Further details:

- Some geofences will be created that need to follow the shoreline. Users should be able to create a geofence that can be defined some specific number of meters/kilometers from the shoreline. ArcGIS is known to have tools that can identify the coastline which may be used to identify geofence boundaries. This will give the Coast Guard more accurate information when vessels cross geofences.
- Identify and implement additional features that may help improve planning tasks and operational response to vessels crossing geofences. For example, detect vessels that are

approaching (i.e., likely to cross if the vessel does not change heading), but have not yet crossed a geofence. Use color to show when a vessel is approaching (yellow)/crossing a geofence (red) so that operators can instantly see the geofence and vessel that is approaching/crossing. This will allow less clutter on the CG OneView operational picture.

- Operators and planners need to share geofences within and across commands or change ownership of the geofence. It may be necessary to provide a historical record of a geofence violation for law enforcement reasons.

Baseline.

The ADAC geofencing project completed in Program Years 5 and 6 by the Maritime Prevention and Response Network and the Alaska Marine Exchange resulted in a geofence/alert capability for static and dynamic targets available for USCG access via the PACTRACS system operated by the Alaska Marine Exchange. This capability is also available to other members of the Alaska Marine Exchange and supports the mariner community across Alaska and the U.S. Arctic region. The parameters and needs developed for this previous project coupled with mission needs solicited from the Anchorage Sector, 17th Coast Guard District during ADAC Program Year 6, identified a significant number of additional operational needs for geofencing to fully support Coast Guard CG One View planning and operational activities. Informing the baseline of new CG One View investigations is the completed work that has been incorporated into the Alaska Marine Exchange PACTRACS application which supports safety and maritime domain management for mariners.

The early stage of investigations collected US Coast Guard's geofencing mission needs and develop an integration strategy with the ADAC All-Hazards Web GIS (AHWG) application (successfully integrated into Homeland Security Information network via DHS S&T Geospatial Management Office) and CG One View. The project team has evaluated the All-Hazards Web GIS application to determine how geofencing might be integrated with the AHWG application, and what additional development is necessary to have a functional geofencing capability. In addition, researchers developed geofencing mission needs, and requested additional baseline needs from the CG One View program manager. In addition to the USCG functional geofencing mission needs, it is essential that we sufficiently understand the CG One View architecture and design parameters so that researchers can seamlessly integrate into CG One View when the project is complete.

While the original plan was to establish Geofence within PACTRACS that supports USCG D17 and Alaska/Arctic mariners, in accordance with Project Champion direction, researchers received the Program Year 6 added the task to accomplish a duplicate process within USCG CG One View. This includes the establishment of the Ozone Widget framework to develop basic geofencing capability to allow static geofence and conducted test notification and alerts with agencies and coastal communities, which have successfully monitored sensitive areas such as marine mammal sanctuary in remote islands in the Bering Sea. The team has also accomplished dynamic alerts that can monitor vessels underway. The PACTRACs edition of the project team has developed, refined and implemented PACTRACS alerts process to include visual alerts in addition to email alerts, useful for marine system watch-standers, to include USCG D17 command and control personnel who monitor PACTRACS in the USCG D17 Command Center.

Accordingly, ADAC investigations have completed the PACTRACS software developments, while the USCG CG One View edition developments have been prepared in support of HQ USCG CG One View program manager, as coordinated by the HQ USCG Project Champion. During ADAC Program Year 6, the project coordinated with CG One View technical developers to identify key components of the current CG One View system architecture that will allow the geofencing prototype to integrate with CG OneView Components. One of the key objectives of this project is to deliver a prototype that can be relatively easily integrated with CG One View. In coordination with the CG One View technical developers, we will use the year 6 geofencing design and mission needs as the baseline to begin development of the Geofencing prototype.

Methodology.

Through a select team of experienced computer information systems architects and working with U.S. Coast Guard stakeholders in Alaska and Virginia, the research team is developing a CG One View prototype following a modified *agile* software engineering development cycle. The two most crucial practices in the agile development cycle are small iterations and close stakeholder involvement. Since the two primary objectives of this project is 1) to produce a working prototype that meets user requirements and 2) can be integrated into CG One View with minimal effort, then the two primary stakeholders are the USCG users at USCG D17 Anchorage Sector and the CG One view technical integrators.

The USCG D17 Sector Anchorage committed to working with the project team in prioritizing and reviewing geofencing functionality as developed. Researchers show end users incremental functionality as frequently as the foundation is developed. Based on USCG feedback, investigators will update the parameters and implement their requested changes. The agile software development process supports the flexibility that a software developer needs to ensure that the final product is very close to what the user needs.

The CG One View technical developers agreed with the investigation team during coordination meetings in confirming *'continuous integration'* as the preferred process to ensure minimum integration issues during transition. Continuous integration ensures that the developers frequently integrate new features to minimize the possibility that the two software baselines (CG One View and Geofencing) diverge as software changes. A continuous integration process will result in a product that can become part of CG One View without major modifications, ideally quickly getting the capability into the hands of those that need it most.

Finally, researchers will coordinate with the ADAC investigation titled "All Hazards WebGIS project developer and CG One View system architects to integrate All Hazards WebGIS transitions into CG One View.

The agile methodology includes:

- Continued requirements elicitation and refinement from USCG stakeholders regarding geofencing feature priorities and refinement of existing requirements.
- Close coordination with CG One View technical developers to ensure continuous integration of newly developed features.

- Software development that builds upon existing AIS datasets and lessons learned from geofencing technology developed in years 5 and 6 for the Marine Exchange.
- User accepting of testing within the limits of the prototype.
- Peer-reviewed publication/presentation for validation and improvement.
- The research team will accomplish the following research tasks in ADAC Program Year 8:

The research objectives include accomplishing the tasks in Program Year 8:

- Continued requirements elicitation and refinement from USCG stakeholders regarding geofencing feature priorities and refinement of existing requirements.
- Coordination with CG One View technical developers to ensure continuous integration of newly developed features.
- Software development that builds upon existing AIS datasets and lessons learned from geofencing technology developed in ADAC Program Years 5 and 6 for the Marine Exchange and CG One View work accomplished in ADAC Program Year 7.
- User accepting of testing within the limits of the prototype.
- Finalize implementation a geofencing prototype based on the Ozone Widget Framework that can be adopted by the CG OneView project.
- Improve situational awareness with regards to geofencing and vessel alerting by using HCI best practices.
- Improve geofence management through improved creation, find and re-use, and deletion using enhanced Meta data for geofences.

Key Milestones.

- Conduct a continuous integration process with CG One View technical software engineers, planned to generate finalized application by 30 September 2021.
- Use Ozone Widget framework to develop geofencing capability using the CG OneView App model, planned by 30 October 2021.
- Implement geofencing/vessel tracking enhancements per requirements from USCG stakeholders and Arctic All-Hazards GIS Platform project, (to include integration of user defined application that incorporates human-computer interface) planned by 15 January 2022.
- Transition results (with documentation and associated technical materials) to the CG OneView project office, planning 31 March 2022.

Key Stakeholder Engagement Plan.

The Project team will continue to engage Project Champion LT on a frequency basis as determined by, LT Richter and Mr. Blackman, but as a minimum the team will seek to conduct monthly teleconferences. Critical coordination is planned with all team members, the PI, and project champion. Project advocates USCG D17 Sector Anchorage. The primary operational customer for this product is the 17th U.S. Coast Guard District, and the tactical customer is U.S. Coast Guard District 17 Sector Anchorage.

Project team will continue to participate and be featured in the planned ADAC "Customers and Partners" Roundtable, in order to inform and receive feedback on project progress. Stakeholder engagement will be central to the success of this project. Deliberate investments in the collection of

information required to develop the workflow diagrams and identify the end-user requirements of the tools and in how recipients can receive this information will be critical. Priority of engagement for research team is HQ USCG Project Champion, and the direct USCG end-users: USCG D17 and USCG D17 Sector Anchorage.

Investigators plan for the representation of our team at the following ADAC events:

- Meetings with Project Champion LT Evan Richter.
- Weekly All Hands meeting (Normally Thursdays, 1130-1230 Alaska Time via teleconference).
- Quarterly Reviews and Quarterly Customer's and Partner's Roundtable.
- Annual meeting at HQ USCG, Washington D.C.

Student Participation.

The project will seek replacement for the two graduating undergraduate student researchers. Specifically, the research team will seek the students that have a computer science background which will enable them to assist with the development of the enhanced geofencing/vessel tracking application. The work will be coordinated with the CG OneView projects so that there is a coherent vison for the geofencing capabilities, and it incorporates human-computer interface (HCI) best practices.

Performance Metrics.

- Design and documentation of Geosystem architecture use cases, and test cases.
- Percentage completion/project velocity of features and use cases.
- Percentage of successful synthetic test cases (simulated vessel movements or other automated tests)
- Number of successful customer acceptance tests.
- Suitable application within CG1View/HSIN.
- Archival ability of created Geofences to support routine use-cases.
- Number and impact of peer-reviewed publications/presentations.

Outcomes/Outputs.

The project planned outcomes are:

- Enhanced geofencing\vessel alerting prototype based on the Ozone Widget Framework.
- Application architecture documentation.
- Geofence management tools developed using the Ozone Widget Framework that allows users to create, find, delete, and share existing geofences based on geofence and alert Meta information.
- Documented user feedback from the USCG 17th District, Sector Anchorage.
- Provide a USCG Tailored User Guide

Transition Plan.

The transition plan will be conducted under the direction of the Project Champion. The primary output of the project is new software capable for integration to USCG's CG OneView. The research team will incorporate the new software into USCG hosted to CG OneView/Homeland Security Information Network (HSIN) parallel to completed PACTRACS developments.
Since a version of the project will also be completed using the Ozone Widget Framework and coordinated with the CG OneView project office, the transition of the enhanced features should be relatively straightforward. Although this project will be using a slightly different version of the Ozone Widget Framework, conversations with the CG OneView project office indicated that the differences between the two architectures would be minor. All software and documentation will be turned over to USCG for inclusion into the next planned version/edition of CG OneView.

Potential programmatic risks to completion.
Overall, the research team assesses programmatic risk as medium.

Risk 1: Geofence Archival system.

Risk 2: Creating an edition in CG1View/HSIN: The CG OneView project priorities may prevent timely coordination. The team will rely on the Anchorage Sector for developing requirements and validating whether the enhanced features are likely to improve District planning and operational tasks. In specific:

- ArcGIS and Ozone Widget technologies may limit what is possible. For example, there may be a limit to precisely identifying coast lines. The team will leverage any existing add on modules that improve coastline identification.
- Open-source software is often not as intuitive to use as the contributors claim, which may delay our ability to set up the development environment. We hope to coordinate with the Arctic All-Hazards GIS Platform project, which has already worked with the ArcGIS Web version. In addition, project team will consult with other ADAC researchers who have particular expertise using ArcGIS. Researchers may also need to consult with the CG OneView project office as they have particular expertise using the Ozone Widget Framework.
- The most significant risk is the development of an effective continuous integration process with CG One View technical staff. We will work with system technical leads to develop a process that supports the project goals while minimizing impact to the CG One View developers.

PROJECT: Remote Unmanned Aircraft System (UAS) Inspection and Response Team Development in the Bering Strait Region

Project Investigator: Jessica Garron, Alaska Center for Unmanned Aircraft Systems Integration (ACUASI), University of Alaska Fairbanks (UAF)

Lead Institution: University of Alaska Fairbanks

Project supporting researchers:

Mr. John P. Henry (Native Village of Unalakleet (NVU)) Alaska

Ms. Margaret Hall (Model Forest Policy Program (MFPP), Priest Lake Idaho).

Additional Key Project Team members:

Dr. Peter Webley, Associate Director of Research, ACUASI
Mr. Nick Adkins, Director of Operations, ACUASI
Mr. R. Lee Winningham, Chief UAS Pilot, ACUASI
Mr. Eyal Saiet, Remote Sensing Specialist, ACUASI
Dr. Nancy Gillam, Executive Director, MFPP
Dr. Gwen Griffith, Program Director, MFPP

Project Champion: CDR Chad Thompson, CG-711.

Program Description

Abstract.
Conducting required rural area key infrastructure testing for safety compliance across Alaska (in particular, Western Alaska) is a time and resource challenge for the U.S. Coast Guard (USCG). Normal USCG processes require USCG inspectors to physically fly from home station to remote regions to conduct hands and eyes on tests. Integrating remote sensing tools, such as unmanned aircraft systems (UAS), into the operational environment of remote, sparsely populated, western Alaska has the potential to increase the efficiency of USCG infrastructure inspection missions, while supporting the expansion of community Science, Technology, Engineering and Math (STEM) capacity. To demonstrate this integration concept, project investigators designed a program to train a set of UAS pilots, (equipped with U.S. manufactured UAS platforms) in the Bering Strait hub community of Unalakleet, Alaska, to conduct infrastructure inspections, specifically oil-containing infrastructure, and emergency response (ER) actions in support of local and/or regional crisis. The major components of the investigations are to train approximately eight pilots within Unalakleet to safely operate UAS and become certified under the FAA Part 107 rule: to co-produce infrastructure inspection protocols (IIP) and emergency response (ER) flight protocols with members of the Native Village of Unalakleet, the USCG (specifically, USCG District 17, Sector Anchorage and the core project team). Planned investigations will determine the feasibility of the expansion of the program, statewide, potentially (and ultimately), nationwide; and to disseminate lessons learned to a broad audience of non-technical and technical stakeholders. This work will be conducted over the course of an 18-month period and employ a combination of remote delivery and face-to-face methods of execution. The critical outcome of this program will be a research knowledge product of the investigations for USCG consideration as well as a set of trained pilots and flyable UAS staged in the Bering Strait region, prepared to efficiently support community and USCG maintenance inspection and emergency response needs if/as desired by USCG or facility.

Objective/Purpose.
The primary objectives of this project are to 1) create a knowledge product providing analysis of experiments using multispectral sensor capacity to support infrastructure monitoring, and to 2) co-produce a UAS-based monitoring program, (using non-Chinese UAS platforms) focused on USCG regulated (33 CFR 154) bulk fuel facility inspections and emergency response, with the Alaska

Native Village of Unalakleet. The secondary objectives are to 3) understand the feasibility of expanding the developed monitoring program to communities throughout the Norton Sound region to effectively support CG facility inspections and the response efforts in remote western Alaska, and 4) determine if this project can be used as a roadmap for that expansion. This program will develop a trained pilot team (planned at five individuals) within the community of Unalakleet, versed in the operation of off-the-shelf U.S. made UAS technologies that can be used to regularly monitor bulk fuel storage facility infrastructure, as well as be available to fly for situational awareness pre and post regional disasters. Discussions of current spill response strategies in the region and the roles communities can fulfill during an emergency response will be explored, as detection and reporting strategies are defined. Note, due to on-going information security concerns, investigators will plan to use only U.S. made equipment, and in particular, not use platforms or components manufactured in the People's Republic of China (PRC). The following addresses the major components of the planned investigations:

Pilot Training - Key to a successful program will be to determine the efficacy of visible spectrum and multispectral sensors to support community inspection flights, and to provide high quality UAS flight training, including the use of sensors for inspections, to five motivated residents of the Unalakleet community. The pilots will be chosen from a pool of applicants that perform emergency operations and environmental compliance tasks as part of their everyday duties. Developing an experienced UAS team that can be deployed locally and regionally will advance operational response capacity in the region as well as promote technology integration in rural Alaska.

Co-Production of Infrastructure Assessment Operational Protocols – This work is to pair current inspection techniques mandated in 33 CFR 154 with UAS capacity to support inspections of fuel storage and delivery infrastructure in accordance with USCG inspection protocols. The research goal is to investigate and co-produce an operational UAS-based inspection protocol that can be utilized on a regular basis, to affirm storage tank and infrastructure integrity in rural regions, to reduce and potentially reduce the need of USCG inspectors from traveling to these regions to conduct such routine inspections.

Co-Production of Emergency Assessment Protocols - The goal of this work is to co-produce emergency flight protocols, that will define image/video collection techniques for gaining situational awareness during all stages of an emergency response. The protocols will include methodology to efficiently deliver collected information to the response Incident Command center for any given response in the Norton Sound region. Baseline data sets collected using the co-produced emergency response flight protocol will be produced as part of this research.

Regional Expansion Feasibility Study – The goal of the feasibility study is to identify benefits, shortcomings and challenges of implementing the designed community-based pilot program in Unalakleet for the long-term, and in other communities in the Norton Sound and Bering Strait region.

Information sharing – The resulting program outcomes will be presented to a broad audience of DHS stakeholders as a principal focus. Research outcomes will be shared with other rural Alaskan communities through face-to-face and on-line engagement efforts, non-technical bulletins and a technical journal publication. Researchers see the long-term viability of training pilots and

developing protocols will be achieved by adopting project outcomes operationally in Unalakleet, by informing the community of emergency responders outside of Unalakleet of the response capacity available there, and by promoting the expansion of the project outcomes to other communities in the Bering Strait region.

The research team working in concert with ADAC Center leadership will provide several options, operating in parallel with USCG Project Champion and USCG Project stakeholders. This includes sharing information via Arctic ERMA and the associated ADAC webpage (see https://arcticdomainawarenesscenter.org/Projects) as well as standard mailing of hard drive materials via secure addresses.

Baseline.

USCG responders identify shortfalls in emergency response (ER) Western Alaska, in particular the Bering Strait and Norton Sound regions. These shortfalls complicate ER strategies to support North Pacific and Arctic shipping routes (USCG, 2018).

Coupled with diminished sea ice coverage in this region, there is more vessel traffic navigating the Bering Sea as the only passage between the Arctic and Pacific Oceans (Huntington et al., 2019) . Due to rising traffic, USCG maritime transportation system managers are now highlighting the need for more effective strategies to prevent and address marine disaster response in the Bering Strait region.

USCG D17 Sector Anchorage, in the aftermath of a costly spill response of a 3,000-gallon spill of illegally stored heavy oil from an unmonitored and deteriorated fuel storage facility on Shuyak Island near Kodiak Island in the winter of 2018, determined to find other potential oil and fuel storage, overdue for inspections. Recognizing the unique ecological conditions and logistics challenges contributing to the threat of a potential oil spill response in the Bering Sea region, the Arctic Domain Awareness Center (ADAC) held two workshops during the spring of 2019, *Arctic IoNS 2019 Alaska Native & Rural Arctic "Insights" Community* Workshop and S*tressing the System…Managing a Complex Arctic Crisis*, [5] to ascertain the inherent capacity to respond to a multi-faceted disaster in remote Alaska. Many outstanding issues were highlighted in response to the presented scenarios, including the need for more frequent inspections of 33 CFR 154 regulated bulk fuel facilities, and the need for rapid damage assessments over communities impacted by crises of various intensity.

A critical motivation for the need to improve inspections (and inspection frequency) of rural bulk fuel facilities stems from a presentation provided by USCG D17 Sector Anchorage highlighting the deteriorated state of number of bulk fuel facilities across remote regions in the Arctic and Western Alaska, some of which, had not been physically inspected by the USCG in several years.

Due to staffing challenges, extraordinary logistics and associated costs of travel to remote/off road system rural Alaska make it difficult for USCG facility inspectors to complete annual on-site bulk fuel

[5] (Please see https://arcticdomainawarenesscenter.org/Arctic_IoNS)

facility inspections, finding ways to gain local observers to support local inspections of such infrastructure is potentially useful, if such inspections provide a sufficient level of quality assurance.

However, in gaining a quality evaluation, such inspections need to more than simply assess at ground level. Using UAS to conduct remote sensing tools for detection of conditions out of the line of sight of the human eye has specific merit and is largely not conducted. Cloudy and stormy weather across Western Alaska often complicates and limits optical observations of storage facilities. One workaround to local on-scene USCG inspections is leveraging Electro-optical (EO) and Synthetic Aperture Radar (SAR) data from satellites.

In the Arctic, such observations and associated data is not readily available, due to a small number of polar orbiting satellites. Airplane-based remote sensing techniques pose a similar problem in terms of sensors available for observations during bad weather or darkness (this region experiences significant hours of darkness (approx. 18-20 hours/per day for 3 months each year) and have the additional limitations of high direct costs to operate.

Unmanned aircraft systems (UAS) potentially provide a localized remote sensing solution that is inexpensive, designed for low altitude flights (specifically safe to operate below generally low cloud ceilings), and adaptable to create intuitive data products. UAS are ideal for hazardous and hard to access tasks associated with research and operational observations in remote Alaska. Safely integrating UAS-based remote sensing tools into remote Alaskan communities for ER activities, will provide the community the tools necessary to provide real-time situational awareness to the Incident Command/Unified Command for any oil or hazardous substances spill response. Accordingly, leveraging UAS as an adaptive and readily trainable sensor to conduct infrastructure assessments are a critical component to the proposed investigations.

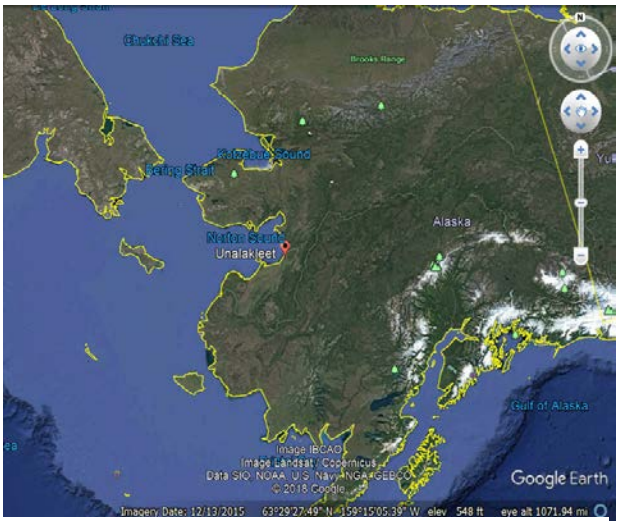

Figure 8 Unalakleet, AK.

UAS are increasingly being used for both regularly scheduled infrastructure inspections (Mader, Blaskow, Westfeld, & Weller, 2016; Mattar, Rami and Kalai, 2018; Rakha & Gorodetsky, 2018), but also for disaster response (Aljehani & Inoue, 2019; Gowravaram, Tian, Flanagan, Goyer, & Chao, 2018). Existing literature provides investigators the opportunity to leverage prior research to take advantage of prior investigations in real-time remote sensing to co-produce localized strategies for

performing critical infrastructure inspections, specifically over 33 CFR 154 regulated bulk fuel facilities, using UAS, and to develop UAS team activation and flight strategies for emergency response.

The Native Village of Unalakleet is a hub community for the Norton Sound region and is the planned partnering community for proposed investigations (please see Figure 1). Through co-producing flight, processing and data delivery protocols with the community, associated information collection protocols can be readily vetted upon creation, increasing the likelihood of successful implementation of community collected UAS data during subsequent inspections. Such research can also be readily leveraged for disaster responses. In sum, planned investigations are designed to support daily operations in Unalakleet, AK and to support emergency operations in the Norton Sound region as defined in the Arctic and Western Alaska Area Contingency Plan (USCG 2018).

Methodology.

The project research method is a sequenced set of coordinated and collaborative activities that incorporate USCG inspection protocols, provide rural region UAS pilot training (via using highly experienced UAS operators from the UAF Alaska Center of Unmanned Aircraft Systems Integration (ACUASI)) to develop routine inspection and then provide follow-on emergency response protocols for UAS operations to conduct rural region infrastructure examinations by vetted and approved local citizens in Western Alaska. The principal focus of infrastructure inspections are petroleum product reservoirs and development of inspection protocols are planned in close collaboration with USCG Sector Anchorage. Following the establishment of UAS rural region infrastructure inspection and ER protocols, investigators then conduct analysis and provide recommendations for suitable expansion of training and response protocols to apply for other USCG inspection and emergency protocol needs.

The sequenced investigation framework is oriented to 1) Providing pilot training of rural residents, 2) Establishing co-production of infrastructure assessment operational protocols, 3) Establishing co-production of emergency assessment protocols, 4) Conduct information dissemination and 5) Providing regional expansion feasibility Analysis. In parallel, a research collaboration with Pacific Northwest National Laboratories (PNNL) is planned to provide a suitable evaluation of PNNL sensor technology miniaturization for UAS research as a complement to Commercial Off-the-Shelf (COTS) sensors which are principally planned for the investigations.

Prior to any regional UAS flights, suitable consultation with village leadership to ensure coordination and information associated the investigations were clear and agreeable. Close coordination with the Unalakleet Village Public Safety Officer (VPSO) is a critical component in establishing a cooperative framework for the research. Communicating planned efforts in local media will also be conducted by the research team. Research method is organized as detailed:

Pilot Training. To develop a community-based Unmanned Aircraft System (UAS) response team, three, pilot/co-pilot UAS teams (plus one back-up/coordinator) will be established in Unalakleet. Potential pilots will be identified in Unalakleet based upon interest and job duties that are complimentary to the experimental program (e.g., bulk fuel facility owners/operators, emergency responders, public safety officers, tribal environmental staff, etc.).

In designing and training the overall inspection team, ADAC and the project investigators are not constructing a service for future funding requests to USCG. The Center and the researchers are seeking to create a capable team of volunteers who support inspections as it is in the interest of their already assigned duties.

Fundamental UAS flight training for pilots and observers will be provided by the Alaska Center for Unmanned Aircraft Systems Integration (ACUASI) of the University of Alaska Fairbanks. Community pilots will be trained on the safe operation of UAS in Alaska's airspace, UAS policy and best practices for the safe use of UAS in Alaska, with specific orientation suitable to the Norton Sound region. This instruction is designed to provide a foundation to community pilots, and preparation for the FAA Part 107 exam. These community-based teams will be trained on the use of a multi-rotor UAS with electro-optical and multispectral sensors, on the aircraft and sensors identified for operational use in Unalakleet.

To encourage on-going community participation in the effort, the proposed project will supply Unalakleet with three UAS, with onboard electro-optical (EO) sensors (E90) and multispectral sensors (MicaSense RedEdge). Community efforts will be coordinated by a dedicated member of the research team who resides in the Norton Sound region.

Three laptops with supporting UAS data processing software will be supplied to the community, and pilot teams for training and operational protocol support. The operational unmanned aircraft and sensor packages will be acquired and tested by the ACUASI instructional and data processing teams in advance of instructional periods to understand and document aircraft and sensor nuances.

Figure 9 Drone footage taken of a Modern Blanket Toss mission in Shishmaref, Alaska, in April 2014. (Photo courtesy Charlie Parr/Alaska Upward Bound).

Initial data processing protocols will be developed during testing by the ACUASI team, that will be used as an outline to support community-specific flight protocols.

ACUASI instructors will teach all aspects of the operational aircraft to the pilots as part of their UAS training program. All participants in the project will train on the same aircraft to allow for additional data collection, regional support of community pilots, and aircraft specific data processing protocol development. Hands-on pilot training will include general practice flights, and test flights for protocol development. To encourage continued pilot practice and data gathering, a UAS storage and access plan for the 3-community based UAS and their supporting laptops will be defined as part of this work.

Co-Production of Infrastructure Assessment Operational Protocols. This work will pair 33 CFR 154 regulated bulk fuel facility integrity inspection requirements with UAS operations, via the co-production of an operational inspection protocol. Through utilizing 33 CFR 154 regulated bulk fuel facility guidelines and State of Alaska (18 AAC 75) guidelines for reservoir/tank farm infrastructure inspections, the project team will develop an operational protocol that can be implemented by the Unalakleet-based pilots to support regular, infrastructure monitoring, data collection, UAS flights. Initial experimentation with the project sensors for capacity to identify anomalies on fuel tanks and infrastructure will be performed by the ACAUSI team in Fairbanks. These baseline laboratory and test flight experiments with the EO, and multispectral sensors will support preliminary identification of possible data products that can be created for decision-makers as a result of operational use of these project sensors. A critical component of the research operational protocols is to analyze whether UAS system can be an effective tool for facility inspections in these remote and austere regions.

Data collection, processing and delivery requirements for providing UAS-captured data for infrastructure assessment will be co-produced among the pilots and the project team, using information gathered during testing in Fairbanks and training in Unalakleet. Bulk fuel facilities inspection protocols will be developed when the entire project team is on-site and iterated against in real-time during test flights. The protocol specific to the Unalakleet tank farm will stay in the community as an option for implementation but will also be translated into a more general protocol that can be applied to other community tank farms. The general tank farm inspection protocol combined with the experimental findings of the sensor testing by ACUASI will be submitted for publication in a technical journal.

Co-Production of Emergency Assessment Protocols. UAS have increasingly been used to provide real-time data, as well as high quality survey data, in support of post-disaster management (Adams, et al., 2014). Multispectral sensors mounted to UAS are known to be valuable in infrastructure monitoring, for regular inspections of water transporting infrastructure (Dufek, Traore, Swanson, Fipps, & Murphy, 2019), as well as for post-disaster surveys (Gowravaram et al. 2018). However the need for well-designed flight operations and data management processes post-disaster (Adams et al., 2014; Aljehani & Inoue, 2019; Thamm, Ludwig, & Reuter, 2013) is often overlooked, as is the need to collect high resolution visible as well as multispectral data sets over an area prior to any disastrous change in the environment.

Members of the Unalakleet community principally maintain a subsistence lifestyle and are extremely knowledgeable about the habits of the resource animals. Through coordination activities by the Norton Sound-based research member, the investigation team will work directly with the community partners and within the communities themselves, to identify local key resources of concern that could be impacted by marine spills in the Bering Sea region. This information, inclusive of geographic areas of concern for these subsistence resources (i.e., marine mammal haul-outs), which will be integrated into the operational protocols for subsequent analyses during scenario assessment.

The research team notes that overall baseline ecological assessments for the Unalakleet region have not been systematically performed since 2011 (M. Harkness, et al., 2011), and will be key to the quantification of any changes resulting from acute or chronic environmental change in the area.

Using UAS with onboard sensors as the operational platform, (with visible and multispectral sensors integrated) an emergency survey protocol for Unalakleet will be co-produced between the pilots and the project team, and test flights corresponding to the co-produced surveying protocol will be conducted. The goal is to investigate and validate that having trained local citizens serve as data first responders to collect image/video capability for gaining situational awareness during all stages of an emergency response (ER) and be able to deliver the information appropriately and efficiently to the incident command post of any given response.

Regional Expansion Feasibility: To determine if the experimental program can be implemented for the long-term in Unalakleet, and in other Bering Sea region communities, the Model Forest Policy Program (MFPP), a national 501(c)(3) nonprofit organization which has worked with communities in the region since 2013, will undertake a feasibility study to identify, assess, and prioritize, based on local input, Norton Sound communities' critical infrastructure, critical and vulnerable community (subsistence) assets, and emergency response (ER) capacity and protocols. ADAC and the research team are focused on creating a capable inspection team at UNK as a proof of principal and will not assume any decision authority for HQ USCG or any USCG components on any aspects beyond the planned research in creating the UNK prototype. Regional Expansion Feasibility analysis is provided as due diligence of beyond the planned research horizon as a courtesy and an overall desire to support HQ USCG Project Champion and USCG stakeholders.

In conducting the study, outreach will be made to the communities of Elim, Golovin, Shaktoolik, Teller, Shishmaref and Koyuk; as well as include any additional, related, Unalakleet infrastructure and emergency response information. Input will be sought from, but not limited to, Indian Environmental General Assistance Program (IGAP) coordinators, public works staff, emergency responders and communications technicians, as well as from regional, state, and federal organizations and agencies (e.g., Kawerak Incorporated, Alaska Native Tribal Health Consortium, Denali Commission, Norton Bay Inter-Tribal Watershed Council, and FEMA). The report of the feasibility study's findings will include infrastructure types and locations, vulnerable community assets, and their prioritization and current means of assessment; identification of critical local Public Works staff, Emergency Response (ER) team members, environmental staff, and remote communications technicians; plus, identification of key local /regional partners and their supporting roles. Research will also seek to clarify the various entities'

Figure 10 Unalakleet tank farm. Photo courtesy of Unalakleet Economic Development Plan 2014-2019.

relationships to an expanded program and communications with emergency response incident management teams in the hub community and response headquarters.

Information Dissemination. The project team will support three planned stakeholder engagement events, plus the publication of project results, in an effort to disseminate knowledge gained during this project. Throughout the program, monthly communications about the project will be disseminated in commonly accessed publications (i.e., layperson publications), such as the Mukluk Telegraph published by the Alaska Native Tribal Health Consortium.

At the completion of the project in the spring of 2022, the team will hold a "*project fair*" in Unalakleet. The project fair is designed to familiarize the Unalakleet community about the efforts of the pilot/co-pilot teams over the past year in support of infrastructure inspections and emergency response capacity. During the project fair, the local pilot teams will demonstrate the skills acquired and the objectives of the project work, for the students of the Unalakleet school during the school day. The goals of the in-school presentations are to encourage students to pursue science, technology, engineering and math (STEM) activities in the short and long-term that can benefit their community, and to excite them to come to the evening event with their families after school.

The evening community event will include a formal presentation of the project goals and achievements by the entire project team, followed by informal and open-ended discussion with the project team. Members of the Unalakleet community, tribal administrators, agency representatives and other residents from around the Norton Sound will be the target audience for this event. Another goal of this engagement is to clarify roles, responsibilities and participants in a spill response at the community level for those communities anticipated to experience the greatest impact from increased shipping through the Bering Strait. These events are key to developing a network of trust that will support, the collection of traditional ecological knowledge (TEK) model variables, community infrastructure capacity assessments, and UAS pilot team identification.

The second face-to-face community engagement event will be the hosting of a booth and delivery of multiple presentations at the Alaska Tribal Conference on Environmental Management (ATCEM) 2021. Further, hosting two webinars around the face-to-face events will allow remote stakeholders outside of Alaska to learn the same material that will be presented face-to face and via the webinar interface to communities across Alaska. Each interactive event will offer in-depth discussions with the project team core (Garron, Henry, Hall), and how the project outcomes can be translated to other communities.

Key findings of sensor testing, and protocol development will also be disseminated via a technical journal submission, and ultimately publication, advancing remote-sensing applications for operational activities and emergency response in rural Alaska.

In accordance with research methodology, the Program Year 8 investigations are organized as a series of sequential tasks:

Task 1: UAS pilot training and certification

Task 2: Coproduction of infrastructure inspection operational protocols

Task 3: Coproduction of emergency response (ER) assessment protocols

Task 4: Regional expansion feasibility assessment

Task 5: Information dissemination

Details:

Task 1 – UAS Pilot Training and Certification. (Concludes by 15 July 2021) In order to meet the project goal to investigate and validate that having trained local citizens serve as data first responders to collect image/video capability for gaining situational awareness during all stages of an emergency response (ER) and be able to deliver the information appropriately and efficiently to the incident command post of any given response, a trained and certified UAS pilot team is essential. Accordingly, selected candidates will be trained in accordance with FAA credentialed UAS instructors at ACUASI. In conjunction with UAS Pilot training and Certification, this task includes the purchase three, off-the-shelf, UAS with integrated electro-optical and multispectral sensors; flight test for air worthiness to determine the capacity of multispectral sensors to support tank farm and critical infrastructure inspections and for fundamental data processing protocol development; integrate UAS into the hands-on instruction of the community-based pilot/co-pilot teams for skill development and operational aircraft familiarization; provide additional instruction on operational airspace, FAA regulations and weather; and community-based pilots sit for their FAA Part 107 rule certification exam (i.e. UAS pilot exam) after the completion of the training. The specific tasks include:

Task 1.1 Develop and Deliver Kick-Off/Recruitment Webinar. Concluded in ADAC Year 7.

Task 1.2 Acquire and train pilots in use of UAVs, Sensors and Software. This task was started in ADAC Program Year 7 and will conclude in Year 8. The newly introduced requirement for extensive remote delivery of program content will increase the amount of software and hardware required for the success of this project. Remote pilot instruction will include synchronous and asynchronous content delivery to the NVU, coupled with UAS flight simulator software to introduce the hand-eye coordination challenges that need to be overcome to safely fly. Once these fundamental components have been delivered and consumed, a set of small, basic model UAS will be purchased for and delivered to NVU for practice flying in small areas. These small drones bridge the gap between the simulator and the operational aircraft, exposing the new pilot teams to the three-dimensional (3D) aspects of UAS flight. The operational aircraft will meet ITAR control guidelines and US federal requirements. Four systems to include the aircraft, the E90 electro-optical sensor, and the RedEdge multispectral sensor will be purchased upon project approval and award. These UAS will be supplied to the NVU with hands-on training from the ACUASI pilot instructional team to take place in NVU. If COVID19 remote Alaska regional protocols limit travel from Fairbanks to NVU, project investigators will fly NVU pilot candidates to Fairbanks to conduct training at UAF. Critical aspects of the training are instructing the pilots in the operational limitations of associated weather (wind, precipitation, temperatures, etc.) of the UAS platforms, gaining reliable on/scene weather in remote areas and providing clear go/no go (safe/not safe) environmental conditions to remote community drone pilots. Equally important is

project investigator communication with local officials in advance of training to ensure advance understanding and cooperation for the conduct of each flight.

Task 1.3 Develop General Protocol for UAS Flights and Data Processing. Operational hardware and software will be tested and leveraged at UAF by the ACUASI team to streamline protocol coproduction and data processing nuances. This work includes flight testing the aircraft in sub-Arctic conditions to identify the operational range of the aircraft in rural Alaska and performing simulated test flights for infrastructure inspection and emergency response situational awareness. Data gathered by the sensors during these test flights will be processed using the identified operational software to determine general data processing flows and pitfalls to be avoided during operational flights. Spectral combinations to effectively discern infrastructure integrity will be experimented with and defined for operational collection. Performing data delivery of test data sets to Project Champion, USCG Stakeholders and advisors will be coordinated as part of this testing, to identify requirements and limitations to operational data delivery from the Native Village of Unalakleet (NVU). Data will also be catalogued in NOAA's Arctic Environmental Response Management Application (Arctic ERMA) a repository for data accessible to USCG maritime environmental response at tactical and operational levels.

Task 1.4 Identify/Notify Pilot Teams. Concluded in ADAC Year 7.

Task 1.5 Deliver Remote UAS Pilot Training. Concluded in ADAC Year 7.

Task 1.6 FAA Certify UAS Pilots. Trained program pilots will be required to take and pass the FAA Part 107 certification exam for UAS operators. Pilot teams will be trained on all aspects of the certification test through ACUASI remotely delivered instruction but will be required to learn and reflect the laws and requirements for UAS flight in US airspace to pass the FAA certification exam independently. Exams are currently offered at FAA testing centers in Fairbanks, AK and Anchorage, AK, but may be available on-line or through local aviation centers if social distance requirements of COVID-19 continue.

Task 1.7 On-Site Flight Training. The final instructional component is training the certified pilot teams in the NVU on the operational hardware and software for infrastructure inspections and emergency response flights. This on-site training will include data processing, delivery and archiving using UAS-collected data and leveraging the remote instruction received by the pilot teams. Using the lessons learned in Fairbanks, the ACUASI team will guide the certified pilots through all aspects of operations using the operational hardware and software, providing the NVU pilot teams the tools to coproduce operational protocols with the project team during the remainder of the project.

Task 2 - Coproduction of Infrastructure Inspection Operational Protocols. (Completes by 15 July 2021) Identify current inspection requirements and protocols for rural Alaskan oil tank farms; co-produce UAS flight protocols to collect integrity information over the Unalakleet tank farm, and its supporting infrastructure with pilots and community stakeholders; practice flight protocols and report any identified anomalies.

Task 2.1 Determine Current Infrastructure Inspection Requirements. Project investigators will work with the Environmental Protection Agency (EPA), USCG, and the State of Alaska to gain and understand documented requirements for the inspection and integrity of fuel carrying and fuel

storage facilities in remote Alaska. Examining and summarizing these requirements is key to the development of a viable UAS inspection solution in support of the observational requirements and local ordinances at the NVU. In addition, understanding the needs of USCG inspectors that are not defined in codified requirements will be ascertained via teleconferences between Project Investigators, local officials at NVU and USCG stakeholders (particularly, USCG D17 Sector Anchorage) for subsequent flight protocol codification.

Task 2.2 Coproduce UAS Infrastructure Inspection Protocol. Project Investigators will leverage knowledge gained during flight testing, training of NVU pilots, and preliminary data processing, key stakeholders will develop an infrastructure inspection flight and data processing protocol. Preliminary flight and inspection protocols developed at UAF will serve as the foundation protocol. This coproduced inspection protocol will be tested through flight and processing in the NVU, iterated against to meet the needs of the USCG inspectors, State of Alaska regulations, local ordinances and NVU pilots. The protocol will include all aspects of infrastructure inspection flights, ranging from FAA requirements, USCG pilot activation requests, to data delivery to Arctic ERMA, and battery charging tips for flight efficiency. The aim is to have this protocol codified in the NVU and applied regionally to support USCG oil infrastructure inspection efforts along Alaska's coast.

Task 2.3 Perform Infrastructure Inspection Baseline Flights and Product Delivery Tests. The culmination of the training and protocol coproduction for infrastructure inspections will be preliminary flights over the NVU oil-bearing infrastructure to determine the baseline integrity of these systems. The operational protocol will be followed start to finish, and end products will be delivered to USCG Sector Anchorage through Arctic ERMA, ADAC's Associated webpage, or another mechanism of their choosing. Information gathered during these preliminary flights will be archived in the NVU for baseline comparisons, will be incorporated as a base component of the regional feasibility study, and will be highlighted during the "project fair" and webinars.

Task 3 - Coproduction of Emergency Response (ER) Assessment Protocols. (Completes by 31 July 2021) Identify critical subsistence areas that may be impacted by an oil tank failure or natural disaster in and around Unalakleet through a survey of critical questions; review key local documents to identify the types, locations and numbers of vulnerable infrastructure; co-produce an emergency survey protocol for Unalakleet between the pilots and the project team to include data processing and information delivery outside of the community. The trained UAS pilots will collect fine resolution baseline data over critical infrastructure, vulnerable community (subsistence) assets, and nearby shorelines to practice how to collect data with a UAS in a systematic way for additional processing and visualization efforts to delineate a "time zero" for the ecology of the community.

Task 3.1 Determine Key Community Assets. The NVU is a subsistence-based community reliant upon the land and the sea for survival. As such, environmental compartments and community support mechanisms, like the airport, power plant and school, are key assets for the survival of the community. Additional assets include the communication infrastructure that connect the NVU to Alaska and the lower 48 united states. This work will determine what the key assets are in the NVU through community engagement, document review and scenario analysis. These assets will inform the flight patterns and data products created as a result of the coproduced ER UAS

protocol, whether the emergency is a marine-based oil spill, flooding event or other large-scale, environmental disaster, impacting the community.

During community asset identification, a set of teleconferences with the project team, the NVU and USCG stakeholders will be conducted to gather USCG requirements for a flexible ER UAS protocol. Focusing on the information that USCG decision-makers need to have during an ER, the project will incorporate these needs into the ER UAS protocol. It is anticipated there will be a range of needs, from timeliness of data delivery to the accessibility of the information in a common operational picture (i.e., Arctic ERMA), many of which can be addressed through the protocol. Barriers to integrating these needs will be based upon the realistic conditions of western Alaska, in that weather is variable and severe, communication bandwidth is limited, and line-of-sight requirements for UAS flights will limit long-range monitoring techniques. Partner building discussions with all stakeholders about these needs and barriers will increase trust among stakeholders and provide expectation management for UAS applications.

Task 3.2 Coproduce ER UAS Protocol for Key Community Assets. An operational UAS protocol has been developed for the use of small UAS (less than 55 pounds) in support of oil discharges, or hazardous substance release, responses and exercises in Alaska, as authorized by the National Oil and Hazardous Substances Pollution Contingency Plan 40 CFR Part 300 (National Contingency Plan or NCP)[Garron, J. (2019). *Protocol for Using Unmanned Aircraft Systems (UAS) during an oil spill response or exercise*. University of Alaska Fairbanks Geophysical Institute Report UAG-R 336, 6p. doi.org/10.6084/m9.figshare.11788755.v2].

This protocol describes the roles and responsibilities for UAS integration into the incident command structure of authorized NRS actions that may include UAS flight requirements and UAS-relevant agency requirements in the presence of wildlife in marine and terrestrial environments, has been vetted with agency, industry and academia, and is currently being integrated into the Arctic and Western Alaska Area Contingency Plan (AWA ACP). Building off of this operational protocol and using the generalized flight and data processing protocol developed in Fairbanks, a UAS protocol for ER data collection flights will be coproduced with the pilot teams of the NVU. This protocol will be applicable to man-made or natural disasters that could impact the NVU and the Norton Sound region.

Research will establish baseline images/video, useful to detect changes. Investigators will seek to leverage automated software to add resolution and fine scale ability to detect changes. Researchers will also investigate preprogramming routes to allow for imagery from the same angle and altitude as yet another detection protocol. While incidental to the principal research focus, such consistent monitoring could also be used to detect non-disaster related changes such as coastal erosion or sinking infrastructure due to permafrost loss. Such information could help USCG more readily identify “at risk” facilities/infrastructure. Investigators will also research suitability of visual aids or markers that could be placed at facilities to aid in scale or sight line calculations.

Included in planned inspection protocols will be specific flight patterns and data processing protocols that will support monitoring of key community assets in the NVU but will also include

guidelines to apply the protocol in other communities outside of Unalakleet by the trained pilot teams if a disaster occurred in another community of Norton Sound. The protocol will also research the basic requirements of a rapid deployment capability, potentially suitable to provide data to USCG decision makers in support of incident command post. Test flights and scenario-based exercises will allow for the project team to iterate against the protocol until high resolution, quality data products can be acquired, delivered in the associated USCG Project Champion Knowledge Product, with data archived in Arctic ERMA consistently as part of the investigations.

Task 3.3 Perform emergency response (ER) Baseline Flights and Product Delivery Tests. The establishment of the ER protocol will be completed with the collection of baseline data over key assets of the NVU. This baseline data-collection effort will leverage the UAS protocol to collect high resolution information about key NVU assets and practice the protocol that can be flown during emergencies, or seasonally, to monitor for change. In support of USCG Maritime Environmental Response coordinated and regulated through Sector Anchorage, baseline data set will be archived in Arctic ERMA as a stand-alone data set, to be used when addressing future disasters in Western Alaska.

Task 4 – Regional Expansion Feasibility Assessment (Completes by 31 August 2021) Feasibility assessment is intended to serve as a suitable roadmap for other rural Alaskan communities should they want to independently establish inspection programs based on the findings of this project. Investigators will review key (individual community) documents (e.g. Local Economic Development Plan, Hazard Mitigation Plans, and Small Community Emergency Plans) for information regarding critical infrastructure and emergency response (ER) plans; develop survey questions to identify, assess, and/or prioritize Norton Sound communities' critical infrastructure (e.g. type, location, number) and emergency response capacity and protocols; develop contact list of potential key respondents on local, regional, state and federal levels; conduct survey by internet, phone interview and/or through written response; compile and analyze results; and write summary report.

Task 4.1 Summarize Regional Critical Infrastructure and ER Information. This work will include summarizing current Norton Sound communities' critical infrastructure, critical and vulnerable (subsistence) assets, emergency response (ER) capacity and protocols as part of the determination of how UAS-based Infrastructure Inspection (II) and emergency response (ER) protocols could be applied in other Norton Sound communities. Bering Strait communities that will be included in this assessment are Elim, Golovin, Shaktoolik, Teller, Shishmaref and Koyuk. Additional communities may be included if requested.

Task 4.2 Conduct Community Survey. To ascertain interest and relevancy of UAS-based Infrastructure Inspection (II) and emergency response (ER) protocols, a contact list will be developed to include Bureau of Indian Affairs (BIA) Indian Environmental General Assistance Program (IGAP) coordinators, public works staff, emergency responders and communications technicians, as well as regional, state, and federal organizations and agencies (e.g. Kawerak Incorporated, Alaska Native Tribal Health Consortium, Denali Commission, Norton Bay Inter-Tribal Watershed Council, EPA, and Federal Emergency Management Agency) active in the region. Literature reviews and if/as needed, surveys will also be used to assist researchers to

identify key assets in the Bering Strait region for possible inclusion into either Infrastructure Inspection (II) or ER flights outside of the NVU.

Task 4.3 Aggregate Survey Results. Results from the survey will be aggregated to describe attitudes and capacity of communities throughout the Bering Strait region to support a local or regional UAS-based II and ER program. Results will also indicate key regional assets to be examined and protected during daily operations as well as during an emergency response.

Task 4.4 Complete Regional Expansion Feasibility Report. The report of the feasibility study's findings will include infrastructure types and locations, critical and vulnerable community (subsistence) assets, their prioritization and current means of assessment; identification of critical local Public Works staff, Emergency Response team members, environmental staff, and remote communications technicians; plus, identification of key local /regional partners and their supporting roles. Research will also seek to clarify the various entities' relationships to an expanded program and communications with emergency response incident management teams in the hub community and response headquarters.

Task 5 - Information Dissemination. (1 November 2021-15 March 2022) Project team will Disseminate results through a set of face-to-face engagement events (Unalakleet Project Fair, webinars, Alaska Tribal Conference on Environmental Management (ATCEM) 2021) and asynchronous publications and reporting mechanisms (ADAC final reporting and journal publication).

Task 5.1: *Create USCG-focused Knowledge Product*. Research team will conduct needed analysis by reviewing accomplishments of research and development of corresponding protocols and associated data to create a useful knowledge product for the USCG Project Champion and USCG other department/agency advisors as determined by the Project Champion. This Knowledge Product will be used by the Project team as baseline of knowledge to conduct onward information dissemination.

Task 5.2 Engage Non-Technical Stakeholders. Engagement of non-technical stakeholders and other interested parties is critical in order to increase understanding of the project by a broader group of individuals including local and regional decision makers. To engage these broader communities, development and dissemination of project updates through such entities as the Institute for Tribal Environmental Professionals (ITEP) (http://www7.nau.edu/itep/main/Home/), the Center for Environmentally Threatened Communities (https://anthc.org/center-for-environmentally-threatened-communities/), the Arctic Rivers Project (https://drive.google.com/file/d/1objP1ip9G5Alkzv9YRnhv5Ei_KeETdJL/view), Kawerak, Inc. (https://kawerak.org/#), Model Forest Policy Program (MFPP), and FEMA – Region 10 Office of External Affairs, on a quarterly basis, at minimum. Methods of circulation are expected to include newsletters, blogs, and listservs. At the end of the project, a case study will be developed and submitted for posting to the Climate Adaptation Knowledge Exchange (https://www.cakex.org/). MFPP will develop an outreach schedule and draft articles and other materials with input and review from other project team members.

Task 5.3 Develop and Hold Community Project Fair. After the completion of pilot training, UAS protocol coproduction and baseline data set collection, a Project Fair will be held in the NVU, with all stakeholders and project partners. This 1.5-day event will include in-school demonstrations by the NVU pilot teams and project leadership, in-field flight demonstrations over community assets by UAS pilot teams, and a community UAS night/potlatch, where all components of the project will be on display through multi-media displays, and all project partners (inclusive of MFPP, ACUSI, and USCG) will be in attendance to answer questions and engage with the community. The project leadership team (ACUASI, NVU and MFPP) has extensive experience holding community events like these in rural Alaska, emphasizing the informal communications critical to rural Alaska that the Project Fair would support.

Task 5.4 Develop and Deliver Program Webinars (2). The entirety of the program, including successes, drawbacks and lessons learned, will be summarized in a 1.5-hour webinar that will be delivered in two webinar sessions. One of the webinars will target rural Alaskan communities, and the second will target USCG partners across America. Additional stakeholder webinar attendance will be encouraged up to the maximum number of attendees that can be supported by the identified webinar software, and will include representatives from NOAA, the State of Alaska, and regional Alaskan Native corporations. These webinars will utilize synchronous and asynchronous information delivery methods to maintain Q&A with the audience, while not maxing out community bandwidth in rural Alaska.

Task 5.5 Present Program and Protocols at ATCEM. The Alaska Tribal Conference on Environmental Management (ATCEM), held every fall in Alaska, brings together tribal environmental coordinators and managers to share mandates and methods for maintaining healthy communities. The summarized project will be presented as a full 1.5-hour session at the 2021 ATCEM, with panelists from NVU, ACUASI, MFPP and the Sector Anchorage to answer questions and represent the partnerships among the stakeholders of the successful UAS pilot training/ protocol production program. This event will serve as a face-to-face venue to encourage expansion of this project on a regional, if not statewide level.

Task 5.6 Develop and Submit Peer-Reviewed Publication on Program. The extensive program developed and conducted by this team will be coalesced into an article for a peer-review journal publication. The journal selected will be from the disaster response genre, and will be an “open access” journal, meaning that subscription fees are not required to read the article, encouraging the broad audience viewership of the information.

Task 5.7 Refine and Update USCG Champion Knowledge Product in order to Submit Final Report. At the conclusion of the program research, investigative team will update the prior developed USCG Champion Knowledge Product in a detailed final report for submission to ADAC, Project Champion and DHS S&T OUP. This report will include the developed protocols, contact names and numbers for certified and trained UAS pilot teams in the NVU, the feasibility report and descriptions of all other project components and lessons learned.

Key Milestones: The milestones listed below are directly correlated to the proposed tasks of the experimental program from ADAC Program Year 7 through 8 and are described in terms of scheduled initiation and estimated completion.

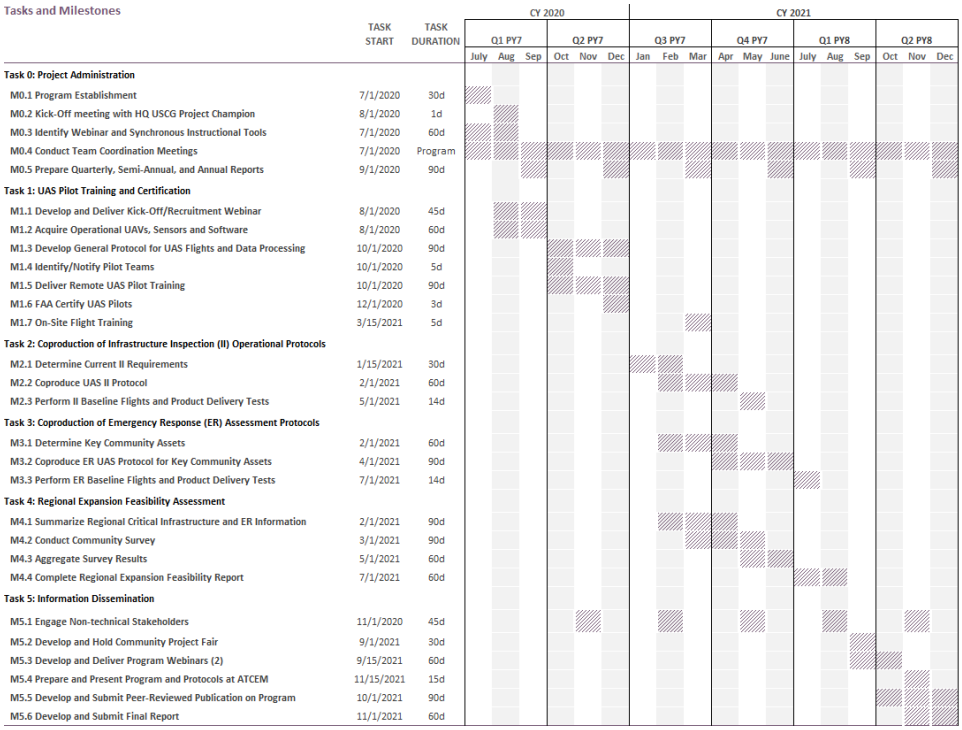

Table 5 Project Tasks and Milestones:

Program Year 8 Tasks and Milestones: The following key milestones are scheduled in accordance with the tasks of ADAC Program Year 8:

Task 1 – UAS Pilot Training and Certification. Principal work completed in ADAC Year 7, task finalization to be completed by 15 July 2021.

Task 2 - Coproduction of Infrastructure Inspection Operational Protocols. Principal work completed in ADAC Year 7, task finalization to be completed by 15 July 2021.

Task 3 - Coproduction of Emergency Response (ER) Assessment Protocols. Principal work completed in ADAC Year 7, task finalization to be completed by 31 July 2021.

Task 4 – Regional Expansion Feasibility Assessment. Task completes by 15 September 2021.

Milestone 4.1: Summarize key (local and regional) documents for critical infrastructure and emergency response information.

Milestone 4.2: Develop regional contact list and conduct regional UAS survey.

Milestone 4.3: Aggregate survey results.

Milestone 4.4: Complete regional expansion feasibility report.

Task 5 - Knowledge Product Development Information Dissemination Task completes by 31 January 2022.

Milestone 5.1: Create USCG-focused Knowledge Project.
Milestone 5.2: Engage non-technical stakeholders.
Milestone 5.3: Develop and hold community engagement events in Unalakleet ("Project Fair").
Milestone 5.4: Develop and deliver two webinars about the experimental program, developed protocols, and feasibility of program expansion.
Milestone 5.5: Present experimental program and the developed protocols at ATCEM.
Milestone 5.6: Develop and submit publication about sensor capacity testing and general inspection methodology to technical journal.
Milestone 5.7: Refine and Update USCG Champion Knowledge Product in order to Submit Final Report.

Key Stakeholder engagement plan. Researchers believe NVU and Sector Anchorage are the primary stakeholder groups involved in the project. The direct participation of the NVU and representatives of Sector Anchorage in all aspects of this project will openly engage these primary stakeholders in the cooperative training of community pilots and the coproduction of flight protocols for infrastructure monitoring and emergency response (ER) along America's western border.

NVU direct participation in UAS pilot training and protocol coproduction will increase the long-term viability of the project through personal investment in successful outcomes for the community and the region. To ensure the sustained engagement of NVU throughout the project duration, UAS pilot teams will be recruited and selected through a non-exclusive application process and formalized through signing a cooperative agreement with the research team to fulfill the training, protocol development, and test flights associated with this project. In return for this commitment, these NVU pilots will be fully trained in the legal and operational use of UAS, will be certified by the FAA as Part 107 UAS pilots (if exam passed), will be co-authors of operational protocols employed by the community and the USCG, and be compensated for their time through salary reimbursement.

Additionally, these UAS pilots will be deployable throughout the region to perform inspection or emergency response flights when hired in the future.

Subject matter experts from Sector Anchorage are critical to the success of the project team, ensuring project scope and scalability will support the overarching USCG mission and will maintain viability beyond the lifecycle of the project. It is also important that regional DHS representatives are able to engage with project participants so that the newly gained capacity of the Norton Sound region can be understood and relied upon for future emergency response (ER) and oil infrastructure inspection support needs. Sector Anchorage engagement with the project team will ensure the creation of useful information products that will support the USCG mission, are translatable to USCG operations Sector Anchorage representatives are respectfully requested and are anticipated to participate in all aspects of this project, as the benefits of this work can only increase, as mission needs of all parties are discussed and aligned. Research team believes it is important to have USCG presence at the proposed Project Fair to show partnership, support, and engagement with the Norton Sound region, and to participate in the webinars. The project team is hopeful that members of the Sector Anchorage team will be able to directly support this project in whatever capacity is possible while still maintaining their primary duties for Alaska.

The feasibility study examining the regional expansion of the project model and outcomes will engage members of the Norton Sound Bay communities that rely on Unalakleet as a hub for commerce and communications. This work will identify and develop a contact list of other tribal environmental officers, public safety officers, and regional leaders to participate in project webinars as well as for the implementation of a survey to gauge interest and regional capacity to expand the prototypical program beyond Unalakleet to other rural Alaskan communities along the Bering Strait. The results of this examination will be integrated into the project to improve methodology for future applications of this work, locally, regionally, and nationally.

Additional information dissemination to stakeholders beyond those outlined in the project Tasks includes working closely with ADAC leadership, HQ USCG Project Champion, USCG Project advisors as directed by the Project Champion and engaged rural Alaskan partners throughout this research project. Regular reporting to general ADAC stakeholders will be accomplished throughout the lifecycle of the project via in ADAC weekly all hands call, and a USCG Project Champion determined roundtable discussions organized by ADAC, allowing for DHS S&T OUP and associated USCG project leadership and advisors to stay informed as to project advances. Disseminating project information in the community through less technical articles, and at Alaska Tribal Conference on Environmental Management (ATCEM), a broad set of Alaskan stakeholders will be reached and introduced to the methodology of the project, allowing for the determination of local adoption throughout Alaska, and nationally.

The project researchers plan for the representation of project team at the following ADAC/ADAC supported events:

- Designated meetings with HQ USCG Designated Project Champion and any Project Champion Directed USCG and/or other Agency/Department Advisors.
- Weekly All Hands meeting (Normally Thursdays, 1130-1230 Alaska Time via teleconference).
- Quarterly Reviews and Quarterly Customer's and Partner's Roundtable.

- Annual ADAC meeting at HQ USCG, Washington D.C.
- Meetings coordinated by ADAC with industry and spill response conferences and symposia.

Student Participation.

ADAC and project team will investigate opportunities for one existing Center fellow to participate in the research project, jointly managed via ADAC Education and Administrative Manager and the research investigators at UAF.

Performance Metrics.

The below are the overall performance metrics planned for the research.

Task 1.: UAS Pilot Training and Certification:

Acquire operational UAVs, sensors and software suitable to operate in an Arctic environment.

Develop general protocol for UAS flights and data processing satisfactory to HQ USCG Project Champion and supporting USCG teams (in particular, Sector Anchorage).

Recruiting and training 7 UAS pilots to FAA standards.

Task 2 - Coproduction of Infrastructure Inspection Operational Protocols:

Determine current tank and fuel delivery infrastructure inspection requirements. coproduce a UAS-based tank and fuel delivery infrastructure inspection protocol and perform infrastructure inspection flights and product delivery tests processing in accordance with FAA, State of Alaska and Local Ordinances to the satisfaction of HQ USCG Project Champion and supporting USCG teams (in particular, Sector Anchorage).

Task 3 - Coproduction of Emergency Response Assessment Protocols.

Determine key community assets for monitoring pre/post emergency response, coproduce emergency response UAS protocol based upon surveys of key community assets and perform emergency response baseline flights and product delivery tests processing in accordance with FAA, State of Alaska and Local Ordinances to the satisfaction of HQ USCG Project Champion and supporting USCG teams (in particular, Sector Anchorage).

Task 4 – Regional Expansion Feasibility Assessment.

Summarize key (local and regional) documents for critical infrastructure and emergency response information, develop regional contact list and conduct regional UAS survey, and aggregate survey results in a regional expansion feasibility report in accordance with FAA, State of Alaska and Local Ordinances to the satisfaction of HQ USCG Project Champion and supporting USCG teams (in particular, Sector Anchorage). Feasibility assessment will be suitable to serve a roadmap for other rural Alaskan communities should they want to independently establish inspection programs based on the findings of this project.

Task 5 - Knowledge Product Development Information Dissemination.

Create USCG-focused Knowledge Project, engage non-technical stakeholders, develop and hold community engagement events in Unalakleet ("Project Fair"), develop and deliver two webinars and develop and submit publication about sensor capacity testing and general inspection methodology to technical journal, to the satisfaction of HQ USCG Project Champion and supporting USCG teams (in particular, Sector Anchorage).

Outcomes/Outputs.

Overall Outputs for the entire project include:

The principal USCG outcome is a knowledge product for the USCG as a possible use case for other areas/applications. This research will provide the USCG a comprehensive knowledge product with associated analysis and supporting data of the practicality of an alternative approach to support to USCG mission to assess visible non-compliance with 33 CFR 154 at bulk fuel storage facilities and develop emergency response preparedness in Western Alaska. This project also provides the USCG the option of potentially leveraging trained regional, deployable, UAS pilot teams near the vicinity of a large number of aged facilities in coastal areas capable of monitoring at risk infrastructure.

The research will provide the USCG a developed set of operational UAS protocols for both monitoring infrastructure for compliance and prevention of potential oil discharge identification and for emergency response support through regional preparedness. This project will investigate and increase research capacity in the Alaskan native community of Unalakleet in the Bering Strait region by training community-based pilot/co-pilot teams on the safe use of UAS, and co-producing community-based data collection and emergency response protocols using the identified remote sensing tools. Investigations will also expand the number and collection methodology efficiency of Bering Strait specific geospatial data sets in both number and availability, key to the effective management of this increasingly trafficked Arctic resource. By co-producing these baseline data sets and data delivery protocols with a convergent research team of Alaska native communities of the Bering Strait, the project will have a higher efficiency and likelihood of success due to investment in the data by all members of the team. Supporting details:

Training UAS pilot teams in the Bering Strait region. The development of pilot teams in the regional hub of Unalakleet creates the ability to acquire real-time, or near real-time situational awareness where there currently is none. Once trained and supplied with equipment, these UAS teams can be deployed via small aircraft, boats, ATVs and snow machines to support USCG mission needs in the immediate and in the long-term. The protocols developed as part of this project will allow for uniformly collected and distributed data products from this region to be provided to USCG for informed tactical decision-making prior to any deployment of personnel. Establishing a community based UAS network in the Bering Strait region has the potential to empower community members, increase community interest in science, technology, engineering, and math (STEM) in the partner communities, and to transform the community and its role in the Incident Command of a Federalized oil spill response. These expert UAS teams could support emergency response (ER) in a direct and pivotal way that has not been established in rural Alaska before, and could change the economic dynamics of what are currently routine inspections and data collection efforts. Community pilot/co-pilot teams informally working with students within Unalakleet to highlight UAS applications in the community is an endeavor that bridges the gap between STEM in the abstract and science in the real.

Infrastructure inspection protocol development. The development of a UAS-based protocol that can be used to inspect oil-bearing infrastructure (tanks and delivery pipes) was identified as a specific solution to support the massive number of bulk fuel storage facility inspections that must be performed by USCG in Alaska. Through developing a tank farm monitoring protocol that can be translated to other communities across Alaska and the nation, this project has the potential to change the way tank farm inspections are conducted, increasing the reliability of these inspections. The end goal of this work is to have the regional UAS teams leverage the developed infrastructure monitoring protocol to perform primary inspection flights to support the prioritization of USCG inspection efforts through remote situational awareness.

Emergency response protocol development. The development of an emergency response data collection protocol that is in-line with the AWA ACP, will allow for immediate and uniform data collections in support of emergency response activities, that will be aligned with USCG data needs, distributable by Arctic ERMA (which is leveraged by USCG watch standers at the District and Sector Levels), and will provide the near real-time situational awareness that would otherwise be unavailable in this region. In addition to the flight protocol, training the pilots on how to implement these protocols in other communities in the region on short notice is also an important piece of the work. The baseline data collections of Unalakleet will serve as a "time zero" measure, and can be referenced for many different future analyses, regardless of the type of emergency.

Bering Strait regional feasibility assessment. Determining the interest and feasibility of expanding this program beyond the NVU will highlight pathways to success for engaged partners in communities throughout the Bering Strait. This assessment can be used to inform USCG operations, routine or emergency, in this region and which communities the USCG can turn to support the mission needs in rural Alaska. The assessment will also provide USCG additional information about key assets of concern for Bering Strait communities that may or may not be included in environmental sensitivity indices currently included in Arctic ERMA, as well as highlight informational gaps that need to be filled to support the USCG mission in the Bering Strait.

Transition Plan.

The transition plan is focused on a comprehensive dissemination of knowledge products and research findings for journals, and other practical measures to help communities and other agencies assess the utility to consider such an approach for remote area use of UAS for inspection purposes. The transition of program findings about sensors and protocol lessons-learned within the community of Unalakleet will be on-going and a critical iterative portion of the project throughout the lifecycle of the project. Additional informal discussions about the project with regional stakeholders and interested parties from across Alaska and USCG, will support the development of additional project communication methods as warranted.

The project team will formally disseminate the results of the program through monthly publications about the project in laymen's periodicals, the community engagement events, and ADAC/DHS reporting mechanisms and publications at the completion of the program. Formal adoption of the operational protocols by the community of Unalakleet will be encouraged through the co-production process and by providing the community pilots the hardware and software to continue the

operational collection, processing and archiving of UAS-based data sets over Unalakleet infrastructure.

The regional feasibility study will identify if the application of project findings to other communities in the Bering Strait region will be a focus of future efforts. If so, part of the transition approach will be to seek funds to continue the program in other Bering Strait communities.

If formal adoption is determined to be warranted, ADAC leadership and the project team will work with USCG Project Champion and USCG Project Advisors to codify protocol components into USCG operational policies. If USCG determines that either or both protocols should be adopted into USCG operations, the project team will coordinate with USCG partners to identify funding and mechanisms to deliver instruction about protocol use, including data processing, delivery and archiving if desired, to identified members of the USCG community.

Programmatic Risks and Mitigation Plans.

#	Programmatic Risks	Mitigation Plan
1	Project team unable to travel to NVU for entire program duration.	Conduct entire program remotely.
2	Unanticipated project personnel changes.	Identify and on-board alternative personnel
3	Multispectral sensor testing not complete before pilot training.	Train pilots on visible sensors and processing techniques in-person, train on multispectral sensors remotely.
4	Pilots do not pass FAA 107 exams.	Find additional funding to retake test.
5	Poor weather conditions for test flights.	Reschedule test flights.
6	Crash one UAV with sensors.	Utilize second UAV with sensors.
7	Sensors will not work.	Seek warrantee from vendor.
8	Lack of consensus on operational infrastructure assessment and emergency protocols.	Defer data requirements protocol(s) to local entity and flight requirements to ACUASI.
9	Low number of participants in first webinar	Increase advertising for second webinar.
10	ATCEM 2021 conference not interested in Project presentation.	Seek no-cost extension and submit abstract for presentation at Alaska Forum for the Environment in February 2022.
11	Technical journal submission not selected for publication.	Revise and resubmit or submit to alternative technical journal.

Project Addendum: Compliance Assurances

Data Needs: This project will be generating its own data through the UAS-based collection efforts of the community-based pilot teams, and determination of key community assets with NVU partners. Any additional baseline data sets integrated into the study will come from publicly available, on-line, data sources hosted by the State of Alaska (tank farm inspection records) or the National Oceanic and Atmospheric Administration's on-line data portal Arctic ERMA (https://noaa.erma.gov).

Human Subject Research (IRB) or Animal Welfare Research (IACUC): No animals or people will be used as subjects in this experiment, as such no IRB or IACUC protocols or approvals are required for

the execution of this project. However, in an effort of goodwill and leveraging quality research practices, the proposed survey questions will be submitted to the UAF office of IRB to acquire a Letter of Exemption for this work that will be included in final reporting and any future publications.

ITAR/Export Controls: No ITAR or export controls are necessary for the execution of this project nor the subsequent publication and commercialization of the results, as no manufacture, export, import or furnishing of defense articles or services are included in this work. In addition, the project team is committed to procuring software and hardware for this manufactured in the United States. If researchers determine there is not a suitable resource manufactured in the U.S., the project team will consult with ADAC and via ADAC, the DHS S&T OUP Program Manager to determine if the specific product is suitable based on security associated with its production and operation.

PROJECT: Alaska and Arctic Maritime Communications and Connectivity Analysis (AAMC&CA)

Project Investigators: Dr. Doug Causey, Principal Investigator, Mr. Jason Roe, Petty Officer, USCG (Ret), ADAC Associate Director and Senior Research Professional, University of Alaska Anchorage (UAA), Anchorage, AK. Dr. Mark Ivey Sandia National Laboratories, Albuquerque NM.

Technical researchers:

Mr. Bruce Heinrich, Arctic Slope Regional Corporation (ASRC) Federal Mission Solutions (ASRC FMS). Note, ASRC is located in Anchorage AK, and ASRC FMS is located at Moorestown NJ.

Mr. Greg Stihel and Mr. Matthew Ahlrichs, Sandia National Laboratories, Albuquerque NM.

CAPT Buddy Custard, USCG (Ret), Alaska Marine Prevention and Response Network, Juneau, AK.

CAPT Ed Page, USCG (Ret), Marine Exchange of Alaska, Juneau AK.

Ms. Ellee Matthews, ADAC Education and Administrative Manager, Mr. Connor Keesecker, ADAC Communications and Research Associate and Ms. Kelsey Frazier, ADAC Research Associate, UAA, Anchorage, AK.

Mr. Wade Albright, Alaska Satellite Facility, University of Alaska Fairbanks (UAF), Fairbanks, AK.

Arctic community outreach coordinator:

Mr. Nagruk Harcharek, Ukpeaġvik Iñupiat Corporation, Utqiaġvik, AK.

Project evaluators: [6]

Dr. Ethan Farquhar, Mr. Richard M. Pratt, Mr. Jeff W. Scott, Pacific Northwest National Laboratories, Richland, WA.

[6] Project requires at least three SMEs in maritime communications of subject matter experts will be established from the outset to monitor and evaluate scientific progress based in part on the project evaluation criteria for objectivity and quality.

Project Advisors:

Mr. Taylor Holshouser, Alaska Ocean Cluster (and in association with Bering Sea Fisherman's Association), Anchorage AK.

Mr. Ken Flowers, Vice President, Government Solutions Iridium Corporation, McLean VA.

Mr. Bruce Hellenga, Operations Manager, ARCTICOM, LLC, Bering Straits Native Corporation, Anchorage AK.

Project Champion

CDR Sam Nassar, HQ USCG CG761, Washington D.C.

Project stakeholders:

Mr. Shannon Jenkins, Senior Arctic Policy Advisor, HQ USCG 5PW, Washington D.C.

Mr. Al Arsenault, Chief Technical Director, USCG R&D Center, New London CT.

Mr. Phil Thorne, Arctic Planner, USCG District 17, Juneau, AK.

LCDR Jereme Altendorf, USCG District 17 Sector Anchorage, AK.

Dr. Phil McGillivary, Science Advisor USCG Pac Area, Alameda CA.

Project Description:

Abstract.
This project provides a comprehensive review of mariner communications and connectivity mission needs for the Alaska and the U.S. Arctic Extended Economic Zone (EEZ), with a particular focus on the Arctic (based on near, mid-term, and long-term time horizons). The investigation will take a sequenced and iterative approach, beginning with a comprehensive literature review, the establishment of a Core Advisory Team, and the development of detailed working groups. These phases will inform and drive the development of a detailed qualitative market survey, which will serve as the primary data-gathering stage in which key stakeholders will identify gaps and shortfalls related to maritime connectivity needs in their respective regions, industries, and communities. The culmination of the latter phases will inform an expert assessment, leading to the creation of a draft knowledge product, which will be assessed and finalized through a final capstone workshop. The principal focus of this planned series of investigations is to review current-to-long term mission connectivity needs, and to assess current and emerging technologies in order to derive an expert-driven comprehensive knowledge product. Planned research will address support to the public good for marine communications and connectivity concerns that affect mariner and Coastal communities across Alaska. Research will assess associated communications and connectivity needs to include regulatory compliance requirements for the International Convention of Safety of Life at Sea 1974 protocols (SOLAS—1974).

Objective/Purpose.
The goal of this project is to create and publish a knowledge product (a comprehensive report) that will contain:

1. Comprehensive review of mariner communications and connectivity mission needs for the Alaska and the U.S. Arctic Extended Economic Zone (EEZ). This includes a review of the baseline statutory requirements in accordance with the International Convention for Safety of Life at Sea Treaty (SOLAS) protocols. Accordingly, this includes vessel carriage requirements in maritime regions across Alaska, as well as USCG requirements to transmit marine information, in order to meet Global Maritime Distress and Safety System (GMDSS) requirements. This review presents a particular focus on the U.S. Arctic EEX and is inclusive of all the Alaska maritime regions, from Southeast Alaska, South Central (which includes Prince William Sound and Cook Inlet regions), Southwest Alaska (inclusive of the Aleutians), Bering, Chukchi and Beaufort Sea regions. The review is also sequenced for time periods (based on near, mid-term, and long-term), with specific analysis in how mission needs would change over time).
2. An updated and expanded market survey and literature review of current and baseline communications technology solutions corresponding to Alaska and the U.S. Arctic EEZ, which include voice and digital mediums. This updated survey will leverage previously accomplished U.S. Coast Guard products. While the qualitative market survey is oriented towards the current available community/commercial/ industry solutions, as well as the needs and shortfalls, the literature review will address the full spectrum of current available materials in communications solutions, to include unclassified approaches being made within the U.S. Federal Government. In keeping with ADAC's DHS S&T OUP Terms and Conditions, the survey and literature review will remain unclassified with no required handling instructions (such as For Official Use Only).
3. A geographic review of the Alaskan and U.S. Arctic regions in terms of communications/ connectivity shortfalls. Currently, there are a number of variances in connectivity in the high latitudes; the proposed study would assess these variances in forming a baseline of connectivity challenges and gaps. The review would also seek to assess connectivity based on known/understood current areas and levels of activity. As much as practical, the geographic review (based on expert opinion) will consider areas of future activities (e.g., trans Alaskan and U.S. Arctic ship routing).
4. A technology-focused review of known/understood existing communications and connectivity capabilities, assessed against researched gaps for the high latitudes.
5. An expert-derived set of options and recommendations via a framework oriented to a Doctrine, Organization, Training, Material, Leadership and Education, Personnel and Facilities (DOTMLPF) framework that addresses methods and means to close communications and connectivity gaps as related to near, mid, and long-term planning and technologies.
    a. Additionally, recommendations will consider and address solutions in the context of buying services vs. organically deriving and developing technologies.
    b. The final knowledge product will include prioritized options (while considering options such as commonality of usability/application of high latitude solutions to lower latitudes).

Baseline.

In order to best support U.S. Coast Guard mission needs to enable communications for mariners, this assessment will seek to address communications and connectivity challenges in technical

means as well as review the kinds of communications that are relevant and useful for mariners operating in these regions.

Modern and advanced tools, such as unmanned and autonomous aircraft, autonomous surface and subsurface vehicles, and multi-spectral sensor suites, provide large volumes of data that become infinitely more useful if quickly transmitted to shore-side analysists and decision makers. This array of improved technology has the ability to significantly advance Arctic domain awareness. However, these advancements correspondingly require modern and high-speed data connectivity, which is largely denied in the high latitudes.

As the U.S. Coast Guard seeks to increasingly leverage these new and innovative technologies to increase presence, operational capacity, and domain awareness in remote environments, the need for robust and adaptive communications and connectivity solutions will continue to grow. Accordingly, USCG platforms operating in the high latitudes should seek modern communications and connectivity technologies to meet these demands by investigating technological advancements for the most suitable near-term and long-range solutions.

In order to illustrate, currently, the U.S. Coast Guard continues long standing practices of communicating traditional mariner information, such as weather reports and reported hazards. In focusing on the future, it is important to assess/ascertain from the community of mariners what communications and associated products are important or essential to receive via U.S. Coast Guard providers to account and mitigate risk and enable mariner decision making.

Additionally, it is also important to assess from the community of mariners, the scope of equipment is currently carried aboard their vessels for communications, navigation, situational awareness and hazards management, and what kind of equipment would be preferred to be carried aboard as technology advances and affordability increases.

Certainly, U.S. Federal mariner carriage requirements continue to specify on-board legacy communications equipment, but with emerging technologies and access to space based communications, remote region internet and more, a series of strategic questions should be posed to consider what legacy means of communications are essential to continue, vs adapting carriage requirements to reflect mariner's ability to connect and communicate via new means as emerging technology access enables. As a comparison, with the advent of Global Positioning System integration and access to space-borne communications, onboard commercial aircraft systems are transforming and associated pilot skill sets, once considered essential, are now not even trained.

Accordingly, as the constellation of Alaskan and U.S. Arctic orbiting satellites rises, (which are forecast to substantially proliferate), will be the corresponding need to continue remote region terrestrial communication transmitters/relays across Alaskan waterways?

Communications and connectivity challenges in the maritime regions of the globe's high latitudes have been highlighted as a concern by USCG and other marine operators for many years. As recent as fall 2019, ADAC informal feedback indicated that the USCGS Healy steamed into the high Arctic without communications connectivity for several weeks. A significant number of similar incidents are

well known across the Alaskan and Arctic maritime community. In particular, through a number of community-based workshops, ADAC has received feedback that many Alaskan and Arctic mariners, including commercial and industry operators, subsistence hunters, and hundreds of village communities, continue to operate in a largely communications deprived environment, unable to connect ship-to-shore or, ship-to-aircraft (and vice versa), for weeks at a time[7].

For example, ADAC's Arctic-focused Incidents of National Significance (Arctic IoNS) workshops conducted in 2016 and 2019 identified shortfalls and gaps in coordinating crisis response operations to cope with workshop scenarios of a disabled cruise ship in Arctic waters (Arctic IoNS 2016), and emergency response for a large coastal region in the aftermath of a large destructive storm (Arctic IoNS 2019). In particular, satellite, cellular, Very High Frequency (VHF) coastal land-mobile radio communications along with associated digital domain awareness capabilities (such as Geographic Information Systems (GIS) derived products to visualize the domain of interest) were identified as critical to effect rapid coordination and cited in both the preparatory literature reviews and workshop findings as a routinely identified, yet unaddressed shortfall[8].

The USCG further identified communication shortfalls as the critical gap in achieving high latitude domain awareness in its 2019 "Arctic Strategic Outlook:"[9]

> "The high latitudes suffer from poor propagation of radio signals, geomagnetic interference, scant landside infrastructure, and limited satellite coverage and bandwidth. Some Arctic communities have cellular phone networks, but these are often constrained by limited coverage, capacity, and reliability. Closing the communications gap is a whole-of-government challenge and will require intensive partnerships across the interagency, industry, and the international community, as well as the State of Alaska and Alaska Native communities. As commercial, recreational, and subsistence-based activities increase, the Coast Guard must also work cooperatively to enhance communications with and between stakeholders."[9]

As a University of Alaska (UA) hosted, and U.S. Department of Homeland Security (DHS) Science and Technology (S&T) Office of University Programs (OUP) sponsored Center of Excellence (COE) in maritime research, ADAC is uniquely positioned to convene the government, industry, and research communities together in strategically designed forums to closely examine capability gaps, as well as both available and needed solutions. Accordingly, As ADAC's mission is to seek solutions that "enable the decision-maker" in advancing Arctic domain awareness, this project is proposing to apply

[7] https://arcticdomainawarenesscenter.org/Downloads/PDF/ADAC_Arctic%20IoNS%202019_Arctic%20Insights%20Community%20Workshop_190711.pdf

[8] https://arcticdomainawarenesscenter.org/Arctic_IoNS

[9] https://www.uscg.mil/Portals/0/Images/arctic/Arctic_Strategic_Outlook_APR_2019.pdf

an effective and well-practiced ADAC research method in order to address a known and high priority problem for the USCG.

With the growing number of vessels operating in the Arctic, combined with increasing international competition in the region, the ultra-low bandwidth, and utter unreliability of existing connectivity systems, the strategic importance of closing critical communications and connectivity gaps and shortfalls will only continue to grow. While acknowledging that the USCG will address certain current shortfalls with near-term commercial-off-the-shelf solutions, there is value in studying and assessing needs for some short-term, and multiple mid-to-longer term horizons in order to support USCG leadership's ability to plan and program processes that field next generation capability. In order to address technological horizons that closely align with USCG Arctic operational needs, innovative technologies should be researched, needs clearly defined, and corresponding solutions rationally identified. Such technologies further need to be available at affordable costs and have the ability to increase reliability while reducing risks for follow-on systems.

Methodology.
Guided by an expert coordination team to organize and conduct investigations, as well as to effectively solicit expert and community opinion, the research method is a sequential and iterative process of review, query, and knowledge product development, which will ultimately be refined and finalized via multi-functional expert assessments. The objective of this project is to identify the potential current state-of-the-art maritime communications suitable for remote Alaskan and Arctic waters, based on a comprehensive literature review, a qualitative market survey, community and stakeholder engagement, and solicitation of expert professional opinion via focused working groups. At the onset of the project, the project team will conduct a virtual conference with the HQ USCG Project Champion, USCG Project Stakeholders and USCG technology developers to discuss project scope and confirm supporting details as well as identifying the ultimate consumers of the end state knowledge product such that the vision and needs are as clearly defined as possible as the vector/pathway for the research.

The primary focus of the project is to understand and assess the communication and connectivity challenges unique to Alaskan and the U.S. Arctic maritime regions (e.g., ice, adverse weather, high latitudes, sparse population densities, lack of infrastructure, and other logistical challenges) that make communications particularly challenging. The scope of investigations seeks to further identify the needs, shortfalls, and outline parameters of the potential corresponding solutions most appropriate to a variety of Arctic mariners.

This project is focused on mariner communications and connectivity in U.S. waters outside that of the military services. As suitable and in accordance with ADAC's established ability to coordinate with Canadian colleagues in government and research communities, including Canadian aspects in these assessments (in particular with the shared challenges of the Beaufort Sea) will be pursued in the investigations. Realizing Canadian input to planned assessments will be accomplished by inviting an array of Canadian professionals to participate in planned convening activities and follow-on working groups.

This project will further engage communities to research these characteristics as they are unique or shared across five major geographic regions of Alaska and the U.S. Arctic region: Southeast, Southcentral, Southwest, West (Bering Sea), and Northern (Chukchi and Beaufort Seas). Accordingly, the project consists of 8 phases discussed below:

- *Phase 0:* Conduct a virtual conference with HQ USCG Project Champion, USCG Stakeholders and USCG technology developers. At the onset of the project, the project team will conduct a virtual conference with the HQ USCG Project Champion, USCG Project Stakeholders and USCG technology developers to discuss project scope and confirm supporting details as well as the ultimate consumers of the end state knowledge product such that the vision and needs are as clearly defined as possible as the vector/pathway for the research.
- *Phase 1*: Conducting a Comprehensive literature review (to continue through Phase 5). Note, the literature review will include information and insights from previously accomplished USCG research products. Note: ADAC Central Office at UAA will serve as the lead of this planned activity.
- *Phase 2:* Forming of project Core Advisory Team. Each Core Team member will lead a working group, using similar approaches as established in ADAC's Arctic Maritime Spill Modeling (AMSM) project workshop method.[10] Note: The AAMCCA "Core team" will include ADAC leadership, Proposed Principal Investigators, Technical Researchers, Community Engagement Coordinator and Project Advisors. Core Team will also invite representatives from the following agencies:
    - Alaska Ocean Observation System (AOOS), Anchorage, AK.
    - State of Alaska Department of Public Safety, Anchorage, AK.
    - State of Alaska Division of Homeland Security and Emergency Management, Anchorage, AK.
    - State of Alaska Marine Highway System, Ketchikan, AK.
    - United Fisherman of Alaska, Juneau, AK.
    - State of Alaska Department of Fish and Game, Commercial Fisheries Division, Anchorage, AK.
    - Alaska Eskimo Whaling Commission, Utqiagvik, AK.
    - Alaska Eskimo Walrus Commission, Nome, AK.
    - St Paul Tribal Government, St Paul Island, AK.
    - Bering Sea Elders, Nome, AK.
    - UAF College of Fisheries and Ocean Science, Fairbanks, AK.

- [10] Please see https://unh.app.box.com/s/8q5hgf1boe53uvsu2pzolq4jo04hp1ka (page 36).

    - North Pacific Fishery Management Council, Anchorage, AK.
    - Alaska Clean Seas, Anchorage, AK.
    - Other offices to be announced.

- *Phase 3:* "Engaging the Community": conducting virtual Meetings across the communities of interest. The Core Team with key project stakeholders will seek to clearly establish Alaskan and Arctic maritime communication and connectivity needs, and to define the scope of project for stakeholders. These meetings will also define goals and boundaries for the virtual assessment in Phase 5. Community engagement will be organized into the following regional constructs:
    - Region 1: Southeast Alaska.
    - Region 2: Southcentral Alaska (extending from Cordova to Kodiak, including Prince William Sound and Cook Inlet).
    - Region 3: Alaska Peninsula and Aleutian Islands.
    - Region 4: Bering Sea (extending from Bristol Bay Northward to Bering Straits, to include Norton Sound).
    - Region 5: Chukchi Sea.
    - Region 6: Beaufort Sea.
- *Phase 4:* Establishing virtual Working Groups. These groups will investigate specific maritime communications and connectivity components/criteria, principally focused on Alaska and U.S. Arctic EEZ.
- *Phase 5*: Conducting a virtual assessment. Planning and conducting a three-segment invitational virtual assessment focused on Alaskan and Arctic maritime communications and connectivity topics.
- *Phase 6*: Conducting Market survey development and dissemination. Note, the survey will include information and insights from previously accomplished USCG research products.
- *Phase 7:* Planning and conducting a drafting workshop. Planning and conducting a follow-on virtual workshop to review Working Group drafts and integrate feedback into a comprehensive knowledge product.
- *Phase 8:* Completing an Alaskan and U.S. Arctic Maritime Communications and Connectivity Knowledge Product, with particular emphasis to Alaskan and U.S. Arctic EEZ challenges.

Details describing each phase of the project are as follows:
Phase 1: Conducting a Comprehensive literature review. A comprehensive literature review will be conducted to identify the gaps and shortfalls of existing communications and connectivity systems in the U.S. Arctic. The literature review will inform the project overall…and will aid in the development of questions included in the qualitative market survey. The literature review will initiate the project and continue through Phase 4 of the planned investigations. As discussed, this literature review will include/leverage prior reviews conducted through USCG research teams.

Phase 2: Forming of project Core Advisory Team. Associated with project initiation, the Project Investigator will organize a kickoff meeting with HQ USCG designated Project Champion and "Core Team," which will serve to steer the project in subsequent phases. Once the specific Core Team members are identified, the Project Investigator will contact the individuals immediately and schedule the Core Team kickoff meeting. The first Core Team meeting will review the project work plan, milestones, and set a schedule for the weekly meetings. Furthermore, members of the Core Team will identify and engage with a number of constituents in the project's five key geographic research regions of Alaska and the regions as described above. These constituents will be asked to recommend key agency, industry, and community stakeholders to additionally take part in the study. Project investigators in concert with associated technical advisors and Core Team will conduct outreach to Alaskan and Fishing community homeported in the Pacific Northwest who operate in Alaskan waters to solicit their respective communication and connectivity needs associated with this project.

Formation of the project Core team will ensure the Project Investigator is meeting the goals and objectives of the project. Throughout the duration of the project, members of the Core Team will participate in virtual assessments and will be able to listen to all working group meetings. The Core Team will review/edit all documents produced during the project, including the final knowledge product. The Core Team will also work with the Project Investigators to develop a final timeline and specific goals for the project. Note, as the engagement activities are focused on professional mariner assessments these planned activities are not believed to not require Institutional Review Board (IRB) human subject investigations approval. However, at the outset ADAC and the project team will ensure the specific plans for the solicitation of professional assessments are submitted and coordinated with the UAA IRB chairperson and DHS S&T Compliance Office.[11]

Phase 3: Engaging the Community": conducting virtual Meetings across the communities of interest. The principal effort of this phase is to determine communications and connectivity needs via Virtual Meetings of the Core Team and Key Stakeholders. In order to address the associated needs and questions, the Project Investigator will organize a minimum of 2 virtual meetings (initial and final…with additional interim meetings as needed) with the Project Champion, Core team, and any other key stakeholders (community members, subsistence mariners, industry mariners, operators, etc.) that are identified by the Core Team during Phase 2. Note: project investigators believe these stakeholders should consist of participants from the 5 regions of the Alaska maritime community targeted by this project as discussed in Phase 2. The Core Team may need to have additional meetings between Phase 1 and 2 to better determine known constituents, and to gather more participants that should be involved in the effort.

The product of the Phase 3 virtual meeting will be a list of the types of needs/questions that must be addressed by the Alaska maritime connectivity analysis. These needs/questions will serve as guideposts for the entire project, and the guideposts will be constantly highlighted/consulted at

[11] Research team will coordinate and comply with DHS S&T protocols by coordinating with personnel assigned to HQ DHS via STRegulatorycompliance@HQ.DHS.GOV

meetings, assessments, workshops, and in working groups, as well as in the final knowledge product. This will be essential to keeping the project focused on USCG needs and will help minimize the tendency of a diverse group of stakeholders to deviate into related, but not mission-relevant topics. During these virtual meetings, Core Team members and stakeholders will also determine the categories that will be used to establish Working Groups (i.e., Working Groups organized based on geographic region, or industry, or commercial vs. private mariners, etc.), as well as the number of individuals to be included in each Working Group.

Phase 4: Establishing virtual Working Groups. The principal task in this phase is forming and providing onward investigations via Alaskan and Arctic Maritime Connectivity Virtual Working Groups. Following the prior virtual meetings among key stakeholders and the project Core Team, the Project team will facilitate the development of Working Groups. The categories of the Working Groups will be established and announced in Phase 3. Phase 4 will include a virtual sign-up and solicitation, in which project stakeholders can volunteer for a specific Working Group or recommend/solicit others to join a specific Working Group (Working Groups should be composed of a compilation of Alaska and U.S. Arctic EEZ mariner professionals…to include commercial and private industry mariners, operators, tribal organizational leaders involved in maritime activities, etc.). The Project Investigator (supported by project team will designate a co-group lead for each Working Group. The Project Investigator will coordinate these expert individuals by establishing one of the co-leads from a governmental agency concerned with high latitudes communications and connectivity.

Phase 5: Conducting a virtual assessment. The principal task in this phase is planning and conducting an Alaskan and Arctic Maritime Communications and Connectivity Analysis Three-Part Virtual Assessment. Once the list of needs/questions guideposts from Phase 3 are coordinated and accepted by the Core Team, and the project Working Groups are established, the Project Investigator and team will initiate planning and development of a 3-part (Monday-Wednesday-Friday) comprehensive assessment, developed via a Workshop Organizing Committee (OC). These assessments accomplished via engagements principally focused on participants from the Alaskan and U.S. Arctic EEZ mariner community.[12] The proposed three-part virtual assessment could take place over three half-day or six-hour sessions, in a Monday-Wednesday-Friday format.

- *Day 1: Virtual Panels*: The Project team anticipates the Virtual Panels will consist of alternating presentations on the different technologies available for connectivity in the Arctic and USCG Leadership presentations on some intended uses for increased connectivity. These small panels will be followed by question-and-answer sessions, and then a brief summary. The two main goals of the Virtual Panels are to 1) provide preliminary discussion and added context for Day 2 Virtual Breakout Groups and 2) to engage and encourage robust industry participation in relevant follow-on virtual breakout groups and working groups.
- *Day 2 Breakout Group Assessments* - Conduct 3 Breakout Group assessments to discuss and review technologies. The proposed Breakout Group assessments could take place over

[12] Note: While these assessments are believed to not require Institutional Review Board (IRB) human subject investigations approval, the project team will ensure the specific plans for the assessments are coordinated with the UAA IRB chairperson.

in three two-hour sessions. Proposed Breakout Group assessments include:

1. Current and near-term Alaskan and U.S. Arctic maritime connectivity technologies.
2. Medium- and long-term Alaskan and U.S. Arctic maritime connectivity technologies.
3. Connectivity transition, utilization, and integration strategies and pathways.

- *Day 3: Breakout Group Presentations and Survey Question Development* – Project team will conduct approximately 30-minute Breakout Group presentations, along with 20- minute question and answer/discussion sessions. Project Investigator (supported by the project team will plan activities associated with the event and provide summary and closing remarks.
    - Each breakout group will also develop approximately 20 potential questions to be included in the follow-on stakeholder market survey. The 20 questions will be provided to the Project Investigator and the OC, who will use the questions to develop a market survey (discussed in Phase 6).

Phase 6: Conducting Market Survey Development and Dissemination. This phase principally consists of developing a qualitative market survey in order to better understand the needs, gaps, and shortfalls of the maritime community in the Arctic. In particular, the market survey seeks feedback from individuals and organizations that may not have been available for the previous virtual meetings or may not have direct relationships with core team members. As such, the market survey aims to gather feedback principally from members of the Alaskan and Arctic maritime community whose voices have yet to be heard in the project process thus far, such as rural and remote communities, subsistence mariners, private and family-owned maritime businesses, commercial businesses, etc. Furthermore, the survey aims to capture the unique challenges experienced by these communities, as well as to gather information regarding the most ideal and appropriate potential solutions. That being said, as there are inherent challenges with internet and cellular access in remote communities, ADAC does not anticipate capturing a large enough sample size to develop a statistical inference of overall community sentiment in each geographic region. Instead, the questionnaire will serve as a qualitative measurement of community experience and expectations surrounding existing communications and connectivity.

Phase 6 of the project will include two "subphases:"
Phase 6A: Market Survey Development - Following the drafting of potential market survey questions created by each breakout group during Phase 5, the Project Investigator, along with the OC, will develop a virtual poll in order for the Core Team and project key stakeholders to vote on the survey questions that they find to be the most applicable, important, and effective in gathering more information regarding the current gaps and shortfalls in Alaskan and U.S. Arctic maritime communication and connectivity, as well as potential future solutions. The draft survey questions included in the poll will be derived from the questions created by each breakout group in Phase 5, as well as those developed by the ADAC project team throughout the process of the literature review.

Phase 6B: Market Survey Dissemination – Based on the results of the poll, the Project Investigators, with assistance from the Core Team, will develop a comprehensive qualitative market survey to be disseminated to applicable members of the Alaskan and Alaskan Arctic maritime community. The general construct of the survey could take a combination of formats, including online, phone, or mail.

The survey questions will remain the same, but the delivery format will be derived from the expert advice of the Core Team and key stakeholders (with particular consideration for communities with limited access to internet and/or phone). Based on Project Team Technical Researchers and Advisors, Core Team and working group expertise, the surveys will be tailored to the unique aspects of regions 1-6 as described previously. While these regions have their internal variances, each region has distinct maritime communications and connectivity differences from other regions as well.

Potential web-based platforms that could be utilized include SurveyMonkey, Poll Anywhere, or Google Survey. The survey is planned to be open for a period of 45 days. Again, as this is planned for professional vs personal opinions, project team assesses the surveys do not require IRB approval, but as a precaution, will coordinate the surveys with UAA IRB Chairperson and DHS S&T Compliance Office.

Phase 7: Planning and conducting a drafting workshop. The principal activity of this phase is to plan and conduct an Alaskan and U.S. Arctic Maritime Connectivity Team Knowledge Product Development Workshop. The goal of the Workshop is to develop a final knowledge product, which should be a comprehensive project report summarizing the findings of the Working Groups and the qualitative market survey. Depending on the situation surrounding COVID-19, this workshop will either take place in-person or virtually. If the event is to take place in-person, a two-part aspect may be suitable with one aspect taking place in an Arctic-based community in Alaska, and a second aspect in Anchorage so as to gather as many expert stakeholders as possible, with particular emphasis on to gather insights from mariners that understand the extreme challenges associated with maritime activities in rural, remote, Alaskan and U.S. Arctic EEZ environments. If the COVID-19 crisis does not allow for an in-person event, the workshop will take place virtually via the same means utilized in the prior phases of the project. The Project Investigator will leverage past deliberations from the virtual assessment, follow-on Working Group activities, and the results of the market survey to stimulate collaboration and consensus on short-term and long-term pathways forward for Alaska maritime connectivity technologies, including general acceptance of standard approaches to resolve identified connectivity and communications challenges.

Key to a successful outcome is to establish and maintain open channels of communication among operators, Alaska Native mariners, technology industry professionals, scientists, and U.S. Federal stakeholders. This follow-up workshop is essential to ensure that the final product is consistent and cohesive, especially because multiple groups will be working on the topics. Accordingly, the *Alaskan and U.S. Arctic Maritime Connectivity Team Knowledge Product Development, Virtual Workshop* will also allow the USCG Project champion and USCG operators to be sure that the proposed products are useful, and that suggested developments will conform to key criteria that fulfill the USCG mission needs.

Phase 8: Creating and Submitting the Final Knowledge Product. The Project Investigator will draft the final knowledge product: *Alaskan and U.S. Arctic Maritime Communications and Connectivity Technologies: The Path Forward,* as a comprehensive report, providing reviews and conclusions, addressing the following:

1. A review of the current state-of-the-art Alaskan and U.S. Arctic maritime communications and connectivity technologies.

2. Recommendations and conclusions for near-term available state-of-the-art Alaskan and U.S. Arctic maritime communications and connectivity technologies suitable for USCG use.
3. Recommendations and conclusions for medium-and-long term future Alaskan and U.S. Arctic maritime communication and connectivity technologies.
4. Detailed recommendations and conclusions on Alaskan and U.S. Arctic maritime communications connectivity transition pathways (focused on Alaskan and U.S. Arctic maritime regions. Once drafted, the Project Investigator in concert with ADAC leadership and provide to the Project Champion, Core Team, and Working Group Co-leads for edits. Once this level of coordination is accomplished, the Project Investigator will send it to USCG (to include Project Champion) for further coordination. Within one month of receiving USCG's comments/edits, the Project Investigator will submit the final knowledge product to DHS and USCG. ADAC and project team authors will comprehensively address improved understanding of the specific shortfalls, with technical knowledge to leverage a composite set of next generation/on the horizon solutions will result in significantly improving the coming challenges to insufficient Alaskan and U.S. Arctic maritime communications and associated connectivity challenges.

Key Milestones for Program Year 8.

- Completion of Phase 5: Alaskan and U.S. Arctic Maritime Connectivity Analysis Three-part Virtual Assessment 15 Jul 2021.
- Completion of Phase 6: Qualitative Market Survey development and dissemination 15 Oct 2021.
- Completion of Phase 7: Alaskan and U.S. Arctic Maritime Connectivity Team Knowledge Product Development, One Day Virtual Workshop 15 Dec 2021.
- Phase 8: Creating and Submitting the Final Knowledge Product 31 May 2022.

Key Stakeholder Engagement.

The Project team will continue to engage with the designated Project Champion on a frequency basis as determined by the Project Champion, but as a minimum the team will seek to conduct monthly teleconferences. Critical coordination is planned with all team members, the Investigator, and project champion. Key project stakeholders include rural Alaska mariners, subsistence mariners, commercial and private industry mariners, HQ USCG CG-5PW, CG-926, CG-7 offices, USCG PACAREA and LANTAREA, and USCG D17, D17 Sector Anchorage and the USCG R&D Center.
Project team will participate and be featured in the planned ADAC "Customers and Partners" Roundtable, in order to inform and receive feedback on project progress.

Investigators plan for the representation of our team at the following ADAC events:

- Meetings with Project Champion.
- Weekly All Hands meeting (Normally Thursdays, 1130-1230 Alaska Time via teleconference).
- Quarterly Reviews and Quarterly Customer's and Partner's Roundtable.
- Annual meeting at HQ USCG, Washington D.C.

Student Participation.

ADAC will coordinate for two UAA based undergraduate fellows to participate in this project to contribute to coordination of assessment meetings, market surveys and literature reviews and specific tasks associated with the drafting of knowledge products.

Performance Metrics.

An independent group (at least three SMEs in maritime communications) of subject matter experts will be established from the outset to monitor and evaluate scientific progress based in part on the evaluation criteria below for objectivity and quality. This SME group will evaluate the project on a quarterly basis, at a minimum, including the final draft report, in parallel review by ADAC management (in accordance with ADAC's Annual management plan). These metrics will include:

1. Project progress measures:
    a. Is the project on time, based on the schedule set forth in the detailed work plan established between ADAC, the Core Team and Project Investigator?
    b. Is the project at, or under, cost based on the budget established by ADAC and Project Investigator?
    c. Are resources (e.g., references, workshop/working group participants) being gathered/recruited in sufficient numbers for the project tasks?
    d. Is the scope of the project adequate or does it need to change to meet unforeseen components oriented on current and emerging maritime communications suitable for Alaskan and U.S. Arctic maritime regions?
    e. Is the quality of the project products acceptable to the Project Champion/Core Team/ADAC? Are the products useful to USCG maritime operators?
2. Scientific/technical measures:
    a. Does literature review or market survey highlight unanticipated discoveries in emerging communication technical advances that may benefit the Alaskan and U.S. Arctic mariner community? Do these discoveries indicate an opportunity to address U.S. Federal mariner carriage regulations in a future context?
    b. Does community engagement provide unanticipated discoveries in how mariners are individually accomplishing communications to reduce their operational risk in event of an emergency at sea?
    c. Does survey questionnaire provide unanticipated insight to specific regional maritime communication/connectivity challenges?
    d. Does community engagement highlight a previously unknown problem or challenge to communications/connectivity that impacts safety of life at sea in one or more planned research region?
    e. Does research discover a previously unknown mariner "best practice" in achieving maritime communications and connectivity suitable for promulgation?
    f. Does research discover a resilient communications/connectivity recommendation that warrants consideration for a change to U.S. Federal mariner carriage requirements?
    g. Does research discover a Canadian technology, mariner practice or recommendation potentially suitable to promulgate to Alaskan and U.S. Arctic mariner communities?
    h. Evaluation of methods for literature review and information gathering:

i. Has an appropriate search strategy been developed and executed to identify source documents, artifacts, and individuals to consult in the course of this study?
ii. Have the data gathered during the course of the study been interpreted and organized using a systematic taxonomy, data fields or framework?
iii. How systematic is the overall approach and execution of the study?

i. Validation of data and recommendations:
i. How complete is the set of documents, artifacts and individuals that were consulted in the study?
ii. Is the data gathered in the study accurate, as assessed by the third-party independent reviewers, or by consulting additional sources?
iii. Are the recommendations' objective, and supported by the data gathered in the study?

Outcomes/Outputs.

The principal outcome of the project will be a comprehensive assessment and public document on the approaches to, and solutions for, addressing Alaskan and U.S. Arctic region communications and connectivity shortfalls and gaps. The long-term goal is to establish a credible and useable technical knowledge framework to support the rising and essential needs of connectivity and communications in the Alaskan and U.S. Arctic regions, delivering a useable product for the maritime community to leverage in making decisions on communications. The timing and need for such a product are well aligned to support the development of new USCG Alaskan and U.S. Arctic Security Cutters and other maritime community needs in the future. The final project is anticipated to meet at least TRL-3 threshold requirements.

The final knowledge product will be a comprehensive report containing:

1. A list of the needs/questions related to Alaskan and U.S. Arctic communications and connectivity that should be addressed to support the non-military maritime community identified tasks and needs.
2. A geographic review of the Alaskan and U.S. Arctic regions in terms of communications/connectivity shortfalls (focused on Alaskan and U.S. Arctic EEZs). Currently, there are a number of variances in connectivity in the high latitudes, the proposed study would assess these variances in forming a baseline of connectivity challenges and gaps.
3. A technology-focused review of known/understood existing communications and connectivity capabilities, assessed against researched gaps for the high latitudes.
4. An expert derived set of options and recommendations via a framework oriented to a Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel and Facilities (DOTMLPF) set of categories in addition to the final knowledge product. Again, this effort is oriented to non-military mariners.
5. The Project Investigators will draft a corresponding peer-review journal article.
6. In consultation with the Project Champion, ADAC will correspondingly post all information related to this research to the ADAC website at: https://arcticdomainawarenesscenter.org/.

Transition Plan.

The Comprehensive Research Report and corresponding peer-review journal article will be promulgated to the Arctic maritime community and across USCG in accordance with HQ USCG Project Champion desires. The knowledge gained from this project will be directly transferable to HQ USCG CG 5PW, CG7 and CG926, in which the project team will seek to be represented on the project Core Team. In accordance with direction from HQ USCG Project Champion, ADAC will also inquire as to suitability of completed knowledge product to potentially support Arctic communications developer as part of the Center's efforts to connect research activities and outcomes to commercial entities. This includes meetings with industry as described in the overall center management activities, and in particular, ADAC's Program Year 7 planned Strengthening Partners in Arctic Industry (SPAI) Symposium. Important to emphasize, the knowledge product and supporting information gained via the planned investigations will support information needs of the U.S. Coast Guard, the State of Alaska, the mariner community of Alaska and the U.S. Arctic region and potentially be of use to Canadian participants.

Potential Programmatic Risks to Completion.
The project team assesses overall risks to project completion as low. The project team is very familiar with the project methodology and is well acquainted across the USCG and has well established connections across the U.S. Federal government, industry and academic disciplines, all of whom are planned as prime contributors and coordinators within the planned project. The product produced from the research is a knowledge document, which is a relatively simple approach to successfully conclude the research endeavor.

THEME 3 – Maritime Technology Research:

1. Propeller Driven Long Range Autonomous Underwater Vehicle (LRAUV) for Under-Ice Mapping of Oil Spills and Environmental Hazards.
2. Arctic-focused Incidents of National Significance (Arctic IoNS) workshop.
3. Arctic-related Medium and Long Term (Arctic MaLTE) workshop.

PROJECT: Development of Propeller Driven Long Range Autonomous Underwater Vehicle (LRAUV) System for Under-Ice Mapping of Oil Spills and Environmental Hazards

Project Investigators: Amy Kukulya (WHOI), Brett Hobson (MBARI) and Dr. James Bellingham (WHOI)

Supporting Team:

Noa Yoder (WHOI)
Amanda Besaw (WHOI)
Ryan Govostes (WHOI)
Steven Seeberger (WHOI)
Daniel Gomez-Ibanez (WHOI)

Brian Kieft (MBARI)
Ben Raanan (MBARI

Lead Institutions: Woods Hole Oceanographic Institution (WHOI) and Monterey Bay Aquarium Research Institution (MBARI)

Project Champion: CAPT Kirsten Trego, HQ USCG/MER

Project Description:

Abstract.
The Propeller Driven LRAUV System is designed as a helicopter-portable platform, with corresponding communications buoys and which functions as a multi-mission capable system. Through designing, fabricating and testing two platforms, two sets of sensing capabilities and three communication and navigation buoys, the LRAUV project team will provide a suitable deployment package to support USCG-led Arctic oil spill response. In sum, the ADAC LRAUV project, led by WHOI and MBARI, creates a rapid response solution to incidents occurring in the maritime environment, and increases situational awareness by characterizing the undersea and under ice conditions of ocean surroundings, autonomously, and capable at great distances from first responders in an Arctic maritime crisis.

Increasing level of commercial marine activity in high latitudes creates an ever-growing risk of oil spills in ice laden waters. Characterizing oil spills in remote and austere Arctic locations is a daunting challenge to the U.S. Coast Guard. Through 7 years of focused research and engineering, the LRAUV team at WHOI and MBARI have taken the original baseline Tethys Long-Range Autonomous Underwater Vehicle (LRAUV), through a significant re-design effort, and have developed and fabricated a specialized easily portable long-range Arctic-capable Tethys platform equipped with oil sensors, new software and navigation and communication systems.

Through these seven years of investigations, in addition to creating (1) LRAUV, the project team has (2) provided demonstrations of the LRAUV survey capability, (3) created a simulator for establishing Standard Operating Procedures (SOP) related to AUV oil spill deployments, (4) designed and created three communications and navigation agnostic Arctic buoys, (5) designed and fabricated exchangeable nose sections with communications and homing capabilities and a mechanical retrieval and docking capability for ease of shipborne handling and recovery, (6) completed a review of a reduced cost design for USCG leveraging additive manufacturing; (7) demonstrated LRAUV system in extensive open water tests in real world oil seeps in Santa Barbara Channel California and (8) tested LRAUV in fresh water under ice in northern New England.

In ADAC Program Year 8, the LRAUV System team's research agenda is focused on fabrication tasks associated with completing the second platform, Stella, develop additional software for improved operator-system interface, conduct investigations of fine detail testing to ensure the platform and communication systems perform in accordance with technical specifications, develop and prosecute expanded under-ice tests to evaluate LRAUV System's performance in the full range of envisioned spill response missions in an ice-laden environment. If an opportunity arises, the team will be ready to test in later program YR8 or YR9 high latitude tests to evaluate critical navigation systems that can only be practically evaluated in an Arctic setting. The research agenda also includes advancing navigation capabilities with the buoy system, conducting helicopter launches with local USCG

Jayhawk vehicles located at USCG Air Station Cape Code in Woods Hole, completing multi-mission mapping and inertial navigation integration and testing, over-the-horizon mission readiness, backseat CPU autonomy completion, producing testing documentation, transition and familiarization to USCG personnel in LRAUV System operations in accordance Project Champion direction.

Specifically, in the coming program year, the LRAUV System team plans to conduct under-ice readiness tests as winter weather conditions permit in New England that meet the requirements for depth, ice and vastness for a full system test, complete the fabrication of a second vehicle (Stella), complete integration of a multibeam sonar sensing capability and inertial navigation system and conduct extensive testing, to include under ice evaluations as a follow-up to tests conducted in Program Year 7. Additionally, the team will fully test improved oil plume mapping algorithms in a simulated real-world environment. The team will work to develop user friendly software interfaces and 'hooks' as well as a 'backseat' capability for autonomy software development needed for new mission behaviors and future sensor integration. The team will also work towards implementing a software simulator in order to be able to 'simulate' missions of LRAUV using the entirety of the system payload as well as real world environmental models (currently underway at MBARI with internal funding).

In follow-up to the successful design and engineering accomplishments of the project, in the coming project year, ADAC and the LRAUV project team will continue an additional research and engineering program to (1) advance collaboration and partnering with the HQ USCG Project Champion designated USCG designated POCs in operating and testing the platform, (2) seek to further reduced cost fabrication by constructing an additional LRAUV (spanned over Program Years (6-8), (3) conduct marine and as New England conditions permit, under-ice tests, (4) complete design and fabricate an additional sensor capability to LRAUV in order to create a multi-mission capable LRAUV.

In Program Year 8, the project team will conduct familiarization training with Coast Guard personnel on how to operate the platform with a dedicated session conducted at Woods Hole MA.

Beyond Program Year 8, the project team is planning (as the culmination tests), high latitude tests in the Arctic region (targeting July 2022). Two options are under consideration, at Point Barrow Alaska and at Thule Air Base Greenland. Via ADAC's established partnership with the Office of Naval Research's International Cooperative Engagement Program for Polar Research (ICE-PPR), ADAC is organizing and seeking logistical support from ONR to accomplish these tests. Planning these tests represent a specific and determined task in ADAC Program Year 8. During the high latitude tests, the project team will conduct dedicated familiarization with participating USCG personnel.

By project conclusion, ADAC and LRAUV project team will have provided USCG a state-of-the-art capability in long range Arctic oil spill detection and characterization via an easily deployable package, advanced Project Champion designated USCG POC AUV competency, created additional LRAUV mission capability to add multiple facets of marine environmental characterization, and conducted sufficient platform testing under-ice and in high-latitude conditions to ensure USCG is provided a suitably evaluated LRAUV System that is Arctic ready.

In parallel to technical development to deliver the LRAUV System to support USCG, ADAC and research team will continue to conduct investigations for commercialization of the system with

industry. Specifically, ADAC and the project team are working with DHS S&T contracted support to realize a commercialization following the completion of research.

Objective/Purpose.

Complete an eighth year of investigations in research and engineering on the LRAUV System to provide DHS S&T and USCG a world class system for high latitude and under-ice spill response and marine environment characterization. Accordingly, the WHOI and MBARI team will advance LRAUV capability for DHS S&T OUP and USCG through additional research and technical development program to (1) advance HQ USCG Project Champion designated USCG technical abilities in operating and testing the platform, (2) seek to further reduced cost fabrication by constructing an additional LRAUV (spanned over Program Years 6-8), (3) conduct Arctic tests or Arctic-like tests in the Great Lakes or Great Slave Lake or equivalent (4) complete integration and testing of an additional sensor capability to LRAUV in order to create a multi-mission capable LRAUV, and (5) create a knowledge product outlining various scenarios and approaches to conduct an LRAUV deployment, and (6) further mature software capabilities including autonomy and simulation devices. In parallel to technical development to deliver the LRAUV System to support USCG, ADAC and research team will conduct investigations for commercialization of the System with industry, this includes specific showcasing ADAC's planned event to host Alaskan and Arctic maritime industry leaders, response organizations, Oil Spill Response Organizations (OSROs), maritime shippers, Arctic cruise industries, first responders, Arctic oriented non-profit groups, State of Alaska and U.S. Federal departments and agencies and National Laboratories in a two day Symposium designed to increase visibility of a variety of Arctic Domain Awareness technologies, to include ADAC research endeavors, seeking to strengthen connections, collaboration and partnering between these communities, and to explore or initiate commercial transition pathways for ADAC completed/completing research.

Baseline.

MBARI originally created the Tethys platform specifically to carry biological and chemical payloads for long distances and extended durations. The vehicle is small, about 30 cm (12 inches) in diameter, and typically requires no special handling equipment. Prior deployments ranged from a few days to over three weeks and were conducted without the direct supervision of surface escort vehicles. The longest-range mission to date was over 1,800 km at a speed of 1.25 meter/second (m/s) off the coast of Moss Landing, California. The vehicle operated as far as 500 km from shore independent of any escort. However, achieving ranges two to three times greater is possible. Maximizing the vehicle range is achievable by operating at a speed of 0.5 m/s, using the buoyancy engine, shifting internal weight, trimming the vehicle to neutral buoyancy, and drifting at zero propeller speed while using minimal sensors.

The LRAUV is suitable to shore-launch (whether on land or on ice pack) and recovery. A small boat can be used to tow the vehicle between a harbor entrances or the vehicle can swim itself from shore without the need of a vessel as shown during the Santa Barbara field trials in 2019. LRAUV is also deemed helicopter transportable to remote areas and the team is currently pursuing options to test launch and recovery of the platform in YR7. The fabricated vehicle is approximately 230 lbs. and is possible to be carried by 2-3 personnel for short distances. LRAUV can operate in shallow (2 meters) to continental shelf range depths (300 Meters). The baselines Tethys system occupies the design space intermediate between underwater ocean gliders and the current generation of propeller driven

AUVs such as the commercialized REMUS family of AUVs developed at WHOI. Existing ocean gliders (propeller-less) such as the Teledyne Webb Slocum, the Scripps Spray, and Kongsberg Sea glider have a sufficient operational range to achieve the desired range goals needed by USCG. However, they do not have the payload capacity or power to carry the chemical and biological and mapping sensors that are required and cannot operate at higher speeds without redesign. Typical gliders operate at speeds of about 0.3 m/s and utilize a power source equivalent to 1W of energy with minimal power consumption.

In contrast, existing propeller driven AUVs such as those manufactured by Hydroid, Bluefin, OceanServer, and Teledyne Gavia consume significantly more power, resulting in a shorter endurance. These commercial propeller-driven systems can operate for a period typically up to 24 hours at speed of 1.5 m/s, and providing ranges of less than 130 km. These AUV's, such as the REMUS-600, can extend their 24-hour range by greatly increasing the size and weight by adding additional battery packs and achieving 3-4-day ranges. As a result, LRAUV is uniquely capable in its combination of payload capacity, range, and endurance for remote under-ice oil detection.

Mission-level control of the LRAUV is achieved by using an architecture called 'state-configured layered-control'. This is an improved variant of the layered control architecture developed by Dr. Bellingham (1991) and implemented on vehicles ranging from Webb gliders to the Dorado AUVs (the first asset deployed during Deep Water Horizon). State-configured layered control supports autonomous adaptive operations for long periods. The software building blocks of the system are behaviors, or control laws, that can be combined to accomplish tasks. These control laws are conditionally connected to the AUV to complete missions that are more complex or respond to certain contingencies. For example, vehicle software is able to detect faults in critical components and respond appropriately, greatly improving the reliability of the AUV. In some cases, through configuration changes, the Tethys may continue a mission after a component failure. For example, depth control of the submersible is a redundant system. If the elevator actuator fails, the vehicle can continue to control depth by shifting internal weight.

Operators interact with the vehicle via an Iridium satellite link in remote areas or via Wi-Fi or cellular in near shore zones by recovering data snippets in near real-time and sending new mission commands to the vehicle as desired. Communication with the vehicle is possible when it surfaces and interpreted at operator-determined intervals. As part of the LRAUV ADAC program, LRAUV can now remain submersed and communicate acoustically to a network of gateway buoys. The radio relay is similar to what exists on LRAUV and consists of RF, Iridium, WIFI and cellular.

More than ten years of development of a web-based operator portal for the LRAUV has been developed[13], which includes a display of science and engineering data. This portal, known as the Dash, is available via MBARI's networked infrastructure and is now also available within WHOI enabling reliable backup from either portal to command control (LRAUV.WHOI.EDU). On a secure portion of the site[14] users can access a command interface and a variety of utilities, such as an alert

page that operators can configure to send mission data via email or mobile phones based upon certain criteria. Prior research has established a design, created operating and navigation software, investigated the range of capabilities associated with critical components, implemented a systems integration plan, and conducted successful field-tests to validate research. The Dash also contains a map for easy tracking of where the vehicle has surveyed. Forward-facing data is publicly available on the web.

Completed research to date provided a suitable design for platform fabricators to construct an LRAUV platform to meet stated parameters in navigation, mission performance, and operator ease of use. Subsequent activities resulted in full fabrication of the LRAUV engineered design with a second platform underway.

In addition to a completed fabrication and integration of the Arctic/oil science payload, project team has provided a completed augmented AUV simulator and test scenarios addressing high-risk elements, including navigation and sensing systems, demonstrating oil-spill following capabilities in Alaskan waters. The completed LRAUV operator simulator (with sea ice geographically situated in Alaska's Cook Inlet), integrates software-modelling code from ADAC's Arctic Oil Spill model (to include oil plume modeling). This simulator is a baseline tool for research and development task to support orientation, training and mission rehearsal for LRAUV operators.

LRAUV has undergone ocean field trials to verify that top-level systems, as well as science sensors contained in the platform nose section: (Seaowl Ecopuck, CTD (Conductivity, Temperature & Depth), PAR (Photosynthetic Active Radiation (Light)), Optode (optical measurement), and up/down ADCP's (Acoustic Doppler Current Profiler)) and have been found fully functioning in accordance with planned parameters. LRAUV now has three nose sections. The small nose contains all of the sensors listed above. The second 'large' nose contains the same sensors but with the added DUSBL (homing array) and dynamic docking (whisker box) system. The medium sized nose contains the multibeam system along with the small nose sensor configuration.

AUV navigation crucial system usefulness to USCG led decisions. LRAUV has multiple modes of navigation to mitigate complex environmental conditions and changing scenarios to include:

1. A GPS system built into the Tethys antenna will routinely obtain GPS fixes when the vehicle surfaces. The WHOI team redesigned the MBARI antenna to be more robust and it now has two configurations, one for under-ice and one for open-ocean along with white LEDs instead of red which conflicted with aids to navigation; If surfacing is not possible Arctic buoys can provide ground-truthing via acoustics.
2. The vehicle will dead-reckon using a Doppler sonar to measure velocity relative to the bottom, and a compass for heading; The team at MBARI is working on upward looking ice tracking and navigation capabilities that can be built on and tested in future under-ice operations.
3. An Ultra-Short-Baseline (USBL) acoustic system will measure range and direction to a transponder/buoy acoustically for docking and marking interesting sites for revisit by the vehicle.

4. Long Base Line (LBL) navigation with two or more buoy transponder systems for aided navigation allowing for triangulated fixes for accurate navigation and mapping missions.

In order to complete an Arctic capable oil spill deployment package, project team designed and constructed Arctic Communication buoys, oriented to an "agnostic" communications design allowing for other industry AUV's such as REMUS to be able to share this capability. These communication buoys include long baseline (LBL) and ultrashort baseline (USBL) systems, ACOMMS, Wi-Fi, RF, Iridium, and future thermistor capability. LBL allows for long range (up to 10 Km per buoy using traditional low frequency acoustics at 10 kHz), while USBL allows for short range (<500 meters, but often exceeding 1 Km) homing and docking for recovery under ice or in open water. The project team is currently working on improving the USBL by leveraging Navy program development in 360-degree hydrophone array technology. This technology has enabled ranges in excess of 1 km and can 'see' the dock from all directions. The buoy system will also allow for data transfer from the LRAUV back to Command Control Center via Iridium for over the horizon communications. In order to transfer data in a format that can be visualized by the receiving party, a software compression is included in the buoy development. These buoys are critical to enable LRAUV to operate as a "system" to effect characterization and communication of an Arctic oil spill, under sea ice, to USCG led unified command.

Advancing LRAUV further, project team designed, implemented and conducted initial testing of a platform WHOI micromodem known as "umodem" to include advanced navigation capabilities inclusive of LBL and USBL systems and 32-byte data packets.

The umodem team at WHOI developed new firmware to allow the buoys to be used as transponders. In sum, umodem, USBL and the whisker capture box are new hardware and software capabilities provided to LRAUV to assist with under ice navigation and docking, but also provide a useful capability for launch and recovery in high seas when it is not possible to approach the vehicle in close ranges.

Additionally, when Autonomous Underwater Vehicles (AUVs) are strategically equipped with multiple sensor technologies, including cameras and sonar, they are capable of remote detection and analysis of oil under sea ice. This approach is known as search, map and classification.

Test data illustrates that AUV's remain the most mature tool for the search, map, and classification procedures routinely performed in seafloor analysis and similar methodology can be effectively applied to under-ice anomaly detection. Beyond the need for rapid detection of oil and gas in the Arctic, based on discussions and conclusions from several Center-led workshops, ADAC and the LRAUV project team notes the important utility for small AUV platforms with a variable endurance range of hours to weeks capable of mapping the seafloor for the purpose of bathymetric surveys and anomaly detection to include leaking pipelines and infrastructure.

The project team's investigations have determined, multibeam sonars are capable of providing a high-resolution swath map with precise readings of hard structure as well as water column oil and gas detections (see figures below). Multibeam sonars are well suited as systems for mapping the seafloor or underside of ice. Accordingly, in order to create a multi-mission capability to LRAUV, the project team PI's, will complete integration of the multibeam sonar system for use on portable AUVs.

The WHOI and MBARI team conducted extensive oil seeps experiments in the Santa Barbara channel in Southern California over two phases in the summer of 2019. The first effort was with the LRAUV System in collaboration with scientist's form NOAA and EPA (for science verification, calibration and overall science expertise) on an array of tests conducted over a 13-day period to work in naturally occurring oil seeps in open ocean to evaluate LRAUV in oiled and non-oiled areas in order to test detection, mapping and fouling questions.

Prior to these open water tests, LRAUV System's SeaOWL sensor was successfully calibrated in the lab and baseline signals were captured which determined needed parameters for anomaly spikes (of suspended oil droplets) to trigger an 'autonomy mapping' mission. These initial tests of mission for sensing actual oil in open water included different mission scenarios such as: a.) finding the source, b.) mapping out the extent of the plume and, c.) finding out where there is no signal of oil in the entire water column for 0 to 300 meters (or max depth of operating area up to 300 meters). Additionally, following the fabrication of an Arctic buoy communication system, the new buoys were deployed in local Cape Cod waters where researchers conducted a successful dye tracking mission, which included deployment in a pattern to maximize vehicle navigation, vehicle docking and vehicle communication back to command control. Researchers successfully tested acoustic communication ranges, data transfer and percentage of vehicle docking tries via USBL (using Remus-100 as a surrogate, as LRAUV was retained in California for testing as described previously). Researchers successfully received navigation fixes from each buoy back to the LRAUV at approximately 10 Km away (noting that environmental conditions fluctuate and can impact sound range).

Subsequent tests were conducted in August 2019 in Santa Barbara on the LRAUV platform as collaborative exercises to simulate rapid response to an oil spill and included a team from EPA, NOAA, USCG participating aboard the USCG buoy tender, CG-175 *George Cobb*. LRAUV's role in the collaborative exercise was to use its long-term operational capability to map the seeps area to detect areas of high and low oil concentrations using its onboard mapping software quickly and efficiently and SeaOwl sensor. The LRAUV platform was deployed from a pier and conducted around the clock surveys for six days operating around the clock informing the team aboard the Cobb and shore side where to survey each day during their response exercise saving time and valuable resources.

During these tests, researchers deployed LRAUV from shore, without a vessel using a pier-side fish crane. Using an IPAD, researchers sent the vehicle on a preliminary search mission to map out areas known to be near source points. The goal was to do a broad search of the area by conducting platform "yo-yos" from 1 meter to 35 meters looking for elevated detections from the SeaOwl while creating an apriority map. Meanwhile, the team readied the two REMUS AUV's and loaded out the USCG George Cobb each day for field operations. LRAUV was monitored from shore and data was passed via either a web-based portal or via cellphone. The team aboard the USCG tender George Cobb, deployed the Arctic Gateway Buoy which was to be used as the data relay for LRAUV back to command control (shore-side). LRAUV was able to reliably test its systems while informing command and first responders of where oil was and was not therefore saving people, ship and vehicle time while deploying other oil spill response kit and freeing the ship up. The researcher team has conducted a full system evaluation, inclusive of auxiliary gear and buoys, in order to review low-cost manufacturing and design improvements for Build-2 and future builds.

LRAUV System researchers have implemented PDM tools consisting of Autodesk Vault and WHOI Roundabout for tracking current and future inventory and allowing time and cost savings for Build-2

ordering and manufacturing. Autodesk Vault enables revision control on drawings and documentation related to the build. With these tools in place, WHOI researchers have all mechanical drawings as well as ordering information for the entire LRAUV platform. Build instructions will be created to augment what MBARI currently has available. The LRAUV team has conducted initial testing under ice in a freshwater lake near Northfield Maine in the winter of 2020, where the system performed in accordance with design parameters. However, key lessons in tactical operations where learned, such as docking and undocking to the Arctic communications buoys that are driving software modifications to the LRAUV operational controls for the platform and the under-ice cable hardware of the Arctic Buoy that will be completed in subsequent research.

Methodology.

The research team consists of a task-oriented team of expert oceanographic mechanical, software and electrical engineers and operators to advance further capability in the creation of a readily deployable, easily handled, variable speed, and long range AUV capable of detecting and mapping oil spills under ice and in open water. The team leverages prior investments in AUV research and oil sensor technology, and under-ice operations. The research method planned for Program Year 8 includes five pillars of coordinated activities. 1) Technical development, 2) local testing in Woods Hole MA and New England, 3) added multi-mission capability and testing 4) documentation of engineering designs and tests, 5) Systems familiarization for the HQ USCG Program Champion designated USCG POCs.

A critical component of ADAC Program Year 8 LRAUV System research method is to leverage mechanical and electrical engineering advances made over the past 7 years to complete technical development of the second LRAUV platform, synchronize development specifications in platform hardware and software, incorporating testing data from open water and under ice to finalize the development of two platforms and three Arctic communication buoys. In addition to these advances of engineering and technical development, LRAUV System team will conduct advanced tests under ice with an optional high latitudes test (if funding is made available) to evaluate and validate LRAUV System capabilities in sensors, navigation, and chemical mapping, while advancing reduced cost manufacture and working with the HQ USCG Project Champion designated transition USCG office to implement an ADAC, MBARI, & WHOI developed LRAUV Systems concepts of application document developed in Program Year 6 and 7.

The ADAC LRAUV project is entering the critical push to finish carry forward activities from Year 7 that have taken longer than anticipated to complete due to COVID19 concerns as well as Year 8 tasks to ready LRAUV as a system fully capable for follow-on tests beyond Year 8. At the completion of Year 8, LRAUV System will be ready to conduct a follow-on Arctic demonstration of the full suite of capabilities required for oil spill response. Since this project has a series of 'Arctic firsts,' the effort is structured in a "***test-evaluate-address***" cycle. Field programs are intended to push the envelope of discrete capabilities (logistics, homing, docking, navigation, sensing, software etc.) to identify strategies for improving system performance and reliability. In parallel with this evolution, the hand-off of LRAUV operations from MBARI to WHOI is laying the groundwork for the goal in providing USCG an available technical support entity capability to provide USCG on-call support as USCG determines suitable for LRAUV as an operational system in open ocean, freshwater bodies and under-ice.

In ADAC Program Year 6, researchers conducted the first under-ice operations at Bog Lake, Maine. Follow-up activity to the tests falls roughly into two categories – basic functionality that needs improvement, and system-level lessons that could generate significant rework. Examples of the former from the most recent tests include improving performance of the docking latch and undocking behavior. An example of the latter is improving ice-buoy endurance as well as a reverse thrust capability for undocking. Research philosophy is to learn all the lessons associated with Arctic tests, making only essential fixes, before making significant system level modifications. Investigative team expectation is that these accumulated lessons, including many not learned yet, will be addressed in a round of transition engineering activity later in the program year. The alternative, making significant upgrades while researchers are still working though Arctic capabilities introduces significant additional testing costs (to test the systems that have been upgraded) and schedule risk.

Early efforts in Program Year 8 will focus on fabrication of the second platform and fine detail tests in follow-up from Year 7 open water and Year 6 under ice tests. LRAUV high latitude tests originally planned for Point Barrow Alaska in July 2020 have been delayed due to Coronavirus/COVID-19 related travel restrictions to North Slope Alaska and the limitations of current funding in ADAC Program Year 8. Accordingly, ADAC and LRAUV Project Leadership have prioritized available funding to finish fabrication and component level evaluations to ensure LRAUV can and will perform to specifications.

With the right weather conditions, localized testing under ice in New England near Woods Hole, may be feasible in ADAC Year 8, and if conditions permit, ADAC and the LRAUV project team will seek to accomplish such testing as efficiently as possible.

In Program Year 8, the project team will conduct familiarization training with Coast Guard personnel on how to operate the platform with a dedicated session conducted at Woods Hole MA.

Beyond Program Year 8, the project team is planning (as the culmination tests), high latitude tests in the Arctic region (targeting July 2022). Two options are under consideration, at Point Barrow Alaska and at Thule Air Base Greenland. Via ADAC's established partnership with the Office of Naval Research's International Cooperative Engagement Program for Polar Research (ICE-PPR), ADAC is organizing and seeking logistical support from ONR to accomplish these tests. Planning these tests represent a specific and determined task in ADAC Program Year 8. During the high latitude tests, the project team will conduct dedicated familiarization with participating USCG personnel.

The one exception to the 'no major upgrades' philosophy of LRAUV System research and development is a series of investments needed to make the software more supportable and usable, or 'user-friendly'. The current code is very 'tight' in the sense that the combination of complex code running on a power efficient, minimalist processor, make code modification an expert only activity. MBARI and WHOI has made a major step forward in opening the code by introducing an additional processor to the platform known as "backstreet driver."

This is a strategy used at WHOI, as a similar strategy was successfully used to make the REMUS vehicles more readily adaptable to new capabilities as part of aquaculture and oil detection surveys. In Program Year 8, the research team has programmed code activities to introduce the

necessary software “hooks” (dedicated points of integration) in order to make the “back-seat driver” functional, and to create a simulator that will allow testing of vehicle software on shore. Investigators believe the simulation activity will ultimately be extremely useful for the USCG, and consequently have budgeted some experimentation with the use of video game development environments (Unity or Unreal Engine) to support non-programmer interaction with the simulator.

As part of transition activities, research team will provide a compilation of LRAUV System test reports which includes data, data analysis, and results separate from Year 8 program reporting.

Unless otherwise specified, ADAC and LRAUV System team will plan on HQ USCG Project Champion as the overall Test Plan approval authority. In order to facilitate USCG familiarization and participation in any LRAUV System tests conducted in Program Year 8, LRAUV System team will provide a test plan that aligns to USCG test protocols for USCG review and feedback.

In accordance with the planned research method for technical development and testing for LRAUV System in ADAC Program Year 8 includes:

- Completing Long-BaseLine (LBL) navigation software and test in Woods Hole waters on Polaris, (LRAUV-platform #1) with two gateway buoys and the third used as a USBL dock.
    - LBL can be configured to be HF (25 kHz) or LF (10 kHz) prior to deployment.
    - LBL navigation will allow LRAUV to improve its navigation capability to help ‘pinpoint’ targets in the water column as well as under-ice and on the seafloor. For example, LBL capability will allow the new sonar payload to create accurate ‘maps.’ This type of navigation is known as triangulation.
    - Conduct further Intuaware software development for vehicle-side LBL and ACOMMS (acoustic communications (data transfer).
    - Establish WHOI software engineer support (through familiarization in source code with MBARI) for, integrating new sensors and creating the onshore simulation.
- Conducting open water test sonar payload and mapping tool capability using LBL and off-the-shelf mapping tools.
- Finalizing a second docking nose and DUSBL system with long nose configuration to match Polaris.
- Finishing LRAUV Platform #2 fabrication, configure and bench test.
- Conducting the following tests and systems evaluations. Note, this activity will be conducted via Prior coordinated/reviewed Test Plan with USCG as discussed above.
    - Conduct open water testing and training of systems (ADAC, MBARI, WHOI & USCG).
- Participating in project meetings and project management, oversight, training.
- Developing ROS and simulator interface.
- Provide familiarization training with Coast Guard personnel on how to operate the platform with a dedicated training session conducted at Woods Hole MA.
- Planning and gaining resources for high latitude tests in the Arctic region (targeting July 2022). Two options are under consideration, at Point Barrow Alaska and at Thule Air Base Greenland.
- Developing and providing USCG the LRAUV system users guide.
- Coordinate and advance commercialization activities with DHS S&T contracted commercialization experts.

In order to achieve the above planned research methods for technical development and testing for LRAUV System in ADAC Program Year 8, the investigation team will organize activities between the following task frameworks:

Task 1: Familiarization and Fabrication. Project team will advance the USCG familiarization designated POCs (as determined by the HQ USCG Project Champion in operating and testing the platform. In parallel with USCG familiarization, Project team, led by WHOI investigators at Woods Hole, MA, will complete vehicle design modifications and fabrication of a second LRAUV platform. Details include:

- Completing AUV technical design and assembly documentation.
- Fabricating second docking nose assembly for LRAUV-2.
- Developing simulator and backseat software. Note: Simulator is accomplished by MBARI and backseat software by WHOI.
- Conduct open water testing and system verification in the waters locally at Woods Hole MA.
- Provide familiarization training with Coast Guard personnel on how to operate the platform with a dedicated training session conducted at Woods Hole MA.

Task 2: Conducting localized tests in the vicinity of Woods Hole MA. As discussed, due to current levels of Program Year 8 funding, ADAC leadership and Project Team have prioritized funding for testing to the following:

- Open water testing and validation of systems sensors, to include the following:
    - Ability to map in 3D.
    - Detecting and quantifying dissolved particles in the water column.
    - Determining specific characterize the physical ocean environment (and determine acute/critical variables, such as assessing hypoxia of the water column in/near spill area).
    - Taking Conductivity, Temperature, and Depth (CTD) measurements.
    - Calibrating LRAUV's SeaOWL sensors in the lab for baseline signals to determine/ allow for anomaly spikes to trigger an 'autonomy mapping' mission. Different mission scenarios will be outlined and tested including a.) finding the source, b.) mapping out the extent of the plume and, c.) broad-scale surveys to find where there is no signal of oil in the entire water column for 0 to 300 meters (or max depth of operating area up to 300 meters).
    - Creating mission macros once testing missions are complete, so the operator can quickly decide the type of mission to run prior to launch. The vehicle simulator will be a valuable tool for running planned missions with simulated currents, etc. based on available environmental data from the test area.

- Conducting Arctic buoy tests in local Cape Cod waters for follow-on to Program Year 6 plume tracking mission. The 3 buoys will be deployed in a pattern to maximize vehicle navigation, vehicle docking and vehicle communication back to command control simulating tests in the Arctic. Investigators will further test acoustic communication range; data transfer success and percentage of vehicle docking tries via USBL. Researchers expect to receive navigation fixes from each buoy back to the LRAUV up to 10 Km away using low frequency (environmental conditions fluctuate and can impact sound range.

Task 3 Sensor testing and integration: The research team will advance Sonar sensor capability development to LRAUV started in Program Year 6 to create a multi-mission capable LRAUV, completing the task in Program Year 8. This includes conducting additional fabrication to support integration of new sensor to existing LRAUV as well as provide additional fabrication/technical support to complement a separate supplemental workplan which will create a second LRAUV platform. The following details these planned investigative activities:

- Develop backseat sonar and INS capability. The sonar planned for LRAUV System is newer, less expensive and less power-hungry and offer a valuable solution for integration Multibeam sonars are versatile, allowing for a multitude of underwater applications, including pipeline inspection, creating high resolution bathymetric maps as well as detection capabilities of oil and gas. However, to date no group has demonstrated operational viability in an under-ice setting of an AUV system equipped with these or any other sensors. In order to demonstrate operational viability, researchers contend that an AUV system, the logistics of deploying it, and the accompanying data processing and visualization pipeline must be sufficiently mature and rapid to permit integration with existing, community standard oil-response tools. To this end, researchers plan to integrate and implement an onboard 'back seat' autonomy computer.

  - New technology multibeam sonar systems are more compact and energy efficient, making it possible to integrate on small vehicles like the LRAUV. In addition to the vehicle platform and sensor technology, advancements have been made in onboard image processing and anomaly detection.

  - In the early 2000's REMUS vehicles were capable of detecting man-made targets of interest and sending 32-byte image snapshots acoustically through the water column to be displayed on a laptop saving hours to days of time in data processing and vital decision making (Freitag, et al. 2006). Today, it is possible to take more complex data sets, like multibeam data, and achieve similar near real-time snapshots. Software development is required to achieve this on the LRAUV platform. Future investment in this capability is recommended (beyond what is feasible in ADAC Program Year 8).

  - This activity leverages advances in marine robotics to provide an AUV capability with 3D mapping of seafloor anomalies capable of operating with minimal human oversight. The sonar has the capability to detect oil and gas in oceanic environments, however our goals here are limited to providing a vehicle and sensor capability for collecting 3D sonar data for making maps. Advancing marine robotics to provide an AUV capability with 3D

mapping of seafloor anomalies capable of operating with minimal human oversight the sonar system integration provides a significant advance in understanding and characterizing the undersea environs.

- Accordingly, project team goals here are focused to providing a vehicle and sensor capability for collecting 3D sonar data for making maps. In Project Year 8, the team will have developed the ability to take 'raw' data from the Norbit sonar and pipe it into the open-source software platform, MB Systems, where the widely used SK7 format is widely used across sensors and vehicles.
    - Additional funding will be needed beyond current ADAC Program 8 funding levels for data visualization of the sonar, i.e., making clean maps, (beyond integration tasks to ensure the sonar is collecting clean data and outputting it into the processing tools in MB Systems). Funding such refinements could readily be included as a commercialization activity or under a service agreement activity in support of USCG Maritime Environmental Response.

- Accordingly, the project objectives for integrating a sonar system to LRAUV are broken into the following actions: (1) integration of Norbit multibeam system on LRAUV, (2) tank and open water testing sensors integrated to LRAUV. Within the scope of this project, project team will conduct suitable evaluation of the new sensor on to LRAUV and can build the mechanical framework for integration, (3) demonstrate bottom imaging capability for small area surveys with sufficient navigation accuracy to using the newly integrated PHINS inertial navigation system, and (4) evaluate applicability of above systems to characterize oil and gas leaks/pools although no funding is earmarked for in water testing in an oil or gas environment. The Project team will look for real-world opportunities to 'rapidly respond' and test the sonar mapping capability and seek funding from ADAC or other government sponsors to support testing exercises.

Task 4: Advance USCG LRAUV System "Concept of Applications" as a transition related activity in support of USCG mission needs, that includes *planning future platform and system tests*. The Project team (in coordination with ADAC leadership and HQ USCG Project Champion and designate POCs) will discuss and plan further systems tests, particularly focused in conducting future testing of the platform under ice and testing in the high latitudes.

Planning future platform and systems tests are highly useful for mission assurance but compete with the challenge posed by on-going COVID19 health restrictions and testing to ensure LRUAV component metrics are completed in the finalized platforms. Accordingly, ADAC will lead efforts to secure funding and conduct planning with the Project Team in to accomplish the following future tests, in coordination with HQ USCG Project Champion:

- Under ice tests: Replicating oil sensor tests from open water evaluations in a graduated approach to testing LRAUV System under-ice. Advancing from February 2020 initial under ice tests to include platform and system handling tests in easy to recover scenarios (such in lake ice conditions) will be the initial steps, followed by more advanced testing dynamics in

longer range scenarios. Subject to weather conditions in winter 2021-2022, there may be an opportunity to conduct localized under ice tests in the vicinity of Woods Hole MA.

- Tests and USCG familiarization in high latitudes. Conducting LRAUV System Testing in high latitudes was postponed due to COVID-19 and the next opportunity to conduct tests are July 2022, which is outside Program Year 8. Originally planned for July 2020 at the Barrow Arctic Research Center, near Point Barrow Alaska (at just over 71 Degrees North), this plan had to be slipped due to State of Alaska and North Slope Borough travel restrictions to prevent spread of Coronavirus/COVID-19 pandemic to potentially vulnerable populations in rural Alaska, particularly Alaska Native villages which suffered incredible losses from the Spanish Flu pandemic of 1918-1919. The principal aspects of these tests are to evaluate LRAUV in the high latitudes and as ice conditions permit, conduct tests in and around Arctic Sea ice. During Year 8, ADAC and the project team will plan and seek resources for testing in the Arctic at one of two options: Point Barrow Alaska or Thule Air Base Greenland. Via ADAC's established partnership with the Office of Naval ICE-PPR, ADAC is organizing and seeking logistical support from ONR to accomplish these tests. During the high latitude tests, the project team will conduct dedicated familiarization with participating USCG personnel.

Project team will continue to advance a scenario-based concept of application for the LRAUV System as a principal transition activity. Specifically, given realistic risks in the Arctic, the research team in coordination with ADAC Center leadership, Project Champion and USCG stakeholders will continue to develop employment concepts provided in how LRAUV, navigation and communications buoys and multiple sensors would be employed as a system, which would inform additional development needs (such as launch/recovery cradles, slings, USCG infrastructure that needs amending etc.) as well as potentially inform transition/future use of capability.

Task 5. Developing and delivering documentation of research, engineering and testing. Project team will provide testing and test-focused expedition reports as developed under DHS S&T OUP funding for this project. This task includes providing USCG a LRAUV System Users guide.

Task 6. Advance commercialization processes for LRAUV System. ADAC and the project team will continue prior year efforts to develop commercialization options for LRAUV System in addition to working with a dedicated DHS S&T commercialization transition team.

Key Milestones:

Overall, LRAUV System work in ADAC Program Year 8 involve the completion of the following five major tasks:
Task 1: Familiarization and Fabrication.
Task 2: Conducting localized tests in the vicinity of Woods Hole MA.
Task 3: Sensor testing and integration.
Task 4: Advance USCG LRAUV System "Concept of Applications" and conduct planning for future platform and system tests.
Task 5. Developing and delivering documentation of research, engineering and testing:
Task 6. Advance commercialization processes for LRAUV System.

In support of these tasks, the research and development goals for LRAUV are:

- Test and demonstrate the LRAUV System's ability to navigate relative to a three-buoy/transponder gateway system using both USBL and LBL. The vehicle will be able to reliable dock and undock itself.
- Complete fabrication and test of the second platform.
- Support USCG Project Champion for USCG LRAUV Concept of Applications, to include planning for future tests and platform advancements.
- Deliver completed products and support materials to HQ USCG Project Champion designated office, and/or prepare to conduct service contract as determined by Project Champion.

Specific schedule and associated milestones are as follows:

1. Complete water testing and documentation of LRAUV vehicle and systems, 15 Jun 2022.
2. Process the data and tune navigation algorithms from the LBL testing missions, 30 Jan 2022.
3. If/as agreed by Project Champion and LRAUV System research team, plan and investigate LRAUV sensor sensitivity originally planned for Year 7 at Cold Regions Research and Engineering Laboratory, approx. 15 Feb 2022.
4. Plan mapping mission using sonar, 28 Feb 2022.
5. Complete fabrication of second LRAUV platform, 1 Nov 2021.
6. Design and initiate fabrication of an additional sensor capability to LRAUV in order to create a multi-mission capable LRAUV, completing the task in Program Year 8 (multibeam).
7. Complete software development of LRAUV data for near real-time visualization 15 Jun 2021.
8. Evaluate Data, make software and hardware adjustments. Perform training to USCG; 30 Jun 2022.
9. Build second capture/USBL docking nose system (30 July 2021).
10. Develop backseat autonomy (WHOI) and SIM capability (MBARI), 30 Mar 2022.
11. Project team will advance the technical competency of HQ USCG Project Champion USCG designated follow-on recipient of LRAUV System. Project team, led by WHOI investigators at Woods Hole, MA, will conduct up to two training sessions. Project team will complete this task via two sessions, the first by 30 Sep 2021 and the second by 30 Jun 2022.
12. Create and provide the comprehensive report not later than 30 Jun 2022.
13. Create and provide a finalized USCG LRAUV Systems Guide not later than 30 June 2022. Initial version of the Guide will be provided to USCG in advance of familiarization training at WHOI.
14. Advance commercialization activities with DHS S&T contracted services team to plan and market LRAUV Systems technologies to commercial developers. These activities will be conducted throughout Year 8.
15. Advance LRAUV Systems services via WHOI as needed for USCG technical support. Establish the coordination mechanism as most suitable to USCG not later than 30 June 2022.
16. Develop a plan and acquire resources to conduct high latitude tests for LRAUV System at either Point Barrow Alaska or Thule Air Base Greenland in July 2022. Finalize plan NLT 30 May 2022.

Key Stakeholder Engagement:

The Project team will continue to engage HQ USCG Project Champion CAPT Trego and her USCG advisors on a frequency basis as determined by the CAPT Trego, but as a minimum the team will seek to conduct monthly teleconferences. Critical coordination is planned with all team members, the PI, and project champion. Key USCG project stakeholders include HQ USCG CG-5PW, CG-926, CG-7 offices, USCG PACAREA and LANTAREA, and USCG D17, D17 Sector Anchorage and USCG R&D

Center. Non-USCG stakeholders include NOAA Office of Response and Restoration, U.S. Department of the Interior, Bureau of Ocean Energy Management and Bureau of Safety and Environmental Enforcement, U.S. Environmental Protection Agency, Oil industry (Exxon Mobil, Shell Oil and American Petroleum Institute).

Project team will participate and be featured in the planned ADAC "Customers and Partners" Roundtable, to inform and receive feedback on project progress. Project team will also participate in maritime oil-spill peer venues as much as practical, while also ensuring close collaboration with USCG Interagency Coordinating Committee on Oil Pollution (ICCOPR) leadership and members, as well as USCG R&D Center and other USCG POCs as designated by the HQ USCG Project Champion to discuss the testing and evaluation reports and technical design documentation.
Investigators plan for the representation of our team at the following ADAC events:

- Meetings with Project Champion.
- Weekly All Hands meeting (Normally Thursdays, 1130-1230 Alaska Time via teleconference).
- Quarterly Reviews and Quarterly Customer's and Partner's Roundtable.
- Annual meeting at HQ USCG, Washington D.C.
- Participate in ADAC coordinated industry and spill response conferences and symposia.

Student Participation.
Currently, there is not a student associated with LRAUV System research and development. In Program Year 5 an ADAC Fellow from Massachusetts Maritime Academy gained hands-on experience with the project. In Program Year 8, ADAC EAM will work with the Project Team to align at least one student Fellow to support program development, even if only via remote means. Research tasks of student work would include drafting technical notes and data analysis from current and prior testing.

Performance Metrics:
Complete fabrication of 2nd LRAUV platform and water test platform to achieve the following parameters in navigation, performance, and operator ease of use with aided navigation from the LBL Arctic Buoy system:

- Navigation performance:
  - Conduct design improvements for Tethys platform to achieve the following drift rate: percentage of distance traveled. Target: < 1.0% with LBL aided navigation.
  - Conduct design improvements for Tethys platform to achieve the following error bounding of navigation drift by ranging from a fixed beacon.

- Performance-specific measures:
  - Modification of Tethys platform in mechanical and electrical engineering to integrate separate oil sensor package to accomplish detection level of oil: measured in terms of minimum sensitivity Target: < 80 ppb.
  - Modification and design improvements for Tethys platform to meet specified AUV range and endurance: Target: 300 km on secondary batteries, twice that on primary.
  - Modification and design improvements for Tethys platform to integrate mapping algorithm for adaptive sampling performance- mapping of spill extent: Target: Area coverage 1000 km2 per vehicle deployment.

- Each Arctic buoy will be able to communicate position data via acoustics up </= 5 Km distance per buoy to undersea vehicle (please note two buoys navigation solutions are needed for a valid fix).
- Position updates from the LRAUV will be pushed to the Arctic buoys and then relayed back to command control (topside laptop anywhere in the world).
- LRAUV will be able to line capture or dock to a fixed beacon with its USBL and capture nose assembly. Target=50% success.
- Integration of a Norbit multibeam system on LRAUV 3D multibeam system to LRAUV and ability to conduct sonar soundings of sea floor in accordance with manufacturer specifications.

- Operator ease of use:
  - Logistical footprint: number of operators required on site, number of kilograms to transport. Target: 2-3 adult operators and < 600kg.
  - Ease of mission configuration: design time to specify grid survey: Target: < 1 hr.
  - Ease of remote interaction: design modifications to allow basic training time required for operators: Training: < 1 week. Advanced operators require months or more for high level interaction and troubleshooting.

Outcomes/Outputs.

The goal of this project is to create an operational system that the USCG can use for characterizing spills in ice-covered ocean environments. Accordingly, while ADAC, MBARI and WHOI are designing, fabricating, testing and documenting the LRAUV System, consisting of two platforms, three Arctic communications buoys, associated sensors, firmware and software, HQ USCG Project Champion will direct the transition instructions and associated activities and parameters in order to meet USCG envisioned applications.

ADAC, WHOI and MBARI focus on creating, testing, and documenting an LRAUV with multiple sensors and supporting navigation and communications buoys to provide and demonstrate a prototype system. Following development, ADAC and the project team anticipate LRAUV System will be feasible and suitable for production. Included in these outcomes is the Project team will focus on creating an AUV sensor capability to provide and demonstrate a mature platform that is feasible and suitable for production and use by a non-expert. System engineering will emphasize the ability to transition capabilities from one AUV platform to the next depending on mission needs.

Accordingly, efforts to (1) to integrate Norbit multibeam sonar system onto the LRAUV, (2) Design and build a new payload nose for Tethys to incorporate the sonar payloads, (3) develop sensor modularity, (4) Plan and perform water tests of man-made targets, (5) Advance autonomous underwater capability to survey oil spills and produce high resolution maps with a modular payload at short and long ranges with multiple AUVs, at high and low latitudes and, to this end, LRAUV under ice answers an unmet need for DHS and the USCG.

During Program Year 8, the project team plans the following outcomes/output:

- Advance the technical competency of USCG designed POCs in operating and testing the LRAUV and Arctic buoys and provide the results of the test in a report.
- A cost design, planning to incorporate suitable and acceptable measures to support the design for follow-on fabrication of LRAUV.
- Complete fabrication of second LRAUV and its subsystems.
- Integrate a multibeam sonar system onto the LRAUV platform.
- Design and build a new payload nose for Tethys to incorporate the imaging payload.
- Collaborate with MBARI to develop sensor modularity and vehicle improvements and operations.
- Plan and perform water tests of man-made targets including oil surrogates using onboard simulation.
- Provide USCG familiarization training at WHOI and a USCG LRAUV Systems Guide.
- Provide DHS S&T OUP and USCG LRAUV System documentation.
- Plan high latitude tests for July 2022 in the Arctic.
- Create conditions for LRAUV System commercialization via planning and plan implementation with RTI International[15].

Outcomes of effort will provide a commercially available off-the-shelf sensor package that is AUV ready, and turnkey for Arctic seafloor and capable to characterize oil under ice. This turnkey system will be designed ease of integration onto the LRAUV vehicle. Predicting and monitoring environmental hazards in the Arctic remains an outstanding challenge for under-ice surveys, and accordingly, the research team's approach builds on proven AUV technology and expands its capability by adding the latest COTS sensor technology for creating 3D maps. The power of this technology for investigation of oil spills in open water or under ice remains largely unexplored, but sample data shows strong potential for oil mapping and detection capabilities in the future.

Transition Plan.

ADAC and LRAUV project team seek an integrated approach as desired by HQ USCG Project Champion to acquire and develop additional LRAUVs commensurate with USCG mission needs. In accordance with DHS S&T OUP-ADAC Grant Terms and Conditions, LRAUV Intellectual Property (IP) rights developed under this project remain jointly held between ADAC, WHOI and MBARI. According to

[15] https://www.dhs.gov/science-and-technology/news/2020/12/17/news-release-dhs-partners-rti-advance-homeland-security-solutions

the DHS S&T Terms and Conditions, DHS and USCG may leverage this IP royalty free to acquire and construct additional LRAUVs to USCG and other DHS maritime mission needs in coordination with WHOI and MBARI's IP and licensing agreements.

ADAC, MBARI and WHOI remain ready to support HQ USCG Project Champion planned transition pathway.

LRAUV System likely represents the most commercially marketable investigation conducted under the ADAC cooperative agreement. In parallel to technical development to deliver the LRAUV System to support USCG, ADAC and research team will continue to conduct investigations for commercialization of the System with industry as the Center's flagship development to commercial engagements over the course of Program Year 8 as outlined in the management section of this workplan. Accordingly, Center management and Project investigation team will seek to showcase LRAUV system, to include ADAC's planned event to host Alaskan and Arctic maritime industry leaders, response organizations, Oil Spill Response Organizations (OSROs), maritime shippers, Arctic cruise industries, first responders, Arctic oriented non-profit groups, State of Alaska and U.S. Federal departments and agencies and National Laboratories in a two day Symposium designed to increase visibility of a variety of Arctic Domain Awareness technologies, to include ADAC research endeavors, seeking to strengthen connections, collaboration and partnering between these communities, and to explore or initiate commercial transition pathways for ADAC completed/completing research. Following the LRAUV's testing plan, and completion of data relay devices, the overall system will be TRL 7 and ready for production in open ocean. Further testing and validating of the LRAUV system by the research team is recommended prior to commercial use in under-ice or high latitude locations. Depending on DHS S&T and USCG acquisition desires, project team relays WHOI and MBARI have around-the clock technical expertise available if any such need arises. This technical support covers hardware, software, design, fabrication, specialty application, and operations and logistical expertise.

WHOI has a history transitioning technology to operational use, especially with the U.S. Navy. WHOI uses a variety of transition methods tailored to the nature of the challenges associated with the transition. Factors influencing the nature of transition include technological maturity, complexity of operations, availability of investment for 'hardening' of systems, market prospects, and more.

In Program Year 7, ADAC and the project team have initiated coordination activities with RTI International, a DHS S&T contracted authority on commercialization and will work with RTI to advance commercialization planning and implementation for LRAUV system as an important outcome in Program Year 8. Additionally, in Program Year 7 ADAC, MBARI and WHOI submitted a Provisional Patent for LRAUV, which will also be advanced in Program Year 8.

Potential programmatic risks to completion.

Design and fabrication of LRAUV on two coasts is demanding and logistically expensive. While an equal partner in LRAUV success, MBARI's capability to surge to meet a myriad of urgent tasks is limited. As a risk mitigation measure, Project team will continue to seek to shift more of the fabrication tasks to WHOI to reduce construction load at MBARI.

The overall schedule of fabrication and testing for Year 8 is aggressive. Accordingly, work that exceeds capacity due to unexpected impacts will push completion dates of Year 8 beyond the

current confines of the DHS S&T OUP Cooperative Agreement. In such case, ADAC, WHOI and MBARI will conclude the requirements of the cooperative agreement to include the DHS S&T OUP approved workplan and conduct future directly with HQ USCG via the established DHS S&T OUP -UAA ADAC Basic Ordering Agreement (BOA).

PROJECT: Arctic Response-related Technologies: Strengthening Partners in Arctic Industry (SPAI) Symposium

Project PIs: ADAC ED, Randy Kee and ADAC EAM, Elizabeth Mathews, UAA

Project Support:

ADAC Communications and Research Associate, Connor Keesecker.

ADAC Research Associate, Kelsey Frazier

Lead Institution: University of Alaska Anchorage

Project Description:

Abstract

In support of commercializing ADAC and other participating mature and completing research, ADAC central management will plan, organize, and facilitate a follow-up *Strengthening Partners in Arctic Industry* (SPAI) Symposium to what was conducted in Program Year 7 in order to promote Awareness Center Technologies, foster academic and commercial research collaboration and partnering and generate new Transition Pathways that support the Arctic response community. While the SPAI Symposium is structured to support a collaborative approach to connect and network the community of science and technology research with industry, it serves as a useful venue to connect completed and completed research with maritime oriented industry for possible commercialization. Similar to Program Year 7, a uniquely titled name for the workshop will be developed and promulgated. *The workshop is planned as a virtual activity.*

Objective/Purpose.

ADAC plans to host Alaskan and Arctic maritime industry leaders, response organizations, Oil Spill Response Organizations (OSROs), maritime shippers, Arctic cruise industries, first responders, Arctic oriented non-profit groups, State of Alaska and U.S. Federal departments and agencies and National Laboratories in a two day Symposium designed to increase visibility of a variety of Arctic Domain Awareness technologies, to include ADAC research endeavors, seeking to strengthen connections, collaboration and partnering between these communities, and to explore or initiate commercial transition pathways for ADAC completed/completing research.

Baseline.

Maritime commercial response organizations and marine industry professionals continue to demonstrate increased interest in technology solutions that increase effectiveness and significantly reduce the cost, manpower, and risk of response operations. ADAC strongly believes that several such technology solutions exist within our portfolio of research projects, and an Arctic Strengthening

Industry Partnerships Symposium will connect Industry professionals with these highly useful technologies and benefit maritime industries and local communities alike, through more efficient and effective operations and more thorough cleanup efforts. ADAC's Arctic Challenges, Innovations, and Commerce Expo (Arctic CICE) conference conducted as a virtual event on 16-17 March 2021 serves as the Center's example and plan for Program Year 8 to explore the networks, resources, and infrastructure needed to enable the commercial entrance of Arctic-related products and technologies into the Arctic domain. Please see: https://arcticdomainawarenesscenter.org/EventHub_C-ICE

Methodology.

Project team is comprised of ADAC center management who will leverage ADAC's well-established convening and organizing abilities and University of Alaska facilities to host a myriad of commercial, academic and government officials to increase visibility of a variety of Arctic Domain Awareness technologies, to include ADAC research endeavors, seeking to strengthen connections, collaboration and partnering between these communities, and to explore or initiate commercial transition pathways for ADAC completed/completing research.

The proposed Symposium will convene maritime industry and technology professionals, along with local, state, and Federal partners in a two-day event devoting one day to domain awareness and hazard identification technologies, and the second day to environmental exploration and response technologies. For each day of the Symposium, participating project teams will co-develop transition-focused use case scenarios or concept of operations as facilitated by ADAC leadership. These use-case based scenarios will be address in project team panel presentations and may include short scenario run-throughs, after which symposium attendees can ask questions and initiate further discussion.

In conjunction with presentations, project teams may develop presentation booths to facilitate hands on, one on one discussions with potential industry partners. The below are examples for reference:

- Arctic and high latitude domain awareness and hazard identification technologies day will consist of short scenario and planned ADAC led "use case" presentations from the Long-Range Autonomous Vehicle, Arctic Ice Conditions Index, HIOMAS, and Geofencing Teams. The Long-Range Autonomous Vehicle use case scenarios could consist of multi-Beam sonar for Arctic Bathymetry, underwater seafloor and infrastructure analysis following an earthquake and/or tsunami, marine mammal monitoring, and fisheries health and migration assessments.

- Arctic Ice Conditions Index use case scenarios include hazard and efficiency assessments for Arctic shipping and tourism and DOD Arctic expeditionary mission planning and hazard assessment. In order to facilitate additional participation, ADAC will convene several advance planning conference calls, widely advertised via ADAC's communication networks, which include the U.S. Arctic Research Commission Daily Update, the Arctic Research Consortium of the U.S., the Interagency Arctic Research Policy Committee, University of Alaska sources and DHS S&T OUP communications.

- Environmental Exploration and Response Technologies Day will consist of short scenario and potential use case presentations oriented to marine environmental response. Planned ADAC led "use case" presentations in support of this day would include efforts the LRAUV System, Marine Induced Polarization, Arctic Mussels, and Arctic Copepods teams. In the LRAUV System use case adding deliberations to include detecting pollution under ice, determining the quantity of pollution under ice, determining the efficacy of continued use of dispersants, and identifying oil seeps in Arctic would be useful. The Marine Induced Polarization team use case would likely include determining the location and quantity of oil under ice, and classification of heavy oil products on the seafloor.

Planned Workshop format:

Day 1:

- Meeting Product / Agenda / Logistics / Introductions.
- Presentations and discussions of the Arctic Strengthening Industry Partnerships Symposium use case scenarios.
- Breakout or Booth sessions in which interested industry professionals can initiate one on one conversations with ADAC leadership and project team researchers to identify commonalities and potential pathways to commercialization of ADAC research.

Day 2:

- Meeting Product / Agenda / Logistics / Introductions.
- Presentations and discussions of the Arctic Strengthening Industry Partnerships Symposium use case scenarios.
- Breakout or Booth sessions in which interested industry professionals can initiate one on one conversations with ADAC leadership and project team researchers to identify commonalities and potential pathways to commercialization of ADAC research.

Key Milestones:

1. Work closely with DHS and USCG counterparts on the Symposium schedule of events.
2. Conduct research to identify the universe of maritime industry professionals (international, domestic, in/out government, etc.); conduct research to determine what commercially available technologies and methods are underway.
3. Provide timely invitations to symposium guests.
4. Organize symposium (via securing facility, inviting participants, developing agenda etc.).
    - Completed symposium participants' selection.
    - Completed symposium participants' invitations.
    - Completed logistics arrangements.
    - Completed symposium announcements.
    - Completed symposium program.

5. Determination to identify appropriate ADAC project team and maritime industry speakers to discuss relevant operational use case scenarios likely to be greatly improved by ADAC technologies.
6. Execute symposium.
7. Develop report representing the Symposium results and identified transition pathways and submit to DHS S&T OUP and USCG for review.

Performance Metrics:

1. Planned and conducted event that showcase ADAC and participating research to a variety of Alaska and Arctic maritime commercial and government officials.
2. Use of "Poll Me" technology to solicit participant feedback will be conducted. Key performance measure will be participant satisfaction with the event.
3. ADAC research project investigators connecting with one or more interested commercial enterprises.

Key Stakeholder Engagement.

ADAC will facilitate participation, via several advance planning conference calls, widely advertised via ADAC's communication networks, which include the U.S. Arctic Research Commission Daily Update, the Arctic Research Consortium of the U.S., the Interagency Arctic Research Policy Committee, University of Alaska sources and DHS S&T OUP communications.

Student Participation.

Center leadership plans that ADAC Fellows will aide preparation and administrative support as part of professional development and opportunity for their professional networking.

Outcomes/Outputs.

The principal output of the Arctic ***Strengthening Partners in Arctic Industry*** symposium is to increase industry interest in completed/completing research of the Center and other participating research and technology presenters.

Transition plans.

ADAC's goal of the Program Year 8 Strengthening Industry Partnerships Symposium is to ultimately transition and commercialize ADAC research for improved Arctic Domain Awareness and Response efficiency and to promote the public good.

Potential programmatic risks to completion.

None.

PROJECT: Arctic Medium- and Long-Term Environment (Arctic MaLTE) Exercise

Project PIs: ADAC ED, Randy Kee and ADAC EAM, Elizabeth Mathews, UAA

Project Support:

ADAC AD/SRP, Jason Roe, Petty Officer, USCG (Ret).
ADAC Communications and Research Associate, Connor Keesecker.
ADAC Research Associate, Kelsey Frazier

Lead Institution: University of Alaska Anchorage

Project Champion: HQ USCG 5PW (Senior Arctic Policy Advisor).

Project Description:

Abstract.
ADAC plans to conduct one Arctic-focused Medium- and Long-Term Environment (MaLTE) exercise ~~workshop~~ to understand and address the medium and long-term strategy, policy and planning needs specific to the USCG Arctic mission. The Arctic MaLTE format is ADAC's structured workshop involving select academics, industry researchers, and government officials, who explore medium to long-range challenges comprehensively, from policy, governance, and science & technology vantages. ADAC has conducted Arctic MaLTE events in Program Year 3, 4, 5, 6 and 7. The outcome of the MaLTE workshop is a comprehensive knowledge product which includes workshop analysis and recommendations. The ADAC Program Year 8 Arctic MaLTE workshop is planned for an analytical follow-up from the *May 2021 Arctic Maritime Horizons exercise*. The purpose of the event is to again gather Arctic minded experts from government, operators, academics, and industry from the international community and the U.S. to conduct a series of short essential information briefs followed by discussions" in breakout groups and returning to the next information brief to collect as much insight in a constrained timeframe as possible to collaboratively address risk factors to the U.S. Arctic MTS discovered in the May 2021 Arctic Maritime Horizons exercise.

The event assessment will be framed to address operational risks to the future MTS in the Arctic region. Based on the range of possible futures, workshop planners seek to characterize risks to waterways management of the Arctic region MTS. Prioritization of proposed solutions will be made using Delphi protocols. Workshop planners will focus recommended solutions which include improve presence and cooperative activities that if/as implemented, should advance improved safety and security for the Arctic and reduce the corresponding risk.

Objective/Purpose.
Overall, ADAC MaLTE workshops are designed to meet medium and long-term strategy, planning and policy problems as determined by HQ USCG (specifically, HQ USCG Senior Arctic Policy Advisor to the Commandant). The planned assessment workshop seeks to advance items of relevance to future horizons through reconvening leaders and experts to examine conclusions of the Arctic Maritime Horizon Exercise of May 2021 in light of subsequent changes to organizational strategies, plans, policies, and implementation activities in order to identify shortfalls, gaps, new synergies and convergence opportunities in shared MTS endeavors in the Arctic. The planned assessment is considered a useful approach based on the hypothesis that exercise participants generate many of their most innovative ideas and solutions immediately after being inspired by authentic speakers

who provoke imagination and creativity. Accordingly, workshop planners seek to leverage this inspiration to quickly generate ideas/brainstorm via dynamic and focused group collaboration. The outcome of the assessment will be a comprehensive knowledge product that captures pre-assessment planning, exercise proceedings and post event analysis. The principal reason for this follow-up exercise is to further analyze the evolving nature of the Arctic MTS by cross examining the AMH21 report against current conditions in order to gain further resilience of the recommendations and proposed way forward in USCG MTS policy choices.

Baseline.

The Arctic continues to advance as a region of increased focus and attention of multinational organizations, nations, industry, and illicit actors. While changes to the physical environment of the region continue to outpace corresponding factors from lower latitudes the Arctic also is experiencing a sharply rising level of human interest and activity. Collectively, these changes are catalyzing the need to frequently reassess current plans and activities in governance organizations vested with safety and security mandates to advance better policies, plans, and activities in support of the peaceful opening of the Arctic. This includes advancing and modernizing the Maritime Transportation System (MTS) in the Arctic.

Per the U.S. Coast Guard's (USCG) 2018 Maritime Commerce Strategic Outlook (MCSO) and the 2019 Arctic Strategic Outlook (ArcSO), the Marine Transportation System (MTS) is the lifeblood of the Nation's economy. The USCG's ability to maintain a safe, secure, and efficient national MTS facilitates more than $5.4 trillion per year in economic activity, supporting more than 30.8 million jobs. Increased maritime activity in the Arctic will create increased demand for the full spectrum of USCG authorities, services and capabilities to manage risk in the Arctic MTS. As geostrategic, and economic conditions have the potential to make key routes through the Straits of Malacca and the Suez and Panama Canals less predictable or affordable, sea lanes in the Arctic are poised to provide valuable alternatives between North America, Europe, and Asia. This has powerful implications for both commerce and military mobility and makes ensuring an efficient MTS in the Arctic important to the Nation's security, resiliency, and prosperity.

Replicating the MTS that exists in the contiguous United States is not a viable option in the Arctic. Therefore, the USCG must complement its existing MTS management tools with innovative policies and technologies, developed in partnership with both the public and private sectors. As a principal instrument to provide safety and security of America's waterways, the USCG will lead the comprehensive integration of the Arctic into the Nation's critically important MTS. This will enable growth in commerce and contribute directly to the strength, resilience, and prosperity of the Nation.

In order to continue (and build upon) AMH21 Exercise insights and recommendations, this "follow-up" exercise seeks to update and advance 1) improved clarity to future risks and requirements of an Arctic MTS that enables responsible maritime activity and growth; 2) further characterize changing conditions of the human terrain and associated impacts to the effective rule of law; 3) Further identify options, opportunities, and courses of action for progressing the Arctic MTS; and 4)improve AMH21's leveraged methodologies for evaluating and quantifying advancements in the MTS.

In order to advance understanding these objectives and identifying needed policies and authorities, ADAC plans to support USCG CG-5PW via an inclusive exercise with multi-national, U.S. Departments and Agencies, Arctic leaders in governance, industry, and academia. This follow-up exercise will be

planned, organized, and conducted "*Arctic Maritime Horizons 2022…a follow-up analysis of the evolving Maritime Transportation System of the Bering, Chukchi and Beaufort Sea regions,*"

As the longer-term compliment to Arctic IoNS, the Arctic MaLTE workshop will look towards the 10-20-year time horizon to investigate potential mission needs based on projected technology gaps driven by the anticipated Arctic operational environment. ADAC will collaborating with HQ USCG 5PW to conduct a future oriented assessment of the maritime transportation system of the U.S. Arctic maritime EEZ, using the tools of Strategic Foresight Assessment (SFA).

Methodology.

As a strategy, planning and policy-oriented exercise, Arctic MaLTE events convene subject matter experts to include Government Officials in both the U.S. and Canada, academic researchers, and respected leaders of the Arctic, to include Arctic residents from indigenous communities and organizations. The assessment structure is framed as a series of focused briefings, highlighting issues, concerns and recommendations, followed by roundtable discussions and breakout sessions using Delphi prioritized solutions that if taken for action through policy decisions, provide pathways to improved governance, safety and security of the emerging MTS for U.S. interests in the Arctic. As a preparatory endeavor, ADAC will conduct a comprehensive literature review through Center Fellows to establish a baseline of published experts to support the exercise. In creating the exercise, ADAC solicits and assembles an appropriate panel of select researchers from the baseline to present to invited operators and government officials in Canada and the U.S. (at Federal, State, Local, and Tribal) to form cross-section expertise resulting in comprehensive discussions. After the plenary, ADAC divides participants across facilitated breakout workshops to discover pathways towards improved unified action.

While focused on strategy, policy, and planning, through this structured plenary and breakout workshop, participants will also likely gain understanding of knowledge gaps and shortfalls in science and technology. In order to capture the discussions in plenary, roundtables and breakout groups, ADAC will create a Rapporteurs report to serve as a principal knowledge product, with prioritized recommendations and conclusions.

Scenario based literature review will present a baseline of understanding by futurist researchers in terms of economic, security and physical environment of the future Arctic. Guided by the Literature Review, expert opinion of selected and polled researchers, and the strategy documents.

Since ADAC's first MaLTE workshop/exercise in 2017, the process of organizing and planning these important convening events are fairly well established within the Center.

This last planned Arctic MaLTE activity associated with ADAC's DHS S&T OUP Cooperative Agreement. Arctic Maritime Horizons 2022 will build upon AMH21 to advance improved understanding in areas of concern in accomplishing strategy, high level goals, policy and planning. ADAC plans to extend invitations to a team of researchers, maritime shippers, Arctic cruise industries, first responders, Arctic oriented non-profit groups, State of Alaska and U.S. Federal departments and agencies with designated Arctic maritime responsibilities and National Laboratories to analyze the preparatory materials to investigate scenarios and plenary discussions to determine needed policy, governance, and science & technology to realize DHS and USCG strategic

goals and objectives, corresponding to Arctic Maritime shipping within the U.S. Extended Economic Zone. ADAC will then publish the findings of the research in a comprehensive report, following HQ USCG Project Champion review.
In order to facilitate participation, ADAC will convene several advance planning conference calls, widely advertised via ADAC's communication networks, which include the U.S. Arctic Research Commission Daily Update, the Arctic Research Consortium of the U.S., the Interagency Arctic Research Policy Committee, University of Alaska sources and DHS S&T OUP communications.

Exercise format:

Day 1:

- Meeting Product / Agenda / Logistics / Introductions
- Presentation and discussion of the scenario.
- Presentations on current aspects of strategy, policy and planning related by experts, operators and government officials.
- A series of roundtables discussions to address shortfalls and gaps.
- The day will conclude with the formation of break out to address research theme gaps and shortfalls related to the scenario and discussions.

Day 2:

- During the morning period, break out groups will discuss the gaps and formulate proposals close those gaps. During the afternoon, breakout groups will convene as a general plenary session to discuss each group's findings and employ Delphi method to prioritize solutions.

Key Milestones.

1. Work closely with HQ USCG Project Champion, associated U.S. government, industry officials, and Canadian counterparts in order to develop the workshop scenario, format, schedule and associated logistics.
2. Conduct research to identify suitable SMEs (international, domestic, in/out government, etc.); conduct research to determine what research is underway to address the likely challenges posed by the scenario and those challenges most relevant to USCG.
3. Organize exercise (via, inviting participants, developing agenda etc.). These include:
    - Completed exercise participants' selection.
    - Completed exercise participants' invitations.
    - Completed logistics arrangements.
    - Completed exercise announcement.
    - Completed exercise program.
4. Identifying appropriate SME speakers to discuss relevant research activities across disciplines that likely address USCG challenges relevant to the scenario.
5. Complete panel selection and invitations.

6. Execute exercise.

7. Complete report/proceedings and slides deck representing the exercise discussions and submitted to HQ USCG Project Champion for review and approval.

8. HQ USCG Project Champion approved Literature Review, Rapporteur's report/proceedings, including releasable list of participants, and presentations will be posted to ADAC's website for ready reference at: https://arcticdomainawarenesscenter.org/Arctic_MaLTE.

Key Stakeholder Engagement.

The Project team will engage with the designated Project Champion, Mr. Jenkins on a frequency basis as determined by the Project Champion, but as a minimum the team will seek to conduct monthly teleconferences. Critical coordination is planned with all team members, the PI, and project champion. Key project stakeholders include USCG PACAREA and LANTAREA, USCG D17, D17 Sector Anchorage and the U.S. Coast Guard Academy Center of Arctic Study and Policy (CASP).
Project team will participate and be featured in the planned ADAC "Customers and Partners" Roundtable, in order to inform and receive feedback on project progress.

ADAC center team will inform about exercise progress at the following events:

1. Quarterly Reviews and Quarterly Customer's and Partner's Roundtable.
2. Annual meeting at HQ USCG, Washington D.C.

Student Participation.

Center leadership plans that UAA-based ADAC Fellows will aide preparation and administrative support as part of professional development and opportunity for networking. Support to this assessment will be an additive task to participating fellows to existing project-based research tasks.

Performance Metrics.

1. Is the project on time, based on the schedule set forth in the detailed work plan established Project Champion?
2. Is the project at, or under, cost based on the established budget?
3. Are resources (e.g., references, workshop/working group participants) being gathered/recruited in sufficient numbers for the project tasks?
4. Is the scope of the project adequate or does it need to change to meet unforeseen changes?
5. Is the quality of the project products acceptable to the Project Champion?
6. What actions need to be taken to continue the project/maintain quality/or improve quality?
7. Impact of follow-on peer-reviewed publications.
8. Transition of exercise insights in terms of policy recommendations. What exercise conclusions are taken by U.S. Coast Guard, DHS, or other Federal Department/Agency to adjust/modify a strategy, plan, program, investment decision or other based on the AMH 22 Exercise report or some major aspect of the exercise discussions?

Outcomes/outputs.

The principal outcome of the project is a knowledge product which provides examines AMH21 via a participative exercise experience. As the follow-up from AMH21, Arctic Maritime Horizons 2022 will continue needed analysis of the developing U.S. Arctic EEZ MTS, which will inform policy concerns of HQ USCG in further advancing implementation plans associated with USCG's 2018 MCSO and 2019 ArcSO oriented to the region. The goal of AMH2022 is to support USCG decision makers in addressing the implementation plans associated with MCSO and ArcSO, and to inform associated safety and security polices for the region. The final project is anticipated to meet at least TRL-3 threshold requirements.

The final knowledge product will be a comprehensive report containing:

1. Preparatory materials and planning information.
2. Comprehensive review of prepared remarks and presentations.
3. Detailed accounting of breakout discussions.
4. Review of prioritized recommendations and onward actions/implementation approaches.
5. Delphi analysis of recommendations and associated priorities
6. Analysis, overall recommendations and strategic suggestions for onward application consideration.

In addition, Project Champion and ADAC will coordinate a corresponding peer-review journal article, oriented to either USCG ***Proceedings*** professional journal of the U.S. Coast Guard or a similar professional publication. ADAC will correspondingly plan to post all information to the ADAC website at: https://arcticdomainawarenesscenter.org/Arctic_MaLTE.

Transition plans.

ADAC's goal of Arctic MaLTE is to understand issues and concerns, analyze those concerns to create understandings of shortfalls and gaps to strategy, policy and planning, and develop solutions to address the shortfalls and gaps. Lastly, through employing Delphi techniques, prioritization of solutions by workshop participants can be well achieved. As a complement to Arctic IoNS, the longer-range focus of Arctic MaLTE advances long lead research, requiring greater community of interest patience in awaiting relevant outcomes. As the ADAC MaLTE event for Program Year 8, Arctic Maritime Horizons 2022 will examine AMH 21, review conditions that affected the conclusions and recommendations of AMH21 and orient the knowledge product of AMH 2022 to transition exercise insights in terms of policy recommendations that influence/impact the U.S. Arctic MTS. As discussed above, "transition" measures for AMH 2022 are to understand/determine what exercise conclusions are subsequently taken by U.S. Coast Guard, DHS, or other Federal Department/Agency to adjust/modify a strategy, plan, program, investment decision or other based on the AMH 22 Exercise report or some major aspect of the exercise discussions.

Potential programmatic risks to completion.

The project team assesses overall risks to project completion as low. The project team is very familiar with the project methodology and is well acquainted across the USCG and has well established connections across the U.S. Federal government, industry and academic disciplines, all of whom are planned as prime contributors and coordinators within the planned project. The product produced from the research is a knowledge document, which is a relatively simple approach to successfully conclude the research endeavor.

THEME 4: Integration of Science and Engineering with Maritime Security Governance and Policy Research

THEME 5: End-to-End (E2E)

THEME 6: Integrated Education

1. Education Outreach and Workforce Development Overview.
2. PROJECT: Minority Serving Institute (MSI) and Significant Minority Enrollment (SME) Workforce Development (WFD) Fellowship Program.
3. PROJECT: Integrated Minority Serving Institute (MSI) and Arctic Summer Internship Program (ASIP).

Integrated Education Overview.

Education outreach and workforce development is a core mission for ADAC. The intent of ADAC's education program is to contribute to the next generation of Science, Technology, Engineering, and Mathematics (STEM) professionals for the Homeland Security Enterprise (HSE). ADAC's geographic focus on the Arctic is unique in the DHS S&T OUP portfolio. The Arctic focused research led by ADAC offers ADAC fellows and interns a variety of unique research and development opportunities to engage with research aimed specifically to respond to the challenges faced by the USCG and other DHS maritime missions operating in the High North. Upon graduation, ADAC fellows and interns will be well suited to provide needed Arctic expertise as future members of the HSE.

The ADAC Education Program is integral to the Center and associated research projects. During the academic year, ADAC fellows will participate in research and Center led activities, providing students with both technical and professional developmental experiences. ADAC Fellows participate in student research either in individual research projects, or in Center activities during the academic year. Additionally, ADAC fellows participate in two 10-week summer internships throughout the duration of their fellowship.

In accordance with the DHS S&T OUP Cooperative Grant, the terms and conditions for applying and maintaining, "good standing" while associated with ADAC are rigorous and demanding. The reward for meeting these conditions is fiscal support for studies, professional and technical development through activities conducted as part of the ADAC Education Program and mentoring and improved access for graduates seeking a career within the HSE.

The ADAC Education Program is open to undergraduate, graduate, and advanced graduate students. Currently, the ADAC Education Program is comprised of students engaged in ADAC projects as Workforce Development fellows (WFD). The fellows are funded via the overall DHS S&T OUP Cooperative Grant to the Center. Additionally, ADAC will continue to seek appropriate institutional support funding to support the Center's education activities in Year 8.

ADAC currently has established fellows at the University of Alaska Anchorage (UAA), the University of Texas El Paso (UTEP), the University of New Orleans (UNO), and the University of New Hampshire (UNH). In Program Year 8, ADAC will carry over all current ADAC fellows from Program Year 7 until either their two years of programmatic funding is complete, or they graduate from their respective academic program. With that said, all ADAC's fellows will graduate from the fellow's program by the end of Program Year 8. ADAC's student recruitment efforts will continue to seek to develop the ADAC Education Program into an ethnic and gender diverse group of student fellows.

Complementing the Fellows program, ADAC plans to host a minimum of two minority students in Program Year 8 to take part in a summer internship during the early spring/summer of 2022. Funding permitting, ADAC will integrate these two minority students with participating Center fellows for the Arctic Summer Intern Program (ASIP), which is discussed in more detail in the project specific section below.

Additional Education Objectives beyond the Fellowship Program.
In coordination with ADAC's constituents at Alaskan Command (ALCOM) and the University of Alaska (UA), in Program Year 8, ADAC seeks to draft and implement an interdisciplinary Master of Science (MS) in Arctic Security. The foundation of the degree's curriculum, where applicable, will be built upon current courses offered through the UA System's three major universities, the University of Alaska Anchorage, Fairbanks, and Southeast. Drafting for the curriculum is anticipated to begin during the first half of ADAC's Program Year 8.

The Program's curriculum will incorporate topics such as Alaska Native and Indigenous Studies, Arctic Policy and Governance, Arctic environmental sciences, communication, leadership and management, and Arctic operational strategies. ADAC seeks to divide the degree into several topic specific tracks in order to allow and attract a diverse array of students. As such, the degree's target audience is broad, in that it seeks to attract current military personnel, working professionals, and full-time students. Furthermore, to increase the access and availability of the degree to a wide variety of students, the degree will be offered entirely online. In addition, in Program Year 8, ADAC will pursue the program accreditation process as established by the University of Alaska.

Quarterly coordination with DHS S&T OUP.
ADAC will conduct a program quarterly review with DHS S&T OUP ADAC Program Manager and DHS S&T OUP Education Outreach and Workforce Development Program Manager. As discussed in Module 1, ADAC leadership will assess the Education Program in detail during ADAC Quarterly Reviews.

Compliance with DHS S&T OUP Workforce development criteria.
ADAC leadership (principally through the Center's Education and Administration Manager) will ensure ADAC complies with the Homeland Security Act of 2002 to provide U.S. citizens training in homeland security-related science and engineering disciplines to maintain U.S. leadership in science and technology.

PROJECT: Minority Serving Institute (MSI) and Significant Minority Enrollment (SME) Workforce Development (WFD) Fellowship Program**.**

Project PI: ADAC Education and Administration Manager, Ellee Matthews

Lead Institution: University of Alaska Anchorage

Supporting Team:

- ***MSI Institutions:*** University of Texas El Paso (Hispanic)

SME Institutions:

- Texas A&M (Hispanic)
- University of Alaska Anchorage (Native American Indian)
- University of Alaska Fairbanks (Native American Indian)

Project Description:

Abstract.
In Program Year 8, ADAC will recruit two student summer interns from under-represented classifications seeking to leverage established partnerships with designated MSI and SME institutions. The ADAC Minority Summer Internship will integrate these two summer interns along with additional participating ADAC fellows for a 2022 ADAC Arctic Summer Intern Program.

ADAC's Arctic Summer Intern Program (ASIP) is a comprehensive internship conducted at the University of Alaska Anchorage. ADAC's ASIP will provide students opportunity to visit across multiple U.S. federal agencies with offices in Anchorage, participate in ADAC research conducted at UAA, as well as with ADAC's research network in Southcentral Alaska, and take part in fieldwork activities throughout the Southcentral region, with a visit to Alaska's most northern village, Utqiaġvik, (formally Barrow) Alaska.

Objective/Purpose
Provide an Arctic focused summer internship program as part of the overall ADAC Fellows program oriented for Minority Serving Institutions, under-represented classifications students and other ADAC Fellows as part of the student program's overall workforce development to prepare undergraduate and graduate level students for entry into the Homeland Security Enterprise. The specifications in expectations for the project are included in the DHS - ADAC Terms and Conditions for Workforce Development Plan.

Baseline.
As part of the ADAC student focus presented under the ADAC Fellows Program, the Center seeks to recruit student summer interns from under-represented classifications. ADAC will advertise the Minority Summer Internship opportunity across ADAC research network (in particular through existing networks with MSI or SMEs), DHS S&T OUP communications, U.S. Arctic Research Commission

(USARC), Arctic Research Consortium of the U.S. (ARCUS), and the Interagency Arctic Research Policy Committee (IARPC).

Funding permitting, the selected summer research interns will travel to UAA. ASIP will focus on providing students workforce development opportunities in operational capacities that will directly benefit the Department of Homeland Security and its components.

Methodology.
Students from under-represented minorities who focus on science, technology, engineering and mathematics (STEM) fields are the most likely candidates to be interested in connecting with many of the projects the Center is pursuing and may be interested in seeking a career associated with the HSE.

Professionally developing students from under-represented classifications conforms to DHS diversity goals. Integrating visiting interns with ADAC fellows provides synergy and networking opportunities for all students. Visiting students may then seek to apply for a fellowship with ADAC or seek similar opportunities with other DHS S&T OUP Centers of Excellence due to their ASIP experience.

Through an Arctic-focused, financially supported summer internship program, ADAC will recruit and connect with students from under-represented minorities. As described in project baseline, ADAC will recruit students via a comprehensive approach with ADAC's network of MSI and SME institutions.

Visiting students from under-represented minorities participating in the MSI summer program will comply with DHS Approved Safety Plan as coordinated with the University of Alaska Anchorage procedures. In all cases, compliance with DHS approved safety procedures is mandatory for ADAC sponsored academic, government and industry institutions and will be applied in both field and laboratory conditions.

As described in the Education and Workforce Development segment, coaching and mentoring of students from under-represented minorities (and other ADAC fellows) is conducted to provide an overview and to orient these students to careers in government service across the DHS Enterprise .

The University of Alaska Anchorage plans to support the administration of the overall ADAC Fellows program, including the MSI/SME summer internship program, and the overall ADAC Fellows program via institutional support resourcing.

Overall ADAC MSI/SME Workforce Development Program Schedule and Objectives.
In this coming program year, ADAC seeks to continue advancing the fellowship program. Accordingly, the following are the key attributes for ADAC Fellows in Program Year 8. In sum, ADAC Fellows will:

- **Summer Onboarding Program** – The new cohort of students will begin Program Year 8 with a summer onboarding program, to begin in July 2021. The onboarding experience will utilize a similar format to the virtual ASIP 2020 program and will focus on preparing students to enter the academic research field from an ADAC fellow perspective, while providing the students with a foundational understanding of the Arctic domain. The program will utilize an

interdisciplinary and holistic approach to teach students of the interconnected nature of the Arctic domain, covering topics ranging from the Arctic biophysical environment to international geopolitics. It will additionally include a comprehensive and esteemed series of guest presenters, Arctic-specific lectures by the program's primary instructor, Dr. Craig Tweedie (UTEP), independent research projects, group projects, and weekly mentorship round table discussions. In sum, the summer onboarding program will set students up for a successful fellowship year, with ASIP 2022 serving as their final capstone in the ADAC Education Program (more details on the 2022 ASIP program in the respective project section).

- Participate in professional exchanges with USCG, in particular via the Arctic IoNS and MaLTE workshops, and any corresponding tabletop seminars.

- Accompany ADAC leadership to forums with U.S. Federal enterprises in the greater Anchorage area.

- Attend monthly Fellow's meetings with Center leadership. These meetings will include professional mentoring, updates on the HSE and discussion about research efforts conducted by ADAC fellows in their respective ADAC projects and beyond. ADAC will continue to host meetings at UAA and use online technologies for students participating remotely. ADAC will invite speakers to provide leadership and career development perspectives oriented to science and technology careers, and/or careers across HSE, to these monthly meetings.

- In collaboration with Project PIs/lead(s) and ADAC's Education and Administrative Manager, Fellows will develop individual student research work plans to map out their expected participation and contribution to ADAC's research projects, or Center led activities. This includes the Arctic Incidence of National Significance (Arctic IoNS) Workshop, and the Medium and Long-Term Environment (MaLTE) Workshop (exact dates still TBD).

- Participate in significant maritime focused forums hosted in Anchorage Alaska. This includes the Arctic IoNS Workshop 2022 (exact dates still TBD), and the Alaska Marine Science Symposium 2022 (exact dates still TBD).

- Participate in an ADAC Summer Internship Program as an option to satisfy one of two required summer research internships. Included in the Summer Internship Program are visits to an array of Anchorage based federal, state, and local agencies associated with the HSE and supporting activities. Also included is a planned Arctic research program at Utqiaġvik (formally known as Barrow), Alaska.

- Integrate two Minority Summer Interns from Minority Serving (MSI) or Significant Minority Enrollment (SME) Institutions to ADAC's Summer Internship Program.

- Participate (as a program graduate) as desired, in post-graduate mentoring and networking by Center leadership seeking entry into the HSE.

Key Milestones:
For Program Year 8, ADAC will conduct the following steps to reach intended goals of the Minority Summer Internships:

1. Recruit two students from under-represented minorities to participate in ADAC's Arctic Summer Intern Program and integrate the MSI students with participating ADAC fellows.
2. Outline expectations and opportunities for recruited students by providing advance preparation information and associated materials.
3. Recruited students will participate in the summer onboarding program, to begin in July 2021.
4. Recruited students will then progress from the summer onboarding program, into ADAC fellows during the 2021/2022 academic year.
5. Recruited students will travel to Alaska and participate in ADAC's 2022 ASIP.

Key Stakeholder Engagement.
Students from under-represented minorities will be invited to join other ADAC fellows taking part in the summer internship program in a scheduled summer ADAC *"Customer's and Partner's Roundtable"* as a mentoring and professional development opportunity. While not designated as Project Champion, DHS S&T OUP Education POC reviews the progress of ADAC's education program on an approximately quarterly basis**.** The MSI/SME summer internship program progress will be included in ADAC's quarterly reviews of the Center's efforts in Education Outreach and Workforce Development with DHS S&T OUP Education Outreach and Workforce Development program management.

Student Participation.
Program is focused on students from under-represented minorities. Program Year 8 anticipates incorporating a total of 7 fellows into the Workforce Development Program. Two of these fellows will continue from Program Year 7, undergraduate UTEP fellow, Brenda Almanza, and graduate UNO fellow, Kathryn Humpal. The additional five anticipated students will be undergraduate students recruited from a combination of UTEP, UAA, and UAF.

Performance Metrics.
Measures of meaningful performance for program success are as follows:

- Recruiting two students from under-represented minorities: Program is considered "Success" when full recruitment goal is achieved. "Caution" is noted for the program when one student has been successfully recruited. The program will receive a "Failure" mark no students are successfully recruited.

- Visiting minority students who follow-on through a student relationship to a DHS CoE who then successfully graduate and enters into employment with the HSE or a related discipline. Program is considered "Success" when one student takes this path over the duration of the ADAC Education Program.

Outcomes/Output.
Coached, mentored and professionally developed students from under-represented minorities enter DHS enterprise workforce.

Transition Plan.
As students prepare to graduate, ADAC Education and Administrative Manager supports student career placement into the positions aligned to HSE. Transition plans will continue past lifecycle of grant for tracking and job initiatives.

Potential programmatic risks to completion.
None.

PROJECT: ADAC Integrated Minority Serving Institute (MSI) and Significant Minority Enrollment (SME) Arctic Summer Intern Program (ASIP)

Project PI: Ellee Matthews, ADAC Education and Administration Manager

Supporting Team:

- Dr. Craig Tweedie, UTEP, Utqiaġvik (formerly Barrow), Field Team Lead
- Randy "Church" Kee, ADAC Executive Director, Field Team Co-Lead
- Jason "Olaf" Roe, ADAC Associate Director & Senior Research Professional, Field Team Co-Lead

Lead Institution: University of Alaska Anchorage

Project Description:

Abstract.
In Program Year 8, ADAC will conduct its fourth Arctic Summer Intern Program (ASIP). ADAC's ASIP will integrate visiting MSI and SME interns with participating ADAC fellows in a comprehensive orientation and mission focused education experience. ASIP includes visits to U.S. federal agencies based in Anchorage that are concerned with Arctic issues, focused time with ADAC researchers at UAA, visiting time with ADAC's network of Alaska-based Arctic researchers, field trips to local sites relevant to ADAC's research mission and interests, individual research concept development to generate new approaches to addressing science and technology solutions to USCG Arctic mission needs, and fieldwork experience in Southcentral region of Alaska, as well as Utqiaġvik.
The summer internship is focused on recruitment of students from underrepresented minorities. Project specifications of the MSI and SME components are described in the associated, preceding project segment and included in the DHS - ADAC Terms and Conditions for Workforce Development Plan.

Objective/Purpose.
Provide an Arctic focused summer internship program as part of the overall ADAC Education Program oriented for Minority Serving Institutions and Significant Minority Enrollment institutions, students

from under-represented classifications and other ADAC Fellows as part of the student program's overall Workforce Development Program to prepare undergraduate and graduate level students for entry into the Homeland Security Enterprise. The specifications in expectations for the project are included in the DHS - ADAC Terms and Conditions for Workforce Development Plan.

Baseline.

DHS S&T OUP Cooperative Grant Terms and Conditions require ADAC to develop and conduct two 10-week summer internships for all Center student fellows during their tenure of association with ADAC. Accordingly, ADAC created an innovative Summer Internship program for ADAC fellows and students from underrepresented minorities.

Additionally, the Center seeks to integrate minority students who are awarded paid internships from ADAC's MSI and SME program to ASIP. Specifically, ADAC has established a project to provide scholarships opportunity for two Minority interns recruited to gain an introduction to Arctic research and the Homeland Security Enterprise (HSE).

Anchorage, Alaska is home to a myriad of U.S. federal field offices focused on Alaska and Arctic Alaska. These field offices are staffed with federal professionals that are either directly or indirectly associated with the Homeland Security Enterprise. Anchorage is also home to many States of Alaska department offices and a number of Arctic-focused Native Alaskan Foundations and Arctic focused commercial enterprises, and a critical seaport, which offer opportunistic education and outreach experiences for ASIP interns. Anchorage's Joint Base Elmendorf Richardson (JBER) is home to a U.S. Northern Command sub-Unified Command (Alaskan Command) and an array of U.S military forces oriented for the defense of Alaska and power projection into the Pacific region. JBER also hosts U.S. Coast Guard District 17, Sector Anchorage, Alaska's Department of Military and Veterans Affairs (and the Alaska National Guard) and the Alaska District U.S. Army Corps of Engineers.

ADAC's leadership team includes a retired USAF General Officer with extensive operational experience, including disaster response and humanitarian assistance missions, plus prior service as a Joint Exercise Director at a U.S. Unified Command. The team additionally includes a retired Coast Guard Petty Officer with twenty years of extensive operational and command center experience with the Center's primary customer.

University of Alaska (UA) and University of Texas El Paso (UTEP) conduct considerable field research near Utqiaġvik, (formerly Barrow) Alaska. Both universities support student activities in this field research. Based on existing logistics, the field teams are well suited to handling up to 5 ASIP interns in ADAC Program Year 8. Furthermore, in order to accomplish the internship program while also focusing ADAC's Center-activities on transition, the Program Year 8 ASIP program will be a shorter internship, including 4-5 days in the Anchorage/Southcentral region, with 9-10 days in Utqiaġvik, Alaska.

ADAC's ASIP will leverage the attributes of the Anchorage area in a comprehensive introduction to the Arctic challenges faced by government agencies and commercial enterprises. ADAC will leverage the expertise of its staff based in Anchorage to conduct a meaningful guided seminar to facilitate student understandings of the challenges faced by USCG Arctic operators. ADAC will leverage the

skills of UAA based researchers to guide students in understanding research oriented to support the Arctic operator. Lastly, ADAC will tap the unique experiences of expert field researchers and established locations at a critical Arctic location to provide students a safe developmental field research experience.

Methodology.

ADAC leads planned activity guided by ADAC's Education Manager that is overseen by the ADAC Executive Director for the Anchorage based portion of the internship program. UTEP and UA Supporting leaders will co-lead the field portion of the internship program and will contribute to an orientation of students at UAA prior to students departing for field activities. ADAC will screen and select a student leadership team to support detailed planning and execution of the program. ADAC will process visiting minority students and participating ADAC fellows into ASIP and conduct and conclude the program as detailed in schedule and milestones.

Key Milestones.

For Program Year 8, ADAC will conduct the following tasks and associated milestones for ASIP:

1. Recruit two students from underrepresented minorities to participate in the Arctic Summer Intern Program that will also include the participation of other ADAC fellows not later than early Spring Semester 2022.
2. Outline expectations and opportunities for recruited students, providing advance preparation information and associated materials, not later than Spring break 2022.
3. Funding permitting, support student travel to Anchorage and participation in ADAC's ASIP.
4. Orient students in ADAC's overall mission, the internship experience, expectations of the program, and safety briefs. Include professional mentoring of government careers in HSE and careers in Arctic-oriented science and technology not later than the first week of ASIP 2022.
    a. The orientation is expected to incorporate 2 days of student activity.
5. Engage University researchers associated with ADAC to participate and relay the breadth of Center research efforts and association with other university research enterprises.
    a. ADAC Project leads/their designated representatives will present.
    b. ADAC will gain overviews from other UA research entities such as UAA Institute of Social and Economic Research, the Institute for Circumpolar Health, UAF's Matanuska Experimental Farm and Extension Center, the Applied Environmental Research Center, and business ventures such as UAA's Business Enterprise Institute.
    c. ADAC will introduce students to field research conducted in and around the Southcentral Alaska region, as well as sites of critical importance to the Arctic region.
    d. The above activities should take approximately 4-5 days of student activities.
6. Depart for ASIP Utqiagvik (Barrow) trip for field research. Team proceeds to Utqiagvik (Barrow) for a ~8-10 day of field-based research and returns to Anchorage, this will be completed not later than 1 week from the start of ASIP 2022.
    a. Upon arrival, team participates in overview, safety briefings and orientation, supporting logistics and training on research tasks at hosted site.
    b. Team participates in field-based research co-led by UTEP and UAF researchers.
    c. Where possible, students will participate in field-based research that supports other ADAC projects.

d. Total time allotted is approximately 6-8 days (including ~2 days for travel to and from Utqiaġvik).

7. ADAC UAA team conducts Anchorage area Arctic focused HSE and associated government visits.
    a. This activity is 5-5 days of student activity.
8. ASIP Intern Research Paper and Project.
    a. This activity is 10 days of student research and paper development.
9. Interns participate in ADAC Customer's and Partner's Roundtable.
10. Complete out-process, obtain survey feedback and conclude Internship, not later than ASIP start plus 10 weeks.

Supporting Logistics: ADAC provides funded support to students, and houses students from outside the Anchorage area at UAA student facilities. UTEP and UA Co-research leads will work with ADAC leadership to establish the field-based logistics required for the success of the field-based component of the program. Student workspace is located at ADAC's office at 1901 Bragaw Street, Anchorage. ADAC does not provide transportation for students for personal matters but will seek UAA transportation assets for local area visits.

Performance Metrics.

Measures of meaningful performance for program success are as follows:

- Recruiting MSI metrics as previously described.
- Executing Outdoor leadership and Field research program 100% safely.
- Collecting feedback from ASIP participants accomplished at end of course survey.

Key Stakeholder Engagement.

Students from under-represented minorities will be invited to join other ADAC fellows taking part in the summer internship program in a scheduled summer ADAC *"Customer's and Partner's" Roundtable* as a mentoring and professional development opportunity. ASIP progress will be included in ADAC's quarterly reviews of the Center's efforts in Education Outreach and Workforce Development with DHS S&T OUP Education Outreach and Workforce Development program management.

Student Participation.

Program is focused on participating ADAC fellows and students from underrepresented minorities.

Outcomes/Outputs.

Coached, mentored and professionally developed students from both under-represented minorities and other enrolment categories participating in the ADAC Fellows Program enter DHS enterprise workforce enriched with their expertise gained by working through the ASIP experience.

Transition Plans.

As students prepare to graduate, ADAC Education and Administrative Manager supports student career placement into the positions aligned to HSE. Transition plans will continue past lifecycle of grant for tracking and job initiatives.

Potential programmatic risks to completion.
Affordable housing in both Anchorage/Southcentral and Utqiaġvik, Alaska. As risk mitigation, ADAC works with NOAA and Sandia National Labs to secure housing.

Appendix A: Acronyms

ACNFS	Arctic Cap Nowcast/Forecast System
ADAC	Arctic Domain Awareness Center
ADCIRC51	Advanced Circulation Model
AESC	Arctic Executive Steering Committee
AFP	ADAC Fellows Program
AI	Artificial Intelligence
AIA	Aleut International Association
AIS	Automatic Identification System
AOOS	Alaska Ocean and Observation System
AOSC	Arctic Oil Spill Calculator
ARN	ADAC Research Network
ASRC FS	Arctic Slope Regional Corporation Federal Systems
BOEM	Bureau of Ocean Energy Management
BSSN	Bering Sea Sub-Network
CAFF	Conservation of Arctic Flora and Fauna
CDG	Career Development Grant
CBP	Customs and Border Protection
C&ES AD	Communications and Educational Support Associate Director
CIS	Critical Indicators System
CFS	Climate Forecast System
CMR	Center for Maritime Research
COE	Center of Excellence
CONAS	Community Observing Network for Adaptation and Security
COTS	Commercial Off-the-Shelf
CFS	Climate Forecast System
DGPS	Differential Global Positioning System
DHS	Department of Homeland Security
DHSEM	Division of Homeland Security and Emergency Management (State of Alaska)
DHS S&T OUP	Department of Homeland Security Science & Technology's Office of University
DIPP	Programs

DR	Data Information Protection Plan Disaster Response
E2E	End to End
ED	Executive Director
EO&WFDD	Education Outreach and Workforce Development Director
ERAU	Embry Riddle Aeronautical University (ERAU)
EO&WFDD	Education Outreach and Workforce Development Director
ERMA	Environmental Response Management Application
ET-Storm Surge	Extra Tropical Storm Surge
FEMA	Federal Emergency Management Agency
FMI	Finnish Meteorological Institute
FIST	Field Information Support Tool
FTD	Federal Tribal Designation
FTIR	Fourier Transform Infrared Spectroscopy
GoMRI	Gulf of Mexico Research Initiative
GNOME	General NOAA Operational Modeling Environment
HA	Humanitarian Assistance
HFO	High Fidelity Observer
HIOMAS	High-resolution Ice-Ocean Modeling and Assimilation System
HIPPA	Health Insurance Portability and Accountability Act
HYCOM	Hybrid Coordinate Ocean Model
IANA	Indian and Northern Affairs
IARPC	Interagency Arctic Research Policy Committee
ICECON	Ice Conditions Index
IICWG	International Ice Charting Working Group
IMO	International Maritime Organization
InSAR	Interferometric Synthetic Aperture Radar
IONS	Incidents of National Significance
JTFN	Joint Task Force North (Canada)
KTG	Kestrel Technology Group
LIDAR	Light Detection and Ranging
LPBK	Local Placed Based Knowledge
LRAUV	Long Range Autonomous Underwater Vehicle
LWIR	Longwave Infrared
MBARI	Monterey Bay Aquarium Research Institute
MIZMAS	Marginal Ice Zone Modeling and Assimilation System

MMA	Maine Maritime Academy
MDA	Maritime Domain Awareness
MN	Member Node
MOTR	Maritime Operational Threat Response
MSI	Minority Serving Institutions
MXAK	Marine Exchange of Alaska
NAIS	North American Ice Service
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NCEI	National Centers for Environmental Information
NCEP	National Center for Environmental Prediction
ND	Nova Dine
NIC	National Ice Center
NOAA	National Oceanic and Atmospheric Administration
NSC	National Security Cutter
NSF	National Science Foundation
NWS	National Weather Service
OODA	Observe, Orient, Decide and Act
OGCWS	Open Geospatial Consortium Web Service
OSA	Open Systems Architecture
OUP	Office of University Programs
ORR	Office of Response and Restoration
ONR	Office of Naval Research
PI	Principal Investigator
PII	Personally, Identifiable Information
PIOMAS	Pan-arctic Ice–Ocean Modeling and Assimilation System
PM	Program Manager
PMD	Project Management Director
POA	Port of Anchorage
PolSAR	Polarimetric Synthetic Aperture Radar
RD	Research Director
RPA	Remotely Piloted Aircraft
SAR	Search and Rescue
S&T	Science and Technology
SETS	Social-Ecological-Technological Systems
SDI	Spatial Data Infrastructure
SME	Significant Minority Enrollment
STCW	Standards of Training, Certification, and Watchkeeping
SWAN	Simulating Waves Near Shore

TAMOC	Texas A&M Oil Spill Calculator
TAMU	Texas A&M University
TRL	Technology Readiness Level
UAA	University of Alaska Anchorage
UAF	University of Alaska Fairbanks
UAV	Unmanned Aircraft Vehicle
UDOP	User-defined Operating Picture
UNM	University of New Mexico
UGV	Unmanned Ground Vehicle
USCG	United States Coast Guard
USCG RDC	United States Coast Guard Research and Development Center
USGCRP	U.S. Global Change Research Program
US MDA	United States Maritime Domain Awareness
USN	United States Navy
USNORTHCOM	United States Northern Command
USV	Unmanned Surface Vehicle
UTEP	University of Texas El Paso
UUV	Unmanned Underwater Vehicle
UW	University of Washington
WHOI	Woods Hole Oceanographic Institution

[i] USCG D17 List of infrastructure includes: Airports in Utqiagvik, Nome and Bethel; CG Aviation Support Facility Cold Bay; CG Aviation Support Facility St Paul; CG Forward Operating Location Kotzebue; Port facilities in Nome; Pier and uplands of the of the dock facility that CG utilizes in Dutch Harbor.

Year Eight Arctic Domain Awareness Center (ADAC) Financial Summary

Summary for Center:

Management and Central Administration Costs: $299,819 total costs borne by the award; other costs are from the University of Alaska Anchorage in direct funding or returned Indirect costs back specifically for the project.

By Themes/Projects/Partner:

- **Theme 1: Maritime Risk, Threat Analysis and Resilience Research (Total Theme Costs: $24,362)**
  - Mitigating the Damage to Arctic Copepods from Surface Oil Spills: When to Apply Dispersants **(Carryforward funding only)**
  - Photo-enhanced toxicity of dispersed and burned crude oil to Arctic mussels **(Carryforward funding only)**
  - Marine Induced Polarization Methods for the Detection and Mapping of Oil in an Arctic Marine Oil Spill; Including Investigation of Oil Within and Under Broken Ice Fields **(Carryforward funding only)**
  - Oil Spill Modeling for Improved Response for Arctic Maritime Spills: The Path Forward **(Student funding in the amount of $24,362; all other funding carryforward)**
    - **University of New Hampshire: $**24,362

- **Theme 2: Maritime Domain Awareness (MDA) Research (Total Theme Costs: $281,220)**
  - Ice Condition Index for the Arctic (ARCTICE) **(Total Project Costs: $60,401)**
    - **University of Alaska Anchorage**: $20,593
    - **University of Washington**: $39,808
  - Arctic Vessel Monitoring Geofencing/Alert Awareness **(Total Project Costs: $220,819)**
    - **University of Alaska Anchorage:** $220,819
  - Alaska and Arctic Maritime Communications and Connectivity Analysis (PMC&CA) **(Carryforward funding only)**

- **Theme 3: Maritime Technology Research (Total Theme Costs: $620,144)**
  - Propeller-driven Long-Range Autonomous Underwater Vehicle (LRAUV) for Under-Ice Mapping of Oil Spills and Environmental Hazards **(Total Project Costs: $620,144; all other funding Carryforward)**
    - **Monterey Bay Aquarium Research Institute:** $90,144
    - **Woods Hole Oceanographic Institute**: $530,000
  - Remote Unmanned Aircraft System (UAS) Inspection and Response Team Development in the Bearing Strait Region **(Carryforward funding only)**

- **Theme 4: Integration of Science and Engineering with Maritime Security Governance and Policy Research (Total Theme Costs: $0)**

- **Theme 5 End-to-End (E2E) (Total Theme Costs: $0)**
  - Arctic Facilities and Infrastructure Environmental Change Risk Index (**Carryforward funding only)**

- **Theme 6 Integrated Education (Total Theme Costs: $124,902)**

- Minority Serving Institution (MSI) and Significant Minority Serving Enrollment Outreach and Workforce Development and ADAC Arctic Summer Intern Program (ASIP) **(Total Project Costs: $124,902)**
  - **University of Alaska Anchorage:** $87,150
  - **University of New Orleans:** $37,752

Year 8 Breakdown of Costs and Sources of Funding:
Budget by Theme/Project and Source of Funding:

Project	Base Funding	Arctic IoNS Residual Fundin	Total Funding Request
	$ 24,362.00	**$ -**	**$ 24,362.00**
Mitigating the Damage to Arctic Copepods from Surface Oil Spills: When to Apply Dispersants	$ -	$ -	$ -
Photo-enhanced toxicity of dispersed and burned crude oil to Arctic mussels	$ -	$ -	$ -
Marine Induced Polarization Methods for the Detection and Mapping of Oil in an Arctic Marine Oil Spill; Including Investigation of Oil Within and Under Broken Ice Fields	$ -	$ -	$ -
Oil Spill Modeling for Improved Response for Arctic Maritime Spills: The Path Forward	$ 24,362.00	$ -	$ 24,362.00
Arctic Facilities Infrastructure Environmental Change Risk Index Project	$ -	$ -	$ -
	$ 165,812.00	**$ 115,408.00**	**$ 281,220.00**
Ice Conditions (ICECON) for the Arctic (ARCTICE)	$ 20,593.00	$ 39,808.00	$ 60,401.00
Arctic Vessel Monitoring Geofencing/Alert Awareness	$ 145,219.00	$ 75,600.00	$ 220,819.00
Alaska and Arctic Maritime Communications and Connectivity Analysis (AAMC&CA)	$ -	$ -	$ -
	$ 400,144.00	**$ 220,000.00**	**$ 620,144.00**
Development of Propeller Driven Long Range Autonomous Underwater Vehicle (LRAUV) for Under-Ice Mapping of Oil Spills and Environmental Hazards	$ 400,144.00	$ 220,000.00	$ 620,144.00
Remote Unmanned Aircraft System (UAS) Inspection and Response Team Development in the Bering Strait Region	$ -	$ -	$ -
	$ -	**$ -**	**$ -**
	$ -		$ -
	$ -	**$ -**	**$ -**
Arctic Facilities and Infrastructure Environmental Change Risk Index	$ -	$ -	$ -
	$ 109,863.00	**$ 15,039.00**	**$ 124,902.00**
Minority Service Institution (MSI) and Significant Minority Enrollment (SME) Education Outreach and Workforce Development and ADAC Arctic Summer Intern Program (ASIP)	$ 109,863.00	$ 15,039.00	$ 124,902.00
	$ 299,819.00	**$ (350,447.00)**	**$ (50,628.00)**
Management & Center Administration	$ 299,819.00		$ 299,819.00
Arctic IoNS Remaining Funding (to be used towards base funding request)	$ -	$ (350,447.00)	$ (350,447.00)
	$ 1,000,000.00	**$ -**	**$ 1,000,000.00**

Year 8 Budget Request by Object Class:

Object Class	Year Eight Base	IoNS Residual	Total Funding
Salary and Fringe Benefits	$ 307,957.00	$ 9,946.00	$ 317,903.00
Travel	$ -	$ -	$ -
Contractual	$ -	$ 50,000.00	$ 50,000.00
Commodities	$ -	$ -	$ -
Equipment	$ -	$ -	$ -
Other (Student Support)	$ 58,500.00	$ -	$ 58,500.00
Other (Subawards)	$ 462,258.00	$ 259,808.00	$ 722,066.00
Other Tuition)	$ 13,611.00	$ -	$ 13,611.00
Indirect	$ 157,674.00	$ 30,693.00	$ 188,367.00
Total	$ 1,000,000.00	$ 350,447.00	$ 1,350,447.00

Budget Notes:

- Projects' Funding have been rolled up in this summary. Most detailed justifications regarding requested budget and expenditures can be found in the individual project analysis.
- Projects that are a subaward are listed as contractual in the composite as they are a procurement action on the part of University of Alaska System.
- Indirect and Facilities and Administrative (F&A) costs are used interchangeably.
- Costs follow 2CFR200 to determine allowability, allocability, and reasonableness. These regulations also determine which costs are allowed indirect and which are not.
- Due to rounding composites might be off +/- $2; however exact costs without rounding are $3.6M.
- Institutional support is higher than the normal distribution of returned indirect costs back to ADAC under the University of Alaska Anchorage distribution; indirect costs at the University of Fairbanks are returned based on their model and are not subject to returning funds for institutional support.

Management and Central Administration Costs:

Total Management and Central Administration Budget Request Year 8 Base Funding: $299,819
(see budget object class and justification below for management composite)

Total IoNS Residual Funding: $0

Management and Central Administration Budget Request by Object Class:

Object Class	Year Eight Base	IoNS Residual	Total Funding
Salary and Fringe Benefits	$ 198,293.00	$ -	$ 198,293.00
Travel	$ -	$ -	$ -
Contractual	$ -	$ -	$ -
Commodities	$ -	$ -	$ -
Equipment	$ -	$ -	$ -
Other	$ -	$ -	$ -
Indirect	$ 101,526.00	$ -	$ 101,526.00
Total	$ 299,819.00	$ -	$ 299,819.00

Management Budget Justification:

Senior Personnel Salaries:

PI, Dr. Douglas Causey is requesting one percent effort (21 hours) at $83.76 per hour for scientific leadership of the project as a direct cost on the award. Other effort is being covered via institutional support. Per the University of Alaska Board of Regent's Policy Manual, PIs must charge a minimum effort of one percent to sponsored research and is associated with appropriate projects that Dr. Causey's expertise will be needed. Dr. Causey is responsible for all associated PI duties of the award to include but not limited to management of the ADAC team, obtaining institutional support, reporting required to DHS as per the Terms and Conditions, close collaboration with the Executive Director and the Research Director to achieve ADAC mission goals, seeking to connect ADAC with partners and opportunities, and responsible for program execution and accomplishment to DHS. A leave reserve of 20.6% is included as required under UA's federally negotiated rates with the Office of Naval Research (ONR).

Support is also requested for Executive Director, Randy (Church) Kee for just less than 3.8 months' effort (640 hours) at $70.52 per hour. The Executive Director is responsible for providing day-to-day direction of all Center activities to meet COE goals, achieve milestones, develop technology, communicate with customers and engage the broader Arctic community across the U.S. and Canada, organizing site visits for demonstrations, interface with the end-users, and will work with ADAC leadership to ensure the Center complies with federal regulations and reporting, meeting regularly with DHS staff at DHS headquarters and represent the program at meetings required to support the needs of DHS management and the greater DHS enterprise, working closely with USCG stakeholders to ensure the Center meets USCG expectations, and ensuring ADAC appropriately conducts internal processes, in particular assessment meetings, engagement forums, and DHS sponsored workshops. All other effort not directly attributed to a project is provided by institutional support. A leave reserve rate of 24.1% is included.

Support is also requested for Associate Director, Jason Roe for approximately 2.5 months' effort (445 hours) at $35.09 per hour. The Associate Director is responsible for providing technical coordination with the USCG, to include investigating feasibility and applicability of ADAC research integration to USCG decision support systems, supporting transition activities and research diversification and commercialization research, and assist ADAC ED in

representing the Center at technical exchanges, with DHS, USCG and industry. All other effort not directly attributed to a project is provided by institutional support. A leave reserve rate of 24.1% is included.

Other Personnel Salaries:
Support is also requested for the Business Enterprise Institute (BEI) Communications and Media Broadcast team for one individuals for a total of 668 hours (approximately three months of time) at $24.31 per hour to assist with all the report writing, perform technical editing, website development, content development, videos, Twitter and Facebook accounts, and all Center activities related to Communications unless specified direct time for a specific project. All other effort not directly attributed to a project is provided by institutional support. A leave reserve rate of 23.2% is included.

Support is also requested for a Research Associate, Connor Keesecker for a total of 1576 hours (approximately 9.1 months effort) at $19.14 per hour to assist with all the increased report writing for the final year, perform technical editing, website development, content development, videos, Twitter and Facebook accounts, and all Center activities related to research initiatives not attributed directly to a project. A leave reserve rate of 23.2% is included.

Fringe Benefits:
Benefits are applied according to the University of Alaska's fixed fringe benefit rates for FY21. Rates are 30.4% for faculty, 42.5% for exempt staff, and 54.1% for non-exempt staff. A copy of the rate agreement is available at: http://www.alaska.edu/cost-analysis/negotiation-agreements/
Total request for salary and fringe benefits for personnel: $198,293

Indirect Costs:
Facilities and Administrative (F&A) Costs are negotiated with the University of Alaska Anchorage's cognizant federal authority and on sponsored research are calculated at 51.2% of the modified total direct costs (MTDC). MTDC includes total direct costs (TDC) minus tuition, scholarships/fellowships, subaward amounts over $25,000, participant support costs, and equipment over $5,000. A copy of the rate agreement is available upon request.
Total request for indirect costs: $101,526

Management Budget Notes:

- Additional salary for members of the Executive team is covered by the University of Alaska Anchorage and Fairbanks Institutional Support commitments.

Budget and Justification by Theme by Project:

Theme 1: Maritime Risk, Threat Analysis and Resilience Research

PROJECT: Mitigating the Damage to Arctic Copepods from Surface Oil Spills: When to Apply Dispersants

Project Investigators: Dr. Christoph Aeppli, Dr. David Fields.

Lead Institution: Bigelow Laboratory for Ocean Sciences, East Boothbay, Maine.

Total Project Budget Request Year 8 Base Funding: $0 (All funding that remains for this project if any will be submitted via carryforward process)

PROJECT: Photo-enhanced toxicity of dispersed and burned crude oil to Arctic mussels

Project PI: Dr. Patrick L. Tomco

Lead Institution: University of Alaska Anchorage

Supporting Team:

Colin McGill, UAA Chemistry Department

Katrina Counihan, Alaska Sea Life Center

Phoebe Zito, University of New Orleans

Total Project Budget Request Year 8 Base Funding: $0 (All funding that remains for this project if any will be submitted via carryforward process)

PROJECT: Marine Induced Polarization Methods for the Detection and Mapping of Oil in an Arctic Marine Oil Spill; Including Investigation of Oil Within and Under Broken Ice Fields

Project Investigator: Dr. Socolofsky, Texas A&M University—College Station

Lead Institution: Texas A&M University—College Station

Project supporting researchers:

Dr. Wynn, USGS (Ret.)

Mr. Hand and Ms. Walker, IntelliSense Marine

Nathan Lamie, Lead Engineer/Facility Operator, CRREL (U.S. Army Corps of Engineers)

Total Project Budget Request Year 8 Base funding: $0 (All funding that remains for this project if any will be submitted via the carryforward process)

PROJECT: Oil Spill Modeling for Improved Response to Arctic Maritime Spills: The Path Forward

Project Investigator: Dr. Nancy E. Kinner

Lead Institution: University of New Hampshire Coastal Response Research Center (CRRC), Center for Spills in the Environment (CSE)

Total Project Request for Year 8 Base funding: $24,362 (see budget object class and justification below for project composite)

University of Alaska Anchorage: $0 (All other funding is via carry forward process)
University of New Hampshire: $24,362 (All other funding is via the carry forward process)

Total IoNS Residual Funding: $0

Project Budget Request by Object Class:

Object Class	Year Eight Base	IoNS Residual	Total Funding
Salary and Fringe Benefits	$ -	$ -	$ -
Travel	$ -	$ -	$ -
Contractual	$ -	$ -	$ -
Commodities	$ -	$ -	$ -
Equipment	$ -	$ -	$ -
Other (Subaward)	$ 24,362.00	$ -	$ 24,362.00
Other (Student Support)	$ -	$ -	$ -
Indirect	$ -	$ -	$ -
Total	$ 24,362.00	$ -	$ 24,362.00

Project Budget Notes:

- F&A costs on the subaward to the University of New Hampshire were satisfied in keeping with Uniform Guidance in previous and therefore no F&A are applied to this subaward at the University of Alaska Anchorage.

Individual Project Budget Components:

University of Alaska Anchorage

Total Budget Request for Year 8 Base funding for the University of Alaska Anchorage: $0 (all other funding is via carryforward process)
Total IoNS Residual Funding: $0

University of New Hampshire:

Total Budget Request for Year 8 Base funding for University of New Hampshire: $24,362 (All other funding is via the carry forward process)
Total IoNS Residual Funding: $0
Budget Request by Object Class for University of New Hampshire:

Object Class	Year Eight Base	IoNS Residual	Total Funding
Salary and Fringe Benefits	$ -	$ -	$ -
Travel	$ 4,180.00	$ -	$ 4,180.00
Contractual	$ -	$ -	$ -
Commodities	$ -	$ -	$ -
Equipment	$ -	$ -	$ -
Other (Student Support Tuition)	$ -	$ -	$ -
Other (Participant Support Costs)	$ 13,839.00	$ -	$ 13,839.00
Indirect	$ 6,343.00	$ -	$ 6,343.00
Total	$ 24,362.00	$ -	$ 24,362.00

Budget Justification for the University of New Hampshire:

Other Personnel Salaries:

Graduate student, TBN (new student) will assist with data collection analysis under the supervision of Dr. Kinner. During the summer the student will provide programmatic coding to NOAA ($3,839) and during the academic year student receives a semester stipend of $10,070 as a Research Associate (one semester of funding);

Total request for salary and fringe benefits: $13,839

Travel:

Funding is budgeted for one trip for student to Anchorage to participate in the summer program and for a workshop. Airfare is estimated at $450 per person. Lodging is limited to $150 per person for four nights with per diem for four days at $100 per day. Miscellaneous expenses are estimated at $430 for care rental, airport parking, etc.

Total travel request: $4,180

Indirect Costs:

Facilities and Administrative (F&A) Costs are negotiated with the University of New Hampshires' cognizant federal authority and off sponsored research are calculated at 26% of the modified total direct costs (MTDC). MTDC includes total direct costs (TDC) minus tuition, scholarships/fellowships, subaward amounts over $25,000, participant support costs, and equipment over $5,000. A copy of the rate agreement is available upon request. The indirect rate applied for this request is based on the current approved F&A Rate Agreement.

Total request for indirect costs: $6,343

PROJECT: Arctic Facilities Infrastructure Environmental Change Risk Index Project

Project PI: Dr. Craig Tweedie, University of Texas El Paso, El Paso TX, and Dr. Matthew Calhoun, College of Engineering, University of Alaska Anchorage (UAA), Anchorage AK

Lead Institutions: University of Alaska Anchorage (UAA) and University of Texas El Paso

Project Supporting Researchers:

Dr. Ben Jones, Institute of Northern Engineering, University of Alaska Fairbanks, Fairbanks AK.
Ms. Kelsey Frazier, ADAC Research Associate, UAA.

Mr. Jeff Libby, Director, Applied Environmental Research Center (AERC), UAA
Dr. Molly Grear and TBA, Pacific NW National Laboratories, Sequim, WA. (TBC)
Mr. Nagruk Harcharek, Ukpeaġvik Iñupiat Corporation, Utqiaġvik, AK.

Total Project Budget Request Year 8 Base Funding: $0 (All funding that remains for this project if any will be submitted via carryforward process)

Theme 2: Maritime Domain Awareness Projects

PROJECT: Ice Conditions (ICECON) for the Arctic (ARCTICE)

Commented [GT1]: NOT APPROVED

Project Investigators: Dr. Jifeng Peng, University of Alaska Anchorage

Lead Institution: University of Alaska Anchorage

Project Supporting Team:

Dr. Shawn Butler, University of Alaska Anchorage.
Dr. Jinlun Zhang, University of Washington.
Ms. Kelsey Frazier, University of Alaska Anchorage.

Total Project Budget Request for Year 8 Base Funding: $20,593
University of Alaska Anchorage: $20,593 (All other funding via carry forward process)
University of Washington: $0 (All other funding via carry forward process)
Total IoNS Residual Funding: $39,808
University of Alaska Anchorage: $0 (All other funding via carry forward process)
University of Washington: $39,808 (All other funding via carry forward process)

Project Budget Request by Object Class:

Object Class	Year Eight Base	IoNS Residual	Total Funding
Salary and Fringe Benefits	$ 13,620.00	$ -	$ 13,620.00
Travel	$ -	$ -	$ -
Contractual	$ -	$ -	$ -
Commodities	$ -	$ -	$ -
Equipment	$ -	$ -	$ -
Other (Subaward)	$ -	$ 39,808.00	$ 39,808.00
Other (Student Support)	$ -	$ -	$ -
Indirect	$ 6,973.00	$ -	$ 6,973.00
Total	$ 20,593.00	$ 39,808.00	$ 60,401.00

Individual Project Budget Components:
University of Alaska Anchorage:
Total Budget Request for Year 8 Base Funding for University of Alaska Anchorage: $20,593
(see budget object class and justification below for project composite)
Total IoNS Residual Funding: $0

Budget Request by Object Class for University of Alaska Anchorage:

Object Class	Year Eight Base	IoNS Residual	Total Funding
Salary and Fringe Benefits	$ 13,620.00	$ -	$ 13,620.00
Travel	$ -	$ -	$ -
Contractual	$ -	$ -	$ -
Commodities	$ -	$ -	$ -
Equipment	$ -	$ -	$ -
Other (Student Support)	$ -	$ -	$ -
Indirect	$ 6,973.00	$ -	$ 6,973.00
Total	$ 20,593.00	$ -	$ 20,593.00

Budget Justification and Narrative for University of Alaska Anchorage:

Senior Personnel Salaries:

Support is requested for Dr. Shawn Butler to assist with the ability to technology transfer the application and programming to NIC. Dr. Butler is requesting approximately one month's effort (156 hours) at $55.52 per hour for her assistance and computer programming expertise. A leave reserve rate of 20.6% in included. All personnel will be responsible for final reports to close this project.

Fringe Benefits:

Benefits are applied according to the University of Alaska Anchorage—approved federally negotiated fringe benefit rates.

Total request for salary and fringe benefits: $13,620

Indirect Costs:

Facilities and Administrative (F&A) Costs are negotiated with the University of Alaska Anchorage University's cognizant federal authority and on sponsored research are calculated at 51.2% of the modified total direct costs (MTDC). MTDC includes total direct costs (TDC) minus tuition, scholarships/fellowships, subaward amounts over $25,000, participant support costs, and equipment over $5,000. A copy of the rate agreement is available upon request. The indirect rate applied for this request is based on the current approved F&A Rate Agreement.

Total request for indirect costs: $6,973

University of Washington

Total Budget Request for Year 8 Base funding for the University of Washington: $0 (see budget object class and justification below for project composite)

Total IoNS Residual Funding: $39,808

Budget Request for the Washington by Object Class:

Object Class	Year Eight Base	IoNS Residual	Total Funding
Salary and Fringe Benefits	$ -	$ 24,743.00	$ 24,743.00
Travel	$ -	$ -	$ -
Contractual	$ -	$ -	$ -
Commodities	$ -	$ -	$ -
Equipment	$ -	$ -	$ -
APL Prorated Direct Costs	$ -	$ 8,709.00	$ 8,709.00
Indirect	$ -	$ 6,356.00	$ 6,356.00
Total	$ -	$ 39,808.00	$ 39,808.00

Budget Justification for the University of Washington:

Senior Personnel Salaries:

Research PI, Dr. Jinlun Zhang is requesting 1.15 months' effort at a monthly rate of $14,099 per month to provide scientific leadership focusing on HIOMAS hindcast and forecast sea ice data to be utilized and integrated into the project. Dr. Zhang will also provide technical support and scientific consultation to Axiom Data Sciences after transitioning the 1 km resolution HIOMAS from ADAC to the company. Axiom will conduct regular HIOMAS hindcast and forecast to support USCG, NOAA, NWS, and other Arctic stakeholders.

Fringe Benefits:

The APL benefits and leave rates are applied according to the University of Washington's approved federally negotiated fringe benefit rates with the Department of Health and Human Services (DHHS). The APL-UW total benefit rate is 52.6%.

Total request for salary and APL fringe benefits and leave rate for personnel: $24,743

Other Direct Costs:

APL Prorated Direct Costs: APL-UW's purpose is Research and it is solely funded through grant and contract revenue. APL-UW's operating expenses meet the definition of Direct Costs as defined by 2CFR200.413 and are directly charged to grants and contracts through he application of the Prorated Direct Costs rate (PDC). The PDC rate of 35.6% MTDC was approved by the Office of Naval Research. PDC is included within the MTDC cost base for F&A recovery.

Total request for other direct costs: $8,709

Indirect Costs:

Facilities and Administrative (F&A) Costs are negotiated with the University of Washington's cognizant federal authority (DHHS) and on sponsored research are calculated at 17.0% of the modified total direct costs (MTDC). MTDC includes total direct costs (TDC) minus tuition, scholarships/fellowships, subaward amounts over $25,000, participant support costs, and equipment over $5,000. A copy of the rate agreement is available upon request. The indirect rate applied for this request is based on the current F&A Rate Agreement dated 23 April 2015.

Total request for indirect costs: $6,356

Project Budget Notes:

- F&A costs on the subaward to the University of Washington was satisfied in keeping with Uniform Guidance in year one and therefore no F&A are applied to this subaward at the University of Alaska Anchorage.

PROJECT: Arctic Vessel Monitoring Geofencing/Alert Awareness

Project Investigators: Dr. Shawn Butler

Lead Institutions: University of Alaska Anchorage (UAA)

Total Project Budget Year 8 Base Funding Request: $145,219 (All other funding is via the carry forward process)

University of Alaska Anchorage: $145,219

Total IoNS Residual Funding: $75,600

Project Budget Request by Object Class:

Object Class	Year Eight Funding	IoNS Residual	Total Funding
Salary and Fringe Benefits	$ 96,044.00	$ -	$ 96,044.00
Travel	$ -	$ -	$ -
Contractual	$ -	$ 50,000.00	$ 50,000.00
Commodities	$ -	$ -	$ -
Other (Subaward)	$ -	$ -	$ -
Indirect	$ 49,175.00	$ 25,600.00	$ 74,775.00
Total	$ 145,219.00	$ 75,600.00	$ 220,819.00

Project Budget Notes:

- UAA already has a prior existing relationship with Axiom Data Sciences; therefore, costs for Axiom Data Sciences are treated consistently and as a vendor with UAA.

Individual Project Budget Components:

University of Alaska Anchorage:

Total Budget Request for Year 8 Base Funding for University of Alaska Anchorage: $145,219 (see budget object class and justification below for project composite; all other funding is via the carry forward process)

Total IoNS Residual Funding: $75,600

Budget Request by Object Class for University of Alaska Anchorage:

Object Class	Year Eight Funding	IoNS Residual	Total Funding
Salary and Fringe Benefits	$ 96,044.00	$ -	$ 96,044.00
Travel	$ -	$ -	$ -
Contractual	$ -	$ 50,000.00	$ 50,000.00
Commodities	$ -	$ -	$ -
Other (Subaward)	$ -	$ -	$ -
Indirect	$ 49,175.00	$ 25,600.00	$ 74,775.00
Total	$ 145,219.00	$ 75,600.00	$ 220,819.00

Budget Justification for the University of Alaska Anchorage:

Senior Personnel Salaries:

Funding is requested for Research PI, Dr. Shawn Butler for 1100 hours of effort (approximately 6.3 months) at $55.52 per hour to oversee Axiom Data Sciences, a student, for the additional scope of work requested by USCG D-17. Dr. Butler will oversee and coordinate validating end-user geofencing and notification requirements, developing enhanced AIS geofencing and notification software, and evaluating the software against stakeholder requirements. A leave reserve rate of 20.6% is included.

Fringe Benefits:

Benefits are applied according to the University of Alaska's fixed fringe benefit rates for FY21. Rates are 30.4% for faculty. A copy of the rate agreement is available at: http://www.alaska.edu/cost-analysis/negotiation-agreements/

Total request for salary and fringe benefits: $96,044

Contractual:

The University of Alaska Anchorage is requesting $50,000 for a contract with Axiom Data Sciences. Axiom Data Sciences will be able to assist with creating a user profile to store desired alert parameters along with an appropriate way for the user to edit, manage, and import/export the geofence parameters. For example, the new software codes may trigger the dissemination of vessel notification information via smartphone application, social media platforms, email, and text messages to the various agencies and communities, depending on user preferences.

Total request for contractual costs: $50,000

Indirect Costs:

Facilities and Administrative (F&A) Costs are negotiated with the University of Alaska Anchorage's cognizant federal authority and on sponsored research are calculated at 51.2% of the modified total direct costs (MTDC). MTDC includes total direct costs (TDC) minus tuition, scholarships/fellowships, subaward amounts over $25,000, participant support costs, and equipment over $5,000. A copy of the rate agreement is available upon request. The indirect rate applied for this request is based on the current approved F&A Rate Agreement.

Total request for indirect costs: $74,775

PROJECT: Alaska and Arctic Maritime Communications and Connectivity Analysis (AAMC&CA)

Project Investigators: Associate Director Jason Roe and Dr. Shawn Butler

Lead Institutions: University of Alaska Anchorage

Total Project Budget Year 8 Base funding Request: $0 (All funding that remains for this project if any will be submitted via carryforward process)

Theme 3: Maritime Technology Research

PROJECT: Development of Propeller Driven Long Range Autonomous Underwater Vehicle (LRAUV) for Under-Ice Mapping of Oil Spills and Environmental Hazards

Project Investigators: Dr. James Bellingham (WHOI), Amy Kukulya (WHOI) and Brett Hobson (MBARI)

Lead Institutions: Woods Hole Oceanographic Institution (WHOI) and Monterey Bay Aquarium Research Institution (MBARI)

Supporting Team:

Amanda Besaw (WHOI)
Sean Whelan (WHOI)
Daniel Gomez-Ibanez (WHOI)

Total Project Budget Year 8 Base funding Request: $400,144
Monterey Bay Aquarium Research Institute (MBARI): $90,144
Woods Hole Oceanographic Institute: $310,000
Total IoNS Residual Funding: $220,000
Monterey Bay Aquarium Research Institute (MBARI): $0
Woods Hole Oceanographic Institute: $220,000

Project Budget Request by Object Class:

Object Class	Year Eight Base	IoNS Residual	Total Funding
Salary and Fringe Benefits	$ -	$ -	$ -
Travel	$ -	$ -	$ -
Contractual	$ -	$ -	$ -
Commodities	$ -	$ -	$ -
Equipment	$ -	$ -	$ -
Other (Subawards)	$ 400,144.00	$ 220,000.00	$ 620,144.00
Indirect	$ -	$ -	$ -
Total	$ 400,144.00	$ 220,000.00	$ 620,144.00

Individual Project Budget Components:
Monterey Bay Aquarium Research Institute (MBARI)
Total Year 8 Base funding Budget Request for Monterey Bay Aquarium Research Institute:
$90,144 (see budget object class and justification below for project composite)
Total IoNS Residual Funding: $0

Budget Request by Object Class for Monterey Bay Aquarium Research:

Object Class	Year Eight Base	IoNS Residual	Total Funding
Salary and Fringe Benefits	$ 59,111.00	$ -	$ 59,111.00
Travel	$ -	$ -	$ -
Contractual	$ -	$ -	$ -
Commodities	$ -	$ -	$ -
Equipment	$ -	$ -	$ -
Other	$ -	$ -	$ -
Indirect	$ 31,033.00	$ -	$ 31,033.00
Total	$ 90,144.00	$ -	$ 90,144.00

Budget Justification and Narrative for Monterey Bay Aquarium:
Senior Personnel Salaries:
Research PI, Mr. Brett Hobson is requesting 80 hours' effort at $89.36 per hour for the following: 45 hours to support the LRAUV construction at WHOI and 35 hours to contribute to the final report and testing.

Support is requested for Software Engineer, Mr. Brian Keift for 200 hours at $88.66 per hour. 65 hours have been requested to continue development of the software infrastructure to support the upward-looking DVL for navigation and an additional safety envelope. 60 hours is requested to improve the vehicle side of the acoustic communication system. 20 hours is requested to write and publish results from field trials. 35 hours is requested to contribute necessary documentation to the final report.

Other Personnel Salaries:
Support is requested for a research specialist for 200 hours at $63.66 per hour, Mr. Ben Raan. Mr Raan will complete the following: 60 hours have been requested to continue development of the software infrastructure to support the upward-looking DVL for navigation and an additional safety envelope. 50 hours is requested for integration and testing of the mission planning and execution of waypoints generated by MB system for mapping. 55 hours to requested to write and publish results from field trials and notes. 35 hours is requested to contribute necessary documentation to the final report

Fringe Benefits:
Benefits are applied according to the Monterey Bay Aquarium Research Institute set annually. The federally negotiated fringe benefit rates for 2018-2021 are negotiated by NOAA. The base is labor dollars and the pool costs consist of payroll taxes, health benefits, retirement benefits, workers compensation, and leave. The predetermined rate for full-time regular and part-time (30-39hrs/wk) employees is 57.15%.
Total request for salary and fringe benefits: $59,111

Indirect Costs:
The negotiated institutional indirect cost rate is 52.5% Modified Total Direct Cost. The base excludes capital items, participant support costs, subcontract costs exceeding the first $25K of each subcontract, internal ship time, and MARS port fees. MBARI also excludes costs associated with fixed assets from OH. The exclusion applies to all costs directly associated with the internal construction costs of an asset including, but not limited to wages, fringe, components, and any costs necessary to make the asset operational. The Federal Cognizant Agency Official at NOAA is Lamar Revis: lamar.revis@noaa.gov, 301-628-1308, Grants Management Division, NOAA, 1325 EAST WEST HWY, Room # 9332, Silver Spring, MD 20910-3283.
Total request for indirect costs: $31,033

Woods Hole Oceanographic Institute (WHOI)

Total Budget Request for Year 8 Base funding for the Woods Hole Oceanographic Institute: $310,000 (all other funding via the carry forward process, see budget object class and justification below for project composite)
Total IoNS Residual Funding: $220,00

Budget Request for the Woods Hole Oceanographic Institute by Object Class:

Object Class	Year Eight Base	IoNS Residual	Total Funding
Salary and Fringe Benefits	$ 188,550.00	$ 89,018.00	$ 277,568.00
Travel	$ -	$ -	$ -
Contractual	$ -	$ 18,924.00	$ 18,924.00
Commodities	$ -	$ 19,988.00	$ 19,988.00
Equipment	$ -	$ -	$ -
Other	$ -	$ 5,875.00	$ 5,875.00
Indirect	$ 121,450.00	$ 86,195.00	$ 207,645.00
Total	$ 310,000.00	$ 220,000.00	$ 530,000.00

Budget Justification for the Woods Hole Oceanographic Institute:

Senior Personnel Salaries:

Funding is requested for A. Kukulya, Principal Investigator, (4.72 mos) will be responsible for overall operations and coordination. She will participate in and oversee the completion of the vehicle build, planning local logistics, and local testing. She will be involved with data analysis reporting. She will also be responsible for coordinating with MBARI.

Other Personnel Salaries:

Funding is requested for D. Gomez-Ibanez, Research Engineer, (.25 mos) will assist with the electrical integration.

Funding is requested for Engineer II, TBD, (4.21 mos) will develop backseat software, assist with the completion of the vehicle build, and participate in local testing.

Funding is requested for J. Kapit, Senior Engineer, (1.0 mos) will assist with the completion of the vehicle build and lead the mechanical integration.

Funding is requested for N. Yoder, Engineer II, (4.75 mos) will participate in system readiness and completion of the vehicle build. She will participate in local testing operations.

Funding is requested for S. Seeberger, Engineer II, (3.0 mos) will participate in systems software integration and the multibeam integration.

Funding is requested for W. Pardis, Engineer I, (0.5 mos) will assist with completion of the vehicle build.

Funding is requested for A. Besaw, Administrative Associate I, (2.95 mos) A small amount of support for administrative assistance is requested to assist with reporting, budget tracking, making travel arrangements and processing reimbursements, purchasing, and other administrative tasks that are related to the project and are not supported by overhead.

Total request for salary and fringe benefits: $277,568

Materials and Supplies(Commodities):

Build supplies are requested @ $15,000 which includes vehicle cabling and hard drives, high speed data download cables, hardware and miscellaneous build materials. Data drives, tools, tape and cradles are requested at $4,988, which will all be used during field-testing locally.
Total request for materials and supplies: $19,988

Other Direct Costs:
Funding is requested for WHOI Technical Assistance (Recharge Center): 228 hours @ $83/hour is requested for support related to system readiness, data analysis and visualization. Technical Assistance is also requested for the multibeam integration and producing testing documentation.

Funding is requested for communications: $3,000 is requested for vehicle iridium, cellular and Argos communications.

Funding is requested for OSL Hurricane is operated as a WHOI cost center with an established day rate calculated by dividing the operating costs by the days of anticipated operation. The Hurricane costs $575 per half-day of use and will be used to support local water testing of the LRAUV for 5 half-days.
Total request for other direct costs: $24,799

Indirect Costs:
MTDC (64.4152%) Indirect costs include expenses associated with conducting scientific research, operating the institution, and maintaining buildings. MTDC is applied to all direct salaries and wages, applicable fringe benefits, materials and supplies, services and travel. WHOI's Fiscal Year runs from Jan. 1 - Dec. 31 (with the calendar year). The 2021 indirect cost rate for WHOI is 63.84% of the Modified Total Direct Costs (MTDC) and 65% for year 2022 and beyond. Since proposal periods cross fiscal years, composite rates or weighted averages are calculated based upon the duration of time spent in each fiscal year in accordance with WHOI's 2021 provisional rate agreement (dated 12/30/2020) and 2019 Provisional Forward Pricing Letter (dated 2/12/2019) with the Office of Naval Research. These weighted averages apply to fringe benefit rates and F&A.
Total request for indirect costs: $207,645

Budget Notes:
The Woods Hole Oceanographic Institution (WHOI) is a non-profit [501(c)(3)] research and education organization subject to the cost principles of 2 CFR 200. WHOI Principal Investigators are responsible for conceiving, funding and carrying out their research programs. Senior Personnel are expected to raise 12 months of support per calendar year for themselves and their staff by writing proposals and obtaining sponsored research grants and contracts from a variety of sources. Some teach voluntarily in WHOI's Joint Program, but support for this is
limited. NSF has confirmed to WHOI that salary support from grants beyond 2 months per calendar year can be justifiable for these Principal Investigators.

The rates included in the proposal are negotiated with our cognizant government agency.

WHOI has a negotiated rate agreement with the Office of Naval Research and uses the method of allocation of indirect costs to Modified Total Direct Costs (MTDC). The

normal exclusions contained in 2 CFR 200.68 (MTDC) apply, as well as the following cost categories; ship use, submersible use, vessel charters and ship fuel.

A proposed labor month is equal to 152 hours or 1824 hours annually versus 2080 hours (40 hours/week for 52 weeks). The difference is for vacations, holidays, sick time, and other paid absences, which are included in the Paid Absences calculation. WHOI cannot "waive" or reduce overhead rates on any sponsored research project due to the structure of our negotiated rates with our cognizant government agency (Office of Naval Research). When a program sets limits on overhead, WHOI must use Institution unrestricted funds to pay the unfunded portion of the overhead costs.

Employee benefits have been proposed using composite weighted average rates that are the total assignable to salaries of regular employees including paid absences, excluding Graduate Research Assistants, overtime salaries & allotted paid leave benefits. The period composite rates are weighted averages of the specific rates for each fiscal year in accordance with WHOI's 2019 provisional rate agreement (dated 12/21/2018) and 2019 Provisional Forward Pricing Letter (dated 2/12/2019) with the Office of Naval Research.

PROJECT: Remote Unmanned Aircraft System (UAS) Inspection and Response Team Development in the Bering Strait Region

Project PI: Dr. Jessica Garron

Lead Institution: University of Alaska Fairbanks

Total Project Year 8 Base funding Budget Request: $0 (All funding that remains for this project if any will be submitted via carryforward process)

Theme 4: Integration of Science and Engineering with Maritime Security Governance and Policy Research

No projects currently awarded align to this Theme; therefore, no funding is dedicated to this theme.

Theme 5: End to End (E2E)

PROJECT: Arctic Facilities and Infrastructure Environmental Change Risk Index
Project Investigators: Dr. Craig Tweedie, University of Texas El Paso, El Paso TX, and Dr. Matthew Calhoun, College of Engineering, University of Alaska Anchorage (UAA), Anchorage AK

Project Supporting Researchers:

Dr. Ben Jones, Institute of Northern Engineering, University of Alaska Fairbanks, Fairbanks AK.
Ms. Kelsey Frazier, ADAC Research Associate, UAA.
Mr. Jeff Libby, Director, Applied Environmental Research Center (AERC), UAA
Dr. Molly Grear and Dr. Kerry Lee, Pacific NW National Laboratories, Sequim, WA.
Mr. Nagruk Harcharek, Ukpeaġvik Iñupiat Corporation, Utqiaġvik, AK.

Lead Institution: University of Alaska Anchorage

Total Project Year 8 Base funding Budget Request: $0 (All funding that remains for this project if any will be submitted via carryforward process)

Theme 6: Integrated Education

PROJECT: Minority Service Institution (MSI) and Significant Minority Enrollment (SME) Education Outreach and Workforce Development and ADAC Arctic Summer Intern Program (ASIP)
Project PI: ADAC Education Manager Elizabeth Matthews

Lead Institution: University of Alaska Anchorage

Total Project Year 8 Base funding Budget Request: $109,863 (all other funding will be via carry forward funding)
University of Alaska Anchorage: $72,111
University of New Orleans: $37,752
Total IoNS Residual Funding: $15,039
University of Alaska Anchorage: $15,039
University of New Orleans: $0

Project Budget Request by Object Class:

Object Class	Year Eight Base	IoNS Residual	Total Funding
Salary and Fringe Benefits	$ -	$ 9,946.00	$ 9,946.00
Travel	$ -	$ -	$ -
Contractual	$ 37,752.00	$ -	$ 37,752.00
Commodities	$ -	$ -	$ -
Other (Student Support)	$ 72,111.00	$ -	$ 72,111.00
Indirect	$ -	$ 5,093.00	$ 5,093.00
Total	$ 109,863.00	$ 15,039.00	$ 124,902.00

University of Alaska Anchorage Budget Justification

Total Year 8 Base funding Budget Request for the University of Alaska Anchorage: $72,111(see budget object class and justification below for project composite)
Total IoNS Residual Funding: $15,039

Budget Request for the University of Alaska Anchorage by Object Class:

Object Class	Year Eight Base	IoNS Residual	Total Funding
Salary and Fringe Benefits	$ -	$ 9,946.00	$ 9,946.00
Travel	$ -	$ -	$ -
Contractual	$ -	$ -	$ -
Commodities	$ -	$ -	$ -
Other (Student Support)	$ 72,111.00	$ -	$ 72,111.00
Indirect	$ -	$ 5,093.00	$ 5,093.00
Total	$ 72,111.00	$ 15,039.00	$ 87,150.00

Budget Justification for the University of Alaska Anchorage:
Senior Personnel Salaries:

Education and Administration Manager, Ms. Elizabeth Matthews is requesting 179.7 hours effort (approximately ten months) at $30.54 per hour for leadership, development, and management of the ADAC Fellows programs. Ms. Matthews will oversee the activities of the students along with ADAC faculty mentors and ensure compliance for workplans. Participate in professional exchanges with USCG, in particular via the Arctic IoNS and MaLTE workshops, and any corresponding tabletop seminars. Ms. Matthews will arrange for ADAC Fellows to accompany ADAC leadership to forums with U.S. Federal enterprises in the greater Anchorage area. attend monthly Fellows meetings with Center leadership include providing professional mentoring, updates on the HSE and discussion about research efforts conducted by ADAC Fellows in their respective ADAC projects and beyond, collaborate with Project PIs/lead(s) and Fellows will develop individual student research work plans to map out their expected participation and contribution to ADAC's research projects, or Center led activities, participate in significant maritime focused forums hosted in Anchorage Alaska, participate in an ADAC Summer Internship Program as an option to satisfy one of two required summer research internships, integrate five Minority Summer Interns from Minority Serving (MSI) or Significant Minority Enrollment (SME) Institutions to ADAC's Summer Internship Program, and participate (as a program graduate) as desired, in post-graduate mentoring and networking by Center leadership seeking entry into the HSE. A leave reserve rate of 24.1% is included.

Fringe Benefits:
Benefits are applied according to the University of Alaska's System approved federally negotiated fringe benefit rates for both Anchorage. A copy can be provided upon request.
Total request for salary and fringe benefits for personnel: $9,946

Other Costs (Student Support):
Support is requested to continue support for five undergraduate students: Brenda Almanza and four new students to assist the ADAC team and Dr. Craig Tweedie with ASIP program content development and coordinate with the ADAC team and USCG and support various projects and complete independent studies as they relate directly to projects at the Center. Support is requested for 10 months' effort at $1,000 per month. Brenda Almanza's tuition for fall and spring is approximately $8,500 and for the other four students tuition is budgeted at $6,805.50 for fall and spring.
Total request for other costs (student support): $72,111

Indirect Costs:
Facilities and Administrative (F&A) Costs are negotiated with the University of Alaska Anchorage's cognizant federal authority and on sponsored research are calculated at 51.2% of the modified total direct costs (MTDC). MTDC includes total direct costs (TDC) minus tuition, scholarships/fellowships, subaward amounts over $25,000, participant support costs, and equipment over $5,000. A copy of the rate agreement is available upon request. The indirect rate applied for this request is based on the current approved F&A Rate Agreement.
Total request for indirect costs: $5,093

University of New Orleans

Total Budget Request Year 8 Base funding for University of New Orleans: $37,752
(All other funding is via the carry forward process)
Budget Request by Object Class for University of New Orleans:

Object Class	Year Eight Base	IoNS Residual	Total Funding
Salary and Fringe Benefits	$ -	$ -	$ -
Travel	$ -	$ -	$ -
Contractual	$ -	$ -	$ -
Commodities	$ -	$ -	$ -
Other (Student Support)	$ 28,552.00	$ -	$ 28,552.00
Indirect	$ 9,200.00	$ -	$ 9,200.00
Total	$ 37,752.00	$ -	$ 37,752.00

Budget Justification for the University of New Orleans:
Other Personnel Salaries:
Graduate Student Katherine Humpal will assist with data collection and analysis under the supervision of Zito. During the academic year she receives a monthly stipend of $2,000 as a Research Associate for a total of $10,000 per semester (fall and spring). Ms. Humpal was only partially funded in the original proposal approved by DHS. This funding allows her to continue on the project. Continued support will allow her to assist with conducting static exposure tests with bay mussels in seawater with oil, Corexit 9500, oil dispersed with Corexit 9500, and oil subjected to *in-situ* burn with three different photoperiods, assess physiological and biochemical responses of bay mussels to the oil, dispersant, and *in-situ* burned oil in the exposure tests at different time points, evaluate metabolic health of mussels in the exposure tests using metabolomics and profile the chemical constituencies of oil, dispersed oil, and burned oil treatments used in the mussel exposures and how each treatment chemically weathers throughout the experiment.
Total request for salary and fringe benefits: $20,000

Tuition Support:
Tuition funding is also requested for graduate student Humpal (Fall and Spring semesters) at $4,276 per semester (fall and spring semester); total tuition request for graduate students is $8,552.
Total request for tuition support: $8,552

Indirect Costs:
Facilities and Administrative (F&A) Costs are negotiated with the University of New Orleans' cognizant federal authority and on sponsored research are calculated at 46% of the modified total direct costs (MTDC). MTDC includes total direct costs (TDC) minus tuition, scholarships/fellowships, subaward amounts over $25,000, participant support costs, and equipment over $5,000. A copy of the rate agreement is available upon request. The indirect rate applied for this request is based on the current approved F&A Rate Agreement.
Total request for indirect costs: $9,200

Project Budget Notes:

- F&A costs on the subawards were satisfied in keeping with Uniform Guidance in previous year and therefore no F&A are applied to this subaward at the University of Alaska Anchorage.

Arctic Domain Awareness Center (ADAC) Formal Carry Forward Request Budget Justification

Year 7 Carry Forward Request – Summary for Center

Prepared by: Heather L. Paulsen, Finance Director
Revised on: May 14, 2021
Note: Financial data for expenditures is from the mid-year review. Since carry forward requests are due prior to the close of the federal budget cycle, these balances are subject to further review in the remaining quarter and subject to change at year end reconciliation. While additional charges continue to post, the charges are not captured in this report; however, the charges are part of the projection analysis to determine appropriate carry forward. Due to COVID-19 many of the estimates received from subawards may need to be adjusted at year end as states issue executive orders that prevent several of the projects to be performed in laboratory, field, or machinery settings or not able to return as quickly as anticipated.

Carry Forward Analysis: This summary includes all sources of funding (year seven main base funding), and previous carry forward requests for proposal funding, and reserve funding from Department of Homeland Security (DHS). Projects that are a subaward are listed as contractual in the roll up as they are a procurement action on the part of ADAC.

Total Carry Forward Request: $1,434,882.63

Budget Category	FY Award Budget #22 - Face Page	Funds Spent From FY Award (Whole Numbers Only)	Projected Balance to be Carried Over (Whole Numbers Only)	Amount Requested for Contin. Award	Sum of Projected Carry-over and Contin Award Request
a. Personnel	$ 578,490.45	$ 63,063.60	$ 112,560.00	$ 307,957.00	$ 420,517.00
b. Fringe Benefits	$ 202,921.00	$ -	$ -	$ -	$ -
c. Total Personnel Costs	$ 781,411.45	$ 63,063.60	$ 112,560.00	$ 307,957.00	$ 420,517.00
d. Equipment	$ -	$ -	$ -	$ -	$ -
e. Supplies	$ 1,558.00	$ -	$ 300.00	$ -	$ 300.00
f. Travel	$ 98,120.00	$ -	$ 18,820.00	$ -	$ 18,820.00
g. Construction	$ 60,000.00	$ -	$ -	$ -	$ -
h. Other	$ 1,816,787.94	$ 1,339,156.94	$ 359,647.00	$ 72,111.00	$ 431,758.00
i. Contractual	$ 2,613,914.59	$ 1,966,932.62	$ 829,256.99	$ 462,258.00	$ 1,291,514.99
j. Total Direct Costs	**$ 5,371,791.98**	**$ 3,369,153.16**	**$ 1,320,583.99**	**$ 842,326.00**	$ 2,162,909.99
k. Indirect Costs	$ 520,541.02	$ 128,935.03	$ 114,298.64	$ 157,674.00	$ 271,972.64
n. Recipeint Share**	$ -	$ -	$ -	$ -	$ -
Total	**$ 5,892,333.00**	**$ 3,498,088.19**	**$ 1,434,882.63**	**$ 1,000,000.00**	**$ 2,434,882.63**
**Institutional Support is returned indirect to the program; no formal pledge to DHS; therefore, not reported as recipient share					
Note: All entities are subawards and therefore listed under contractual					

Carry Forward Justification:
Carry forward is being requested for the following projects:

- University of Alaska Anchorage (UAA) in the amount of $38,400.26 for Photo-enhanced toxicity of dispersed and burned crude oil to Arctic mussels;
- Induced Polarization Associates (IPA) in the amount of $63,396.58 and IntelliSense Marine LLC in the amount of $17,110.37, and the University of Alaska Anchorage in the amount of $60,480 for Marine Induced Polarization Methods for the Detection and Mapping of Oil in An Arctic Marine Oil Spill, including investigation of oil within and under broken ice fields. Total request for carryforward for this project is $140,986.95;
- University of New Hampshire (UNH) in the amount of $30,493.23 for Oil Spill Modeling for Improved Response to Arctic Maritime Spills: The Path Forward;

- Ukpeaġvik Iñupiat Corporation (UIC) in the amount of $9,920, University of Alaska Anchorage (UAA) and University of Alaska Fairbanks (UAF) in the amount of $116,664.38, and University of Texas El Paso (UTEP): 50,204 for Arctic Facilities and Infrastructure Environmental Change Risk Index. Total carryforward request for this project $156,948.38;
- Alaska Marine Prevention and Response Network (AMPRN) in the amount of $15,475, ASRC Federal Mission Solution in the amount of $114,614, Ukpeagvik Inupiat Corporation (UIC) in the amount of $13,778 for Alaska and Arctic Maritime Communications and Connectivity Analysis. Total carryforward request for this project $143,867;
- Monterey Bay Aquarium Research Institution (MBARI) in the amount of $156,335 and Woods Hole Oceanographic Institute (WHOI) in the amount of $200,000 for Development of Propeller Driven Long-Range Autonomous Underwater Vehicle (LRAUV) for Under-Ice Mapping of Oil Spills and Environmental Hazards. Total carryforward request for this project $356,335;
- Model Forest Policy Program (MFPP) in the amount of $27,311.84, Native Village of Unalaskleet (NVU) in the amount of $73,674.98, University of Alaska Fairbanks in the amount of $103,618 and University of Alaska Anchorage in the amount of $12,800 for Remote Unmanned Aircraft System (UAS) Inspection and Response Team Development in the Bearing Strait Region. Total carryforward request for this project $217,404.84;
- University of Alaska Anchorage in the amount of $350,447 for Arctic-related Incidents of National Significance (IoNS) Knowledge-based Projects and for the ADAC supported Arctic Air Table Top Exercise.

Note: Carry forward for subawards is rolled into contractual services since the monies received to these institutions is done via a procurement method (i.e. subaward). No carry forward is being requested for ADAC center management. Details of each specific carry forward request are within the project roll ups and supplemental funding requests in the subsequent pages.

Year 7 Management and Central Administration Costs

Management and Central Administration

No carry forward being requested for Management and Central Administration costs.

Year 7 Carry Forward by Project

Theme 1: Maritime Risk, Threat Analysis and Resilience Research Projects

PROJECT: Mitigating the Damage to Arctic Copepods from Surface Oil Spills: When to Apply Dispersants
Project Principal Investigators: Drs. Christoph Aeppli and David Fields, Bigelow Laboratory for Oceans Sciences
No carry forward being requested for this project.

PROJECT: Photo-enhanced toxicity of dispersed and burned crude oil to Arctic mussels
Project Principal Investigators: Drs. Patrick Tomco and Colin McGill, University of Alaska Anchorage, Katrina Counihan, Alaska SeaLife Center, and Phoebe Zito, University of New Orleans.

Total Carry Forward Request: $38,400.26

Budget Category	FY Award Budget #22 - Face Page	Funds Spent From FY Award (Whole Numbers Only)	Projected Balance to be Carried Over (Whole Numbers Only)	Amount Requested for Contin. Award	Sum of Projected Carry-over and Contin Award Request
a. Personnel	$ 34,287.00	$ 25,334.00	$ 8,953.00	No additonal funding	$ 8,953.00
b. Fringe Benefits	$ -	$ -	$ -	requested for this pr	$ -
c. Total Personnel Costs	$ 34,287.00	$ 25,334.00	$ 8,953.00	Year 8.	$ 8,953.00
d. Equipment	$ -	$ -	$ -	$ -	$ -
e. Supplies	$ -	$ -	$ -	$ -	$ -
f. Travel	$ -	$ -	$ -	$ -	$ -
g. Construction	$ -	$ -	$ -	$ -	$ -
h. Other	$ 13,851.00	$ 13,851.00	$ -	$ -	$ -
i. Contractual	$ 37,752.00	$ 21,308.00	$ 16,444.00	$ -	$ 16,444.00
j. Total Direct Costs	**$ 85,890.00**	**$ 60,493.00**	**$ 25,397.00**	**$ -**	**$ 25,397.00**
k. Indirect Costs	$ 17,557.00	$ 4,553.74	$ 13,003.26	$ -	$ 13,003.26
n. Recipeint Share**	$ -	$ -	$ -	$ -	$ -
Total	**$ 103,447.00**	**$ 65,046.74**	**$ 38,400.26**	**$ -**	**$ 38,400.26**

**Institutional Support is returned indirect to the program; no formal pledge to DHS; therefore, not reported as recipient share

Note: Alaska Sea Life Center and the Univeristy of New Olreand are listed under contractual as a subaward; UAF Facility use is listed under contractual as a recharge center

Carry Forward Justification:

Drs. Tomco and McGill's project entitled, "Photo-enhanced toxicity of dispersed and burned crude oil to Arctic mussels" was funded from the Issues Request for Proposals (RFP) and therefore, the original budget was a two-year project. The project team is expected to meet deliverables and tasks; however, the project started April 18, 2019 and due to a breaking of an instrument that was needed for analysis that could not be repaired during COVID, the project is slightly delays. The mussel's exposure work continued slower than expected in program year 7 due to COVID-19 mitigation that significantly limited access to laboratory spaces to conduct bench analytical work. While most phases of the project remain on schedule to complete in program year 7, the chemical extraction of mussel tissues was slowed at UAA due to significant restrictions on the number of bench space users and instrument time permissions. Additionally, unanticipated instrument repairs were required for the Nuclear Magnetic Resonance (NMR) Spectrometer, which is an instrument utilized to collect project data. The instrument has been repaired and the majority of sample data have been collected. Preliminary data appear to be of acceptable quality, however, a comprehensive statistical data analysis will reveal if all spectra are of appropriate quality, or if a couple samples would need to be re-run. This would require running a small number of flagged samples at the beginning of program year 8. The funding that is being asked to carry forward is the budget for year two of the project. The following entities associated with this project are requesting carry forward funding:

- Support for salaries for Dr. McGill. The UAA team is responsible for overseeing the project, metabolomics, and acting as the main point of contact for project stakeholders (including the HQ USCG Project Champion and ADAC central leadership). Tomco will provide project updates at weekly ADAC call and monthly HQ USCG Project Champion steering meetings. One month of salary in both years is requested at $8,953 per year. Team member McGill (40 hours in year 2) will oversee the analysis of biochemical data in the summer of 2021. He will perform extractions and analyze the collected data, e.g. peroxide formation, ATP/ADP, and cell apoptosis. A 10.3% leave reserve is included. Remaining funding for personnel is $8,953; this will allow for summer salary that occurs after June 30th.
- Support is also requested for NMR analysis to meet project milestones and bill the instrument time ($15,000). The work will not be billed until the instrumentation has been used to successfully acquire project data, which is anticipated in November 2020

and associated compressed gas cylinders that are needed for the NMR analysis ($1,444).
- The indirect costs associated with the request for carryforward funding for the University of Alaska Anchorage portion of the project is $4,553.74.

The funding will complete the following tasks specifically as outlined in the approved Work Plan:

- Phase 2: Conduct physiological and biochemical assays (started but will need to complete)
- Phase 3: Perform metabolomics analysis
- Phase 4: Profile chemical constituencies of water-accommodated petroleum and photo-degraded petroleum
- Phase 5: Synthesize data and prepare knowledge products

Tasks are on schedule to be completed by April 2022. Therefore, there is no impact on the future funding of the project or activity.

PROJECT: Marine Induced Polarization Methods for the Detection and Mapping of Oil in An Arctic Marine Oil Spill, including investigation of oil within and under broken ice fields.
Project Principal Investigator: Dr. Scott Socolofsky, Texas A&M University—College Station, Ms. Kari Walker and Mr. Kevin Hand, IntelliSense Marine LLC

Total Carry Forward Request: $140,986.92

Budget Category	FY Award Budget #22 - Face Page	Funds Spent From FY Award (Whole Numbers Only)	Projected Balance to be Carried Over (Whole Numbers Only)	Amount Requested for Contin. Award	Sum of Projected Carry-over and Contin Award Request
a. Personnel	$ -	$ -	$ -	No additonal funding is being	$ -
b. Fringe Benefits	$ -	$ -	$ -	requested for this project in	$ -
c. Total Personnel Costs	$ -	$ -	$ -	Year 8.	$ -
d. Equipment	$ -	$ -	$ -	$ -	$ -
e. Supplies	$ -	$ -	$ -	$ -	$ -
f. Travel	$ -	$ -	$ -	$ -	$ -
g. Construction	$ -	$ -	$ -	$ -	$ -
h. Other	$ -	$ -	$ -	$ -	$ -
i. Contractual	$ 369,253.00	$ 248,746.08	$ 120,506.92	$ -	$ 120,506.92
j. Total Direct Costs	**$ 369,253.00**	**$ 248,746.08**	**$ 120,506.92**	**$ -**	**$ 120,506.92**
k. Indirect Costs	$ 20,541.00	$ 61.00	$ 20,480.00	$ -	$ 20,480.00
n. Recipeint Share**	$ -	$ -	$ -	$ -	$ -
Total	**$ 389,794.00**	**$ 248,807.08**	**$ 140,986.92**	**$ -**	**$ 140,986.92**

**Institutional Support is returned indirect to the program; no formal pledge to DHS; therefore, not reported as recipient share
Note: All entities are subawards and therefore listed under contractual

Carry Forward Justification:
The project entitled, "Marine Induced Polarization Methods for the Detection and Mapping of Oil in An Arctic Marine Oil Spill, including investigation of oil within and under broken ice fields" was funded from the Issues Request for Proposals (RFP) and therefore, the original budget was a two-year project; the project was given additional funding in year 7 from Arctic IoNS funding to assist with the further deliverables. Due to COVID and missing the ability to create ice, the project team is slightly behind. The project team is expected to meet Program Year 7 deliverables and tasks; however, due to the delays in acquiring electronic components, the Marine IP Arctic Ready System will not be completed in time to travel to CRREL or perform open water testing before the end of ADAC Year 7. Therefore, there will be funding that will not be able to be spent in ADAC year 7 for salaries and supplies that will need to be continued

into ADAC year 8 to complete the project on the timeline. The following entities associated with this project are requesting carry forward funding:

- Support to continue the subaward agreement between the Induced Polarization Associates and UAA in the amount of $63,396.58; this funding is to be utilized for salaries, supplies, travel and vessel time to complete the field season. The funding also includes appropriate indirect costs. This funding is requested to support the following project team members: Mr. Mike Williamson, Mr. Art Wright, and engineering staff. Mr. Williamson provides technical acumen, program leadership and scientific guidance for the research program. Mr. Williamson bills at $148.05 per hour. Mr. Wright provides technical acumen and operational safety for Marine IP deployments, including direct leadership for planning, execution, and safe operations for both the open water and ice testing phases of this research. Mr. Wright is billed at $148.05 per hour. Engineering personnel continue to lead and advise all technical and engineering tasks from design engineering through ice tank and open water testing, managing all technical aspects and metric deliverables throughout the research program. Staff is billed at $84.17/hour. All rates are fully burdened and associated indirect cost utilizes the de minimus rate of 10%.
- Support to continue the subaward agreement between IntelliSense Marine and UAA in the amount of $17,110.37; this funding is to be utilized for salary and associated fringe benefits for the project team to include Ms. Kari Walker and Mr. Kevin Hand to continue to oversee all program technical planning, development, and testing programs from inception through final reporting. Ms. Walker will be responsible for all program test plan and design, oversight of all technical deliverables, QA/QC of data collection, and documentation processes. Mr. Hand will be responsible for research plan execution, program deliverables, and financial reporting and compliance. The Principal Investigators are each billed at a rate of $162.03/hour.
- Support in the amount of $40,000 for the University of Alaska Anchorage for a contract for CRREL to create sea-ice. F&A associated with the contract is $20,480.

The funding will complete the following tasks specifically as outlined in the approved Work Plan:

- Research Task 7. Conduct Field Trials of Arctic-Ready Marine IP System. The full Marine IP system will be field tested aboard a vessel in Puget Sound. Puget Sound field trials are targeted for August 2021.
- Research Task 8. Conduct testing of the Arctic-Ready Marine IP system at the CRREL facility. Test the Arctic-Ready Marine IP System in a simulated Arctic environment to ensure that the system can stand up to long distance shipping and the operation of the system in harsh Arctic conditions. CRREL field trials are targeted for November 2021.

Tasks are on schedule to be completed before March 2022. Therefore, there is no impact on the future funding of the project or activity and all deliverables are anticipated to be met timely.

PROJECT: Oil Spill Modeling for Improved Response to Arctic Maritime Spills: The Path Forward

Project Principal Investigator: Dr. Nancy Kinner, University of New Hampshire

Total Carry Forward Request: $30,493.23

Budget Category	FY Award Budget #22 - Face Page	Funds Spent From FY Award (Whole Numbers Only)	Projected Balance to be Carried Over (Whole Numbers Only)	Amount Requested for Contin. Award	Sum of Projected Carry-over and Contin Award Request
a. Personnel	$ -	$ -	$ -	No additonal funding is being	$ -
b. Fringe Benefits	$ -	$ -	$ -	requested for this project in	$ -
c. Total Personnel Costs	$ -	$ -	$ -	Year 8.	$ -
d. Equipment	$ -	$ -	$ -	$ -	$ -
e. Supplies	$ -	$ -	$ -	$ -	$ -
f. Travel	$ -	$ -	$ -	$ -	$ -
g. Construction	$ -	$ -	$ -	$ -	$ -
h. Other	$ 16,637.00	$ 16,637.00	$ -	$ -	$ -
i. Contractual	$ 53,688.61	$ 23,195.38	$ 30,493.23	$ -	$ 30,493.23
j. Total Direct Costs	**$ 70,325.61**	**$ 39,832.38**	**$ 30,493.23**	**$ -**	**$ 30,493.23**
k. Indirect Costs	$ -	$ -	$ -	$ -	$ -
n. Recipeint Share**	$ -	$ -	$ -	$ -	$ -
Total	**$ 70,325.61**	**$ 39,832.38**	**$ 30,493.23**	**$ -**	**$ 30,493.23**

**Institutional Support is returned indirect to the program; no formal pledge to DHS; therefore, not reported as recipient share

Note: All entities are subawards and therefore listed under contractual

Carry Forward Justification:

Dr. Kinner's project entitled, "Oil Spill Modeling for Improved Response to Arctic Maritime Spills: the Path Forward" was funded from the Issues Request for Proposals (RFP) and therefore, the original budget was a two-year project. Dr. Kinner's team is expected to meet year two deliverables and tasks by April 2022; because of COVID funding had to be reallocated among categories and the project needed to hire a computer science graduate student to perform analysis. The funding that is being asked to carry forward is the remaining budget for year two (ADAC year 7). The following entities associated with this project are requesting carry forward funding:

- Dr. Nancy E. Kinner who offers leadership of CRRC/CSE staff and gives general oversight of this project, facilitates the Phase 1 meeting, two workshops, all breakout group discussions, monthly working group meetings, along with Core Team meetings and workshop Organizing Committee meetings. Additionally, as the PI, she oversees the writing of the working group white papers, the workshop report and the final knowledge product, as well as other outcomes stated in this proposal. An estimated 80 hours (at salary rate of $120/hour; applied to summer salary) is devoted to this activity over the 24-month period for this PI. Fringe rates are 8.4% for a total request of $9,592.78;
- Personnel also includes support from the Center's Manager, Kathy Mandsager, which is a fulltime, benefitted position. Tasks include scheduling, organizing and distributing of workshop logistics, workshop report review process design and editing, as well as all activities regarding monthly working group meetings (organization, participation, note-taking and agenda-development). An estimated 196 hours is allotted for these tasks at salary rate of $30/hour. Fringe benefits are calculated at 42.3%. For a total of $10,475.26;
- General costs to host 2 workshops as well as year-long working groups is estimated at $3,600 which includes shipping, printing, IT services, webinar services, website hosting, and conference calling services.
    - Total remaining materials and supplies for hosting workshops via webinar and teleconference being requested is $3,580.50,

  These costs are being requested to be repurposed towards the salary of the graduate student.

- Associated indirect costs being requested is $389.44

The funding will complete the following tasks specifically as outlined in the approved Work Plan:

- Phase 6: Completion of Knowledge Product. Project team will accomplish this task in ADAC Program Year 7.

Tasks are on schedule to be completed by April 2022. Therefore, there is no impact on the future funding of the project or activity and all deliverables are anticipated to be met timely.

PROJECT: Arctic Facilities and Infrastructure Environmental Change Risk Index

Project Principal Investigator: Drs. Craig Tweedie, University of Texas El Paso and Matthew Calhoun, University of Alaska Anchorage

Total Carry Forward Request: $156,948.38

Budget Category	FY Award Budget #22 - Face Page	Funds Spent From FY Award (Whole Numbers Only)	Projected Balance to be Carried Over (Whole Numbers Only)	Amount Requested for Contin. Award	Sum of Projected Carry-over and Contin Award Request
a. Personnel	$ 65,779.00	$ 11,302.00	$ 54,477.00	No additonal funding is being	$ 54,477.00
b. Fringe Benefits	$ -	$ -	$ -	requested for this project in	$ -
c. Total Personnel Costs	$ 65,779.00	$ -	$ 54,477.00	Year 8.	$ 54,477.00
d. Equipment	$ -	$ -	$ -	$ -	$ -
e. Supplies	$ -	$ -	$ -	$ -	$ -
f. Travel	$ -	$ -	$ -	$ -	$ -
g. Construction	$ -	$ -	$ -	$ -	$ -
h. Other	$ 9,000.00	$ -	$ 9,000.00	$ -	$ 9,000.00
i. Contractual	$ 93,163.00	$ 33,039.00	$ 60,124.00	$ -	$ 60,124.00
j. Total Direct Costs	**$ 167,942.00**	**$ 33,039.00**	**$ 123,601.00**	**$ -**	**$ 123,601.00**
k. Indirect Costs	$ 39,134.00	$ 5,786.62	$ 33,347.38	$ -	$ 33,347.38
n. Recipeint Share**	$ -	$ -	$ -	$ -	$ -
Total	**$ 207,076.00**	**$ 38,825.62**	**$ 156,948.38**	**$ -**	**$ 156,948.38**

**Institutional Support is returned indirect to the program; no formal pledge to DHS; therefore, not reported as recipient share

Note: All entities are subawards and therefore listed under contractual

Carry Forward Justification:

Drs. Tweedie and Calhoun's project entitled, "Arctic Facilities and Infrastructure Environmental Change Risk Index" was funded from reserve funding at the request of D-17 for a knowledge product. The team is expected to meet deliverables and tasks by April 2022. There have been delays due to IRB protocols and review. The funding that is being asked to carry forward is the remaining budget for the project. The following entities associated with this project are requesting carry forward funding:

- Ukpeagvik Inupiat Corporation in the amount of $9,920 as the subaward to UIC was recently issued by the University of Alaska Anchorage and with a month remaining prior the fiscal year, UIC will more than likely not bill this year. UIC is responsible for the facilitation of virtual meetings and identifying stakeholders with community members;
- University of Alaska and Fairbanks in the amount of $116,664.38 for salary for members of the project team, participant support costs and associated indirect costs.
- University of Texas El Paso in the amount of $50,204 as the subaward to UTEP is being issued and has not been signed yet. UTEP personnel are participating waiting on final issue of the subaward.

Tasks are on schedule to be completed by April 2022. Therefore, there is no impact on the future funding of the project or activity and all deliverables are anticipated to be met timely.

Theme 2: Maritime Domain Awareness (MDA) Projects

PROJECT: Arctic Oil Spill Modeling

Project Principal Investigators: Dr. Scott Socolofsky, Texas A&M University and Dr. Jifeng Peng, University of Alaska Anchorage

No carry forward being requested for this project.

PROJECT: Arctic Ice Conditions Index (ARCTICE)

Project Principal Investigators: Dr. Jifeng Peng, University of Alaska Anchorage

No carry forward being requested for this project.

PROJECT: Arctic Vessel Monitoring Geofencing/Alert Awareness

Project Principal Investigator: Dr. Shawn Butler, University of Alaska Anchorage

No carry forward being requested for this project.

PROJECT: Alaska and Arctic Maritime Communications and Connectivity Analsyis (PMC&CA)

Project Principal Investigators: Associate Director Jason Roe and Dr. Shawn Butler, University of Alaska Anchorage

Carry Forward Request: $143,867

Budget Category	FY Award Budget #22 - Face Page	Funds Spent From FY Award (Whole Numbers Only)	Projected Balance to be Carried Over (Whole Numbers Only)	Amount Requested for Contin. Award	Sum of Projected Carry-over and Contin Award Request
a. Personnel	$ 13,647.00	$ 13,647.00	$ -	No additonal funding is being	$ -
b. Fringe Benefits	$ -	$ -	$ -	requested for this project in	$ -
c. Total Personnel Costs	$ 13,647.00	$ 13,647.00	$ -	Year 8.	$ -
d. Equipment	$ -	$ -	$ -	$ -	$ -
e. Supplies	$ -	$ -	$ -	$ -	$ -
f. Travel	$ -	$ -	$ -	$ -	$ -
g. Construction	$ -	$ -	$ -	$ -	$ -
h. Other	$ -	$ -	$ -	$ -	$ -
i. Contractual	$ 314,819.00	$ 170,952.00	$ 143,867.00	$ -	$ 143,867.00
j. Total Direct Costs	**$ 328,466.00**	**$ 184,599.00**	**$ 143,867.00**	**$ -**	**$ 143,867.00**
k. Indirect Costs	$ 47,226.00	$ 47,226.00	$ -	$ -	$ -
n. Recipeint Share**	$ -	$ -	$ -	$ -	$ -
Total	$ 375,692.00	$ 231,825.00	$ 143,867.00	$ -	$ 143,867.00

**Institutional Support is returned indirect to the program; no formal pledge to DHS; therefore, not reported as recipient share

Note: All entities are subawards and therefore listed under contractual

Carry Forward Justification:

Associate Director Jason Roe and Dr. Shawn Butler's project entitled, "Alaska and Arctic Maritime Communications and Connectivity Analysis" was funded from reserve funding at the request US Coast Guard for a knowledge product. The team is expected to meet deliverables and tasks by April 2022. The funding that is being asked to carry forward is the remaining budget for the project. The following entities associated with this project are requesting carry forward funding:

- Alaska Marine Prevention and Response Network in the amount of $15,475 as the subaward tasks are later in the project for consultation and billing will not take place until next year;
- ASRC Federal Mission Solutions in the amount of $114,614 as the project will be billed mostly in the upcoming year but project is moving forward;

- Ukpeagvik Inupiat Corporation in the amount of $13,778 as the subaward to UIC was recently issued by the University of Alaska Anchorage and with a month remaining prior the fiscal year, UIC will more than likely not bill this year. UIC is responsible for the facilitation of virtual meetings and identifying stakeholders with community members;

Tasks are on schedule to be completed by April 2022. Therefore, there is no impact on the future funding of the project or activity and all deliverables are anticipated to be met timely.

Theme 3: Maritime Technology Research:

PROJECT: Development of Propeller Driven Long-Range Autonomous Underwater Vehicle (LRAUV) for Under-Ice Mapping of Oil Spills and Environmental Hazards

Project Principal Investigator: Dr. James Bellingham and Ms. Amy Kukulya, Woods Hole Oceanographic Institute and Mr. Brett Hobson, Monterey Bay Aquarium Research Institution

Carry Forward Request: $356,335

Budget Category	FY Award Budget #22 - Face Page	Funds Spent From FY Award (Whole Numbers Only)	Projected Balance to be Carried Over (Whole Numbers Only)	Amount Requested for Contin. Award	Sum of Projected Carry-over and Contin Award Request
a. Personnel	$ -	$ -	$ -	No additonal funding is being	$ -
b. Fringe Benefits	$ -	$ -	$ -	requested for this project in	$ -
c. Total Personnel Costs	$ -	$ -	$ -	Year 8.	$ -
d. Equipment	$ -	$ -	$ -	$ -	$ -
e. Supplies	$ -	$ -	$ -	$ -	$ -
f. Travel	$ -	$ -	$ -	$ -	$ -
g. Construction	$ -	$ -	$ -	$ -	$ -
h. Other	$ -	$ -	$ -	$ -	$ -
i. Contractual	$ 1,750,001.00	$ 1,393,666.00	$ 356,335.00	$ 620,144.00	$ 356,335.00
j. Total Direct Costs	**$ 1,750,001.00**	**$ 1,393,666.00**	**$ 356,335.00**	**$ 620,144.00**	**$ 356,335.00**
k. Indirect Costs	$ -	$ -	$ -	$ -	$ -
n. Recipeint Share**	$ -	$ -	$ -	$ -	$ -
Total	$ 1,750,001.00	$ 1,393,666.00	$ 356,335.00	$ 620,144.00	$ 356,335.00

**Institutional Support is returned indirect to the program; no formal pledge to DHS; therefore, not reported as recipient share

Note: All entities are subawards and therefore listed under contractual

Carry Forward Justification:

Carry forward for Long Range Autonomous Underwater Vehicle Monterey Bay Aquarium Research Institution (MBARI) in the amount of $156,355 is requested for the following:

- Salary for B. Hobson for 231.2 hours ($20,662) to support offshore operation during testing, B. Kieft for 230 hours ($20,391) to continue to develop a new double ping option, some format changes for the circular DUSBL, sea trials to include testing and refinement for the circular DUSBL, software integration and assisting with testing, and B. Raanan for 230 hours ($14,644) to continue to develop a new double ping option, some format changes for the circular DUSBL, sea trials to include testing and refinement for the circular DUSBL, software integration and assisting with testing;
- Fringe benefits related to the salaries in the amount of $31,831. The federally negotiated fringe benefit rates for 2018-2021 are negotiated by NOAA. The base is labor dollars and the pool costs consist of payroll taxes, health benefits, retirement benefits, workers compensation, and leave. The predetermined rate for full-time regular and part-time (30-39hrs/wk) employees is 57.15%;
- Travel funding for the ice testing in the amount of $14,000;
- Materials and supplies in the amount of $1,000 for the under ice demonstration;
- Indirect costs in the amount of $53,827.
-

Woods Hole Oceanographic Institute ($200,000) is requested the following entities associated with this project:

- Salary various personnel fully burdened in the amount of $117,070;
- Field supplies for preparation for testing and deployments in the amount of $5,000;
- Associated Indirect Costs are $77,930

Tasks are on schedule to slightly delayed due to the current slowdown in workflow associated with the COVID national crisis, we are experiencing delays associated with limited staff on site. In order to continue development of the LRAUV Build-2 and its systems and local testing of Polaris, the project team would like to prioritize what we can accomplish on the main build and re-prioritize completion Stella and its mapping payload in YR8 along with carrying out docking and navigation testing on Polaris. Furthermore, funds are needed to continue providing engineering analysis, software development and planning as well as continuity on the vehicle build. Additionally, the LBL and continuation of the docking tests will be pushed to July due to quarantines, fieldwork and shipping delays for the docking gear box. Therefore, there is no impact on the future funding of the project or activity and all deliverables are anticipated to be met timely so that year seven milestones and deliverables will be met regarding the build of a second LRAUV and the sonar integration can happen in early Fall with minimal impact as other activities can occur simultaneously.

PROJECT: Remote Unmanned Aircraft System (UAS) Inspection and Response Team Development in the Bearing Strait Region

Project Principal Investigator: Dr. Jessica Garron, University of Alaska Fairbanks

Carry Forward Request: $217,404.84

Budget Category	FY Award Budget #22 - Face Page	Funds Spent From FY Award (Whole Numbers Only)	Projected Balance to be Carried Over (Whole Numbers Only)	Amount Requested for Contin. Award	Sum of Projected Carry-over and Contin Award Request
a. Personnel	$ 96,614.00	$ -	$ 49,130.00	No additonal funding is being	$ 49,130.00
b. Fringe Benefits	$ -	$ -	$ -	requested for this project in	$ -
c. Total Personnel Costs	$ 96,614.00	$ -	$ 49,130.00	Year 8.	$ 49,130.00
d. Equipment	$ 108,100.00	$ -	$ -	$ -	$ -
e. Supplies	$ 12,500.00	$ -	$ 300.00	$ -	$ 300.00
f. Travel	$ 30,146.00	$ -	$ 18,820.00	$ -	$ 18,820.00
g. Construction	$ -	$ -	$ -	$ -	$ -
h. Other	$ 400.00	$ -	$ 200.00	$ -	$ 200.00
i. Contractual	$ 167,513.00	$ 66,026.16	$ 101,486.84	$ -	$ 101,486.84
j. Total Direct Costs	**$ 415,273.00**	**$ 66,026.16**	**$ 169,936.84**	**$ -**	**$ 169,936.84**
k. Indirect Costs	$ 107,112.00	$ 59,644.00	$ 47,468.00	$ -	$ 47,468.00
n. Recipeint Share**	$ -	$ -	$ -	$ -	$ -
Total	**$ 522,385.00**	**$ 125,670.16**	**$ 217,404.84**	**$ -**	**$ 217,404.84**

**Institutional Support is returned indirect to the program; no formal pledge to DHS; therefore, not reported as recipient share

Note: All entities are subawards and therefore listed under contractual

Carry Forward Justification:

Dr. Garron's project entitled, "Remote Unmanned Aircraft System (UAS) Inspection and Response Team Development in the Bearing Strait Region" was funded from Arctic IoNS funding which resulted in a request for proposals (RFP). The team is expected to meet deliverables and tasks by April 2022. The funding that is being asked to carry forward is the remaining budget for the project. The following entities associated with this project are requesting carry forward funding:

- Model Forest Policy Program (MFPP) in the amount of $27,311.84 as the subaward to MFPP was recently issued by the University of Alaska Anchorage and some

expenditures have been able to happen delay in some cases is a direct result due to COVID;

- Native Village of Unalaskleet (NVY) in the amount of $73,674.98; due to COVID travel and training has not been able to happen yet and therefore will happen in summer 2021;
- University of Alaska Fairbanks in the amount of $103,618 for salary for members of the project team, travel, contractual, and commodities costs and associated indirect costs;
- University of Alaska Anchorage in the amount of $12,800 for indirect associated with subawards that have not billed the $25,000 threshold yet;

Tasks are on schedule to be completed by April 2022. Therefore, there is no impact on the future funding of the project or activity and all deliverables are anticipated to be met timely.

PROJECT: Arctic-related Incidents of National Significance (Arctic IoNS) and Arctic Medium and Long Term Environment (Arctic MaLTE) Workshops

Project Principal Investigator: ADAC Executive Director Randy Kee, University of Alaska Anchorage

Total Carry Forward Request: $350,447.00

Budget Category	FY Award Budget #22 - Face Page	Funds Spent From FY Award (Whole Numbers Only)	Projected Balance to be Carried Over (Whole Numbers Only)	Amount Requested for Contin. Award	Sum of Projected Carry-over and Contin Award Request
a. Personnel	$ 12,780.60	$ 12,780.60	$ -	No additonal funding is being	$ -
b. Fringe Benefits	$ -	$ -	$ -	requested for this project in	$ -
c. Total Personnel Costs	$ 12,780.60	$ 12,780.60	$ -	Year 8.	$ -
d. Equipment	$ -	$ -	$ -	$ -	$ -
e. Supplies	$ -	$ -	$ -	$ -	$ -
f. Travel	$ -	$ -	$ -	$ -	$ -
g. Construction	$ -	$ -	$ -	$ -	$ -
h. Other	$ 1,659,115.94	$ 1,308,668.94	$ 350,447.00	$ -	$ 350,447.00
i. Contractual	$ 10,000.00	$ 10,000.00	$ -	$ -	$ -
j. Total Direct Costs	**$ 1,681,896.54**	**$ 1,331,449.54**	**$ 350,447.00**	**$ -**	**$ 350,447.00**
k. Indirect Costs	$ 11,663.67	$ 11,663.67	$ -	$ -	$ -
n. Recipeint Share**	$ -	$ -	$ -	$ -	$ -
Total	**$ 1,693,560.21**	**$ 1,343,113.21**	**$ 350,447.00**	**$ -**	**$ 350,447.00**

**Institutional Support is returned indirect to the program; no formal pledge to DHS; therefore, not reported as recipient share

Carry Forward Justification:

The University of Alaska Anchorage is requesting carry forward in the amount of $350,447.00 for the following to be utilized in year for the following projects (see year 8 budget justification for project costs):

- Ice Conditions (ICECON) for the Arctic (ARCTICE) for $39,808 ;
- Arctic Vessel Monitoring Geofencing/Alert Awareness for $75,600;
- Development of Propeller Driven Long Range Autonomous Underwater Vehicle (LRAUV) for Under-Ice Mapping of Oil Spills and Environmental Hazards for $220,000;
- Minority Serving Institution (MSI) and Significant Minority Enrollment (SME) Education Outreach and Workforce Development and ADAC Arctic Summer Intern Program (ASIP) for $15,039.

Theme 4: Integration of Science and Engineering with Maritime Security Governance and

Policy Research

No ADAC projects currently awarded.

Theme 5: End-to-end (E2E)

No ADAC project currently awarded.

Theme 6: Integrated Education

PROJECT: Education and Outreach and Workshop Development
Project Principal Investigator: ADAC Education and Administration Manager, Elizabeth Matthews, University of Alaska Anchorage
No carry forward being requested for this project.

PROJECT: Minority Serving Institutions (MSI) and Significant Minority Enrollment (SME) Summer Internship (MSI) Note: MSI integrated with ADAC Arctic Summer Intern Program (ASIP)
Project Principal Investigator: ADAC Education and Administration Manager, Elizabeth Matthews, University of Alaska Anchorage
No carry forward being requested for this project. ADAC had a Programmatic Change Request to rebudget funding in the ASIP to allow for a transition of a 10-week long internship that will be conducted virtually and support students that were not able to be supported through cancelled internships because of COVID.