



**US Army Corps
of Engineers®**
Engineer Research and
Development Center



International Workshop on Cold Regions Defense Infrastructure

13–15 September 2022, Hanover, New Hampshire

Thomas A. Douglas, Lauren Bosche, Edith Martinez-
Guerra, Caitlin Tibbetts, Orian Welling, Clint Smith,
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Abstract

The Inaugural International Workshop on Cold Regions Defense Infrastructure united engineers and scientists of the US Department of Defense with defense representatives from the other nations comprising the International Cooperative Engagement Program for Polar Research (ICE-PPR): Canada, Denmark, Finland, Norway, Sweden, and New Zealand. Through the ICE-PPR Memorandum of Understanding, Project Arrangements (PAs) enable the seven nations to share measurements, models, and access to research sites and facilities. The goal of the workshop was to work as a coherent team to identify needs and develop PAs for three major topic areas: infrastructure, water/wastewater, and energy. Increasing interest in earth's polar regions necessitates identifying capabilities and gaps for these critical mission-relevant topic areas.

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Preface

Funding for the event was provided by the Engineer Research and Development Center (FLEX-4 Program) and by the US Navy OPNAV N94 International Engagement Office and the US Navy Office of Naval Research (PE 0605853N, Project 0149, Office of Naval Research Global/Senior National Representative Supported Workshops).

Work was performed by the Biogeochemical Sciences Branch (Mr. Nathan Lamie, chief) and the Force Projection and Sustainment Branch (Dr. Orian Welling, chief) of the Research and Engineering Division, US Army Engineer Research and Development Center–Cold Regions Research and Engineering Laboratory (ERDC-CRREL). At the time of publication, Dr. John Weatherly was acting division chief. The acting deputy director of ERDC-CRREL was Dr. Ivan P. Beckman, and the director was Dr. Joseph L. Coriveau.

Work was also performed by the Environmental Engineering Branch (Dr. Michael Rowland, chief) of the Environmental Processes and Engineering Division, ERDC Environmental Laboratory (EL). At the time of publication, Mr. Warren Lorentz was division chief. The deputy director of ERDC-EL was Dr. Brandon Lafferty, and the director was Dr. Edmond Russo Jr.

Further work was performed by the Airfields and Pavements Branch (Ms. Anna M. Jordan, chief) of the Engineering Systems and Materials Division, ERDC Geotechnical and Structures Laboratory (GSL). At the time of publication, Mr. Justin S. Strickler was division chief. The deputy director of ERDC-GSL was Mr. Charles W. Ertle II, and the director was Mr. Bartley P. Durst.

Additional work was performed by the Warfighter Engineering Branch (Mr. Jeff Burkhalter, chief) of the Operational Science and Engineering Division, ERDC Construction Engineering Research Laboratory (CERL). At the time of publication, Dr. George Calfas was division chief. The deputy director of ERDC-CERL was Ms. Michelle Hanson, and the director was Dr. Andrew Nelson.

Additional work was performed by the Data Signatures Analysis Branch (Ms. Jennifer Smith, chief) of the Research Division, ERDC Geospatial Research Laboratory (GRL). At the time of publication, Mr. Jeffrey Murphy was division chief. The deputy director of ERDC-GRL was Ms. Valerie Carney, and the director was Dr. David Hibner.

The authors thank Ms. Ilea Diaz-Lluberes, ERDC-GRL, and Ms. Sulymar Arocho Rodriguez, ERDC-EL, for reviewing this document.

COL Christian Patterson was commander of ERDC, and Dr. David W. Pittman was the director.

Executive Summary

The Inaugural International Workshop on Cold Regions Defense Infrastructure united engineers and scientists of the US Department of Defense (DoD) with defense representatives from the other nations comprising the International Cooperative Engagement Program for Polar Research (ICE-PPR): Canada, Denmark, Finland, Norway, Sweden, and New Zealand. Through the ICE-PPR Memorandum of Understanding, Project Arrangements (PAs) enable the seven nations to share measurements, models, and access to research sites and facilities. The goal of the workshop was to work as a coherent team to identify needs and to develop PAs for three major topic areas: infrastructure, water/wastewater, and energy. Increasing interest in earth's polar regions necessitates identifying capabilities and gaps for these critical mission-relevant topic areas.

The US Army Engineer Research and Development Center's Cold Regions Research and Engineering Laboratory (ERDC-CRREL) hosted nearly 130 workshop participants (including senior leaders, operators, scientists, and engineers) representing the services, interagency, and international partners (Figure ES-1 and ES-2). Representatives from Canada, Norway, Sweden, Chile, and Germany were present. Denmark, Finland, and New Zealand participated remotely.

Figure ES-1. Workshop participants. Senior leaders are in the front.



Figure ES-2. The US Army Engineer Research and Development Center's Cold Regions Research and Engineering Laboratory headquarters building in Hanover, New Hampshire.



Senior defense leaders at the workshop included the following:

- RADM Lorin Selby,* chief of Naval Research for the US Navy and the US lead for ICE-PPR
- MG Constance Jenkins, director of Logistics and Engineering, J4, Headquarters, North American Aerospace Defense Command and US Northern Command at Peterson Space Force Base, Colorado
- MG Bob Whittle, deputy commanding general for US Army North (Fifth Army)
- BG James Kokaska, deputy commanding general, Reserve Affairs, and deputy chief of engineers, Reserve Component, US Army Corps of Engineers
- BG Louis Lapointe, deputy commanding general (Canada)–Operations, US Army 11th Airborne Division
- Dr. Joseph Corriveau, director, ERDC-CRREL, and workshop host
- Dr. John Farrell, executive director, US Antarctic Research Program
- Dr. Jennifer Mercer, section head for the Arctic Sciences Section, Office of Polar Programs, National Science Foundation

* For a full list of the spelled-out forms of the title abbreviations used in this document, please refer to *US Government Publishing Office Style Manual*, 31st ed. (Washington, DC: US Government Publishing Office, 2016), 227–30, <https://www.govinfo.gov/content/pkg/GPO-STYLEMANUAL-2016/pdf/GPO-STYLEMANUAL-2016.pdf>.

- Mr. Greg Pollock, principal director and senior advisor, Office of the Secretary of Defense
- Mr. Craig Rettie, director, Research and Technology Integration Combat Capabilities Development Command Soldier Center

Workshop outcomes included developing collaborative work plans to meet identified Arctic and extreme cold weather gaps in built and expeditionary infrastructure, water/wastewater, and energy. Under the auspices of ICE-PPR, the work plans formulated at the workshop are actively being developed into PAs. This process includes developing problem statements, objectives, scopes of work, and task details and sharing tasks across different partner nations. ERDC is playing a major leadership role in coordinating and implementing three ICE-PPR PAs, one each for infrastructure, water/wastewater, and energy.

This executive-style report identifies and describes the PAs developed within each focus area, detailing proposed efforts and identifying paths for resourcing. The services and ICE-PPR can leverage this report to identify resources to address requirements and emerging needs. It is also anticipated that the framework established by workshop planners and facilitators can be modeled for future ICE-PPR topic-area workshops.

1 Introduction

1.1 Background and Motivation

The Arctic region is a strategic national security concern of increasing interest and relevance. Operating in any of earth's polar and cold regions (the Arctic and Antarctic, as well as high elevations and Subarctic and seasonally frozen locations) remains an extremely challenging endeavor due to harsh and rapidly changing weather, austere infrastructure, and a general lack of operational experience. The polar defense engineering and scientific community recognizes these challenges and has identified capability gaps and launched strategic infrastructure and operational energy initiatives. The International Cooperative Engagement Program for Polar Research (ICE-PPR) was established in 2019 to enable defense departments working in earth's polar regions to collaborate across a variety of research and engineering topics. The International Workshop on Cold Regions Defense Infrastructure was proposed in the spring of 2022 as a means of moving the international community forward in addressing these emerging needs.

1.2 Workshop Overview

The three-day workshop (Appendix A and Appendix B provide the poster and agenda, respectively) opened with a short morning plenary session to outline the Project Arrangement (PA) development process and goals and to present the major research challenges. All workshop participants attended preworkshop meetings for the three topic areas established rapport among participants and started focusing the topic area toward identifying the main gaps, requirements, and both current and needed capabilities. Thus, for the remainder of day 1, all of day 2, and half of day 3, attendees divided into the three topic areas to identify specific needs and appropriate measurements and technologies to develop multinational PAs. (Appendix C provides photos from the workshop). Outbriefs from the specific topic areas were finalized on the morning of the third day and briefed to the plenary group, general officers/flag officers, and other senior leaders in the afternoon. The outbrief objective was to seek help from the senior leaders to identify resources and paths forward. Surveys conducted before and during the meeting further identified emerging trends and needs. An evening poster session and social event promoted broader discussions.

1.3 The Opening Plenary

The workshop started with a welcome from the host, Dr. Joseph Cor-riveau, director of the US Army Engineer Research and Development Center's Cold Regions Research and Engineering Laboratory (ERDC-CRREL); remarks from workshop leadership; short talks to contextualize the workshop focus from Deputy Assistant Secretary of Defense for the Arctic and Global Resilience, G2, and ERDC leads; and an Arctic Edge briefing by Special Operations Command North. Representatives from each ICE-PPR country provided briefs on the status and priorities of their Cold Regions defense infrastructure. The last session of the opening plenary focused on setting workshop expectations before the breakout sessions began.

Thematically, the opening plenary focused on the geopolitics of the Arctic, the Arctic operational context, and the ambitions of ICE-PPR and the workshop in the process of facilitating international collaborations. The international briefs provided information on each country's defense resources, research and development capabilities, and defense infrastructure challenges related to Cold Regions.

1.4 Tabletop Exercise Facilitated by the Ted Stevens Center for Arctic Security Studies

A realistic tabletop scenario provided an excellent opportunity for senior leaders to reflect on potential challenges when engaging in missions within the Arctic and high north.* A critical outcome of the tabletop exercise included perspectives from the Arctic operators and practitioners, which also highlighted the real-world challenges when operating in the Arctic. Reflections from Arctic-experienced operators led to detailed open discussions, including audience participation. The wealth of information exchanged included key points and topics brought to light from other Arctic practitioners in attendance. These key interactions provided an opportunity to reflect more deeply about the extensive challenges linked to geopolitics, logistics, communications, water resources, and energy surrounding the real-world scenario.

* This paragraph has been modified and used with permission from Ms. Christine Duprow, Stevens Center.

As stated earlier, the majority of the time spent during the workshop was with the attendees broken into three focus area groups. The following sections summarize the workshop efforts and paths forward for each of the three focus areas (infrastructure, water/wastewater, and energy).

2 Infrastructure Topic Area

2.1 Preworkshop Synopsis

ERDC established the Arctic Infrastructure Research Group (AIRG) in 2020 as a forum to classify Arctic infrastructure needs, identify gaps, and pursue solutions and technical advancement. AIRG membership includes all branches of DoD, who meet monthly to discuss broad aspects of physical infrastructure utilized to facilitate Arctic military operations and support, including topics in shelter, water/wastewater, and energy. The group focuses on development and evaluation of novel solutions addressing near-term and long-term technology gaps, providing efficient and long-lasting structures for all types of Arctic operations. For the workshop, water/wastewater and energy were separated from the broader infrastructure topic area, and the infrastructure topic area focused on expedient and enduring structures.

In the months leading up to the workshop, the leads solicited the AIRG for participation and topics of interest. Under the infrastructure topic area, three subtopics were drafted based on US performers and requirements:

- Arctic-capable, soft-walled expeditionary shelters and materials
- Arctic-capable, large-scale expeditionary shelters
- International Organization for Standardization (ISO)–compatible shelter mobility systems

During AIRG monthly discussions prior to the workshop, PA training provided by facilitators from Forge Forward Inc. gave background information on developing PAs to prepare for the upcoming workshop. The ICE-PPR PAs have three goals: determine objectives, prepare a scope of work, and identify sharing of tasks. The lead for each subtopic gave an overview of each topic to begin an open discussion and familiarization of the topic. This allowed international input from Sweden and Canada. Content included current initiatives, “Points of Pain” gaps that are being addressed or need to be addressed, and potential paths forward and items of interest for further collaboration.

Preworkshop subtopic 1, Arctic-capable, soft-walled expeditionary shelters, was led by Ms. Karen Scagnelli from the US Army Combat Capabilities Development Command (DEVCOM) Soldier Center. Ms. Scagnelli

discussed issues with using fabric in conditions of extreme cold temperatures and wind, such as durability, anchoring, heating, and current fabrics that are not rated for these extreme conditions. Recent laboratory testing assessed break strength, tear strength, puncture resistance, Gelbo flex tests, etc. A list of possible topics other than fabrics need to be explored, such as highly deployable Arctic shelters, insulation, the use of inflatables, the use of platforms to protect frozen ground, etc.

Preworkshop subtopic 2, Arctic-capable, large-scale expeditionary shelters, led by Mr. Richard Peck from the Air Force Civil Engineer Center (AFCEC), discussed large-scale shelters that can support, for example, fighter-sized aircraft, among other heavy-load capabilities. Currently, the large-area maintenance shelters (LAMS) do not meet the extreme arctic requirements for temperature, wind, or snow load. Previous experience has shown that fabric does not remain pliable below temperatures of -25°F (-3.8°C). Another need is to not require heavy equipment, such as cranes, to place these large shelters. The goal is to narrow down solutions in the next 2–3 years to field a prototype solution in Alaska. There was also discussion of stacking ISO containers to serve as the structural components of the shelter. Some promising designs use this concept of a lightweight frame and fabric using a telescoping forklift (or similar) instead of a crane.

Preworkshop subtopic 3, ISO-compatible shelter mobility systems, was led by Mr. Bob Graney, product manager from Force Sustainment Systems, discussed ISO-compatible units and challenges associated with transporting these units in the Arctic. Force Provider (FP) modules have been tested to -25°F (-3.8°C). This modularity concept focuses on placing an ISO container FP unit on skis to tow and move around on snowy terrain without the use of a crane. Subtopic 3 also assessed the potential of other vehicles to act as tow vehicles.

Swedish participants expressed that their country is actively expanding their cold weather science and technology (S&T) efforts. The questionnaire received from international participants from Norway indicated that their goal for the workshop was to gain a common understanding on how to plan, prepare, and support military operations in an Arctic-environment with the right kind for infrastructure, including deployable shelters and other key infrastructure assets.

2.2 Progress through Workshop Activities

The Infrastructure topic area was led by Mr. Kevin Bjella from ERDC-CRREL. Notetakers included workshop organizers Ms. Justine Yu (ERDC Construction Engineering Research Laboratory [CERL]) and Dr. Caitlin Tibbetts (ERDC Geotechnical and Structures Laboratory [GSL]). Ms. Kiera Thompson Towell (ERDC-CRREL) also assisted as a notetaker; and Ms. Sarah Agan from Forge Forward Inc. helped facilitate the sessions.

The Infrastructure topic group consisted of approximately 40–45 participants and started Breakout Session A with a general discussion of the most pressing needs and what each participant wanted to get out of the workshop. Networking and partnerships were identified as a common goal across the participants of the workshop. The main needs discussed were establishing clear requirements, determining the priority within the Arctic strategy, assessing knowledge and technology transfer avenues, and promoting advocacy to receive funding. The international partners from Norway, Sweden, and Germany were interested in networking opportunities, developing a broader awareness of the research needs in cold regions, and identifying how a host nation can support allied nations.

The remainder of Session A consisted of group-member presentations that showcased the three subtopics and associated needs, technologies, solutions, and challenges. The following presentations were provided:

- Cold Regions Perspective DoD installations in the Arctic—Mr. Kevin Bjella
- US Army Combat Capabilities Development Command Cold Weather and Fabric Shelters—Mr. Ryan Devine
 - Subtopic: Arctic-capable, soft-walled expeditionary shelters
- Product Manager Force Sustainment—Mr. Bob Graney
 - Subtopic: ISO-compatible shelter mobility systems
- Air Force Next Generation Expeditionary Large Shelter—Mr. Richard Peck
 - Subtopic: Arctic-capable, large-scale expeditionary shelter
- Naval Facilities (NAVFAC) Engineering and Expeditionary Warfare Center (EXWC) Expeditionary Programs Office Arctic Activity Overview—Mr. Greg Ehlert

Breakout Session B started with a presentation by MAJ Ommund Liland from the Norwegian Defence Estates Agency on the “Host Nation Perspective on Infrastructure in the High North.” The presentation discussed Norway’s cold-response exercise and multiple deployable infrastructure concepts. MAJ Liland outlined their Arctic infrastructure solutions as a combination of large multipurpose maintenance structures, modular ISO container shelters, and soft-walled shelters. LtCol Anders Skyttebol and LtCol Lars Oesterlund from the Swedish Armed Forces stated that they use similar infrastructure concepts and equipment to Norway. There was some additional discussion about the needs of the international partners as host nations and what capability gaps still exist. CPT William Klein from the US Army 11th Airborne Division then discussed his experience and needs for better soft-walled shelters for survivability.* The major concerns were to have a design that is modular, adaptable, and undetectable.

Session C focused on facilitating a full group discussion on common research needs and potential project collaborations for the development of the PA. The group started with problem statements from the discussions and presentations, then created a broad objective to cover the full scope of the potential research areas. Session D was used to refine the problem statements and tasks outlined for the PA and to prepare the PowerPoint brief for the senior leaders.

2.3 International Perspective

International participants in the Infrastructure group included

- MAJ Ommund Liland from the Norwegian Defence Estates Agency;
- LtCol Anders Skyttebol from the Swedish Armed Forces;
- LtCol Lars Oesterlund from the Swedish Armed Forces; and
- M.Sc. Philipp Jaeger from the Federal Office of Bundeswehr-Infrastructure, Environmental Protection and Services.

MAJ Liland’s presentation and the following discussion made clear that Norway and Sweden, as host nations in the Arctic, have their own unique perspectives and needs in the Arctic. The representatives from Norway

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and Sweden explained they already have infrastructure in place throughout their countries and can tap into the existing power grid and water systems. There is no need for them to have expeditionary solutions for austere environments because they plan to stay in their own country and use their domestic infrastructure. They also have supplies prepositioned if they need to mobilize in their country. M.Sc. Jaeger from Germany stated that they do not have as much experience in the extreme cold regions, but they would plan to use soft-walled solutions initially, then build up using contractors for larger buildings if they needed to establish in the Arctic. The main focus of the partner nations was determining what the needs of the US were so that they could support allied nations as host nations.

2.4 Challenges

Participants noted the following as challenges in working in the Arctic:

- Poorly defined temperature requirements (-60°F or -65°F)
 - Suggestion: Developing a Three-Tier Climate Operations Index
 - * Type I = Southern Arctic Coastline (infrequent cold, heavy snow, and freezing precipitation)
 - * Type II = Northern Arctic Coastline (moderate long-duration cold, moderate snow, and long-duration high winds)
 - * Type III = Interior Continental (long-duration deep cold, low wind, and moderate to low snow loading)
- Freezing precipitation
- Freeze–thaw cycling
- Permafrost stability
- Darkness

2.5 Workshop Outcomes

2.5.1 Problem Statement

The problem statements were developed as follows:

- There is no common extreme cold weather (ECW) testing location to conduct validation of emerging infrastructure solutions.
- The current suite of expeditionary shelters does not meet the ECW conditions.
- No shelters are available for fighter and support aircraft in ECW.

- Current ground infrastructure cannot endure seasonal variations to sustain forces.
- There is no common catalog for interoperable ECW infrastructure.

2.5.2 Objective

The objective is to research and develop effective, survivable, and interoperable (joint and combined) ECW and Arctic infrastructure.

2.5.3 Scope

The scope of work includes the following tasks:

Task 1: Establish an international, environmentally representative training and evaluation center where equipment effectiveness and interoperability can be demonstrated and validated, with the following goals:

- Arctic version of ERDC's Contingency Basing Integration Training and Evaluation Center (CBITEC), Fort Leonard Wood
- Combined S&T to streamline and accelerate acquisition timelines and support earlier decision-making
- Coalition involvement
- Diagnostic monitoring
- Field testing and training with military forces
- All-season Arctic conditions
- Potential Sites:
 - Camp Roedsmoen—Rena, Norway
 - Camp Setermoen—Setermoen, Norway
 - Kalixfors, Sweden
 - ERDC's Arctic Infrastructure Research Center (AIRC)—Fairbanks, Alaska, United States

Task 2: Develop scalable ECW expeditionary shelters with reduced logistical burden, prioritizing the following qualities:

- Modular
- Tactically transportable
- Lightweight
- Reduced signature
- Sustainable
- Climate focused

- Adaptable

Task 3: Develop ECW large-scale shelters for aircraft and vehicle and maintenance and warehousing operations, prioritizing the following qualities:

- Sustainable
- Climate focused
- Adaptable

Task 4: Enable rapid, enduring lines of communication for sustainment of forces, addressing the following conditions and constraints:

- Bed down (expeditionary)
- Sustainable (resupply)
- Recovery (major repairs)
- Rapid geotechnical assessment
- Seasonal limitations
- Permafrost
- Strength and thickness of lake and river ice
- Spring and summer thawing
- Muskeg

Task 5: Create a common ECW infrastructure catalog to be integrated and interoperable with partner nations and that addresses the following:

- Based on Joint Construction Management System (JCMS) facility library
- Identification of current coalition ECW-capable structures
- Planning considerations
 - Duration
 - ECW levels
 - Location (soils, proximity to urban settings)

3 Water/Wastewater Topic Area

3.1 Preworkshop Synopsis

The water/wastewater group started weekly meetings in August 2022 to provide group members with overviews of what the group would work to accomplish at the workshop, the PA process, and relevant water/wastewater topics. Dr. Clint Smith (ERDC Geospatial Research Laboratory [GRL]) led these meetings, which were open both to participants who planned to attend the workshop and those who could not attend. All aspects of the workshop topic-area planning and design were also supported by Ms. Lauren Bosche (ERDC-CRREL), Dr. Edith Martinez-Guerra (ERDC Environmental Laboratory [EL]), and Mr. Cary Paul of Forge Forward Inc.

3.2 Progress through Workshop Activities

The water team was led by Dr. Clint Smith (ERDC-GRL). Notetakers included workshop organizers Ms. Bosche and Dr. Martinez-Guerra. Mr. Fahmi Atwain (ERDC-GRL) also assisted as a notetaker, and Mr. Cary Paul from Forge Forward Inc. helped facilitate the sessions (Figure 1).

The water/wastewater topic group started in Breakout Session A on the afternoon of the first day with group-member presentations that showcased needs, technologies, solutions, and challenges. The following presentations were provided:

- Graywater Reuse System Air Force Civil Engineer Center / Readiness Directorate (AFCEC/CXXM [Expeditionary Engineering Division, Modernization Branch])—Mr. Richard Peck
- BEAR (Basic Expeditionary Airfield Resources) Water Freeze Protection Solutions for Deployed Water Systems—Mr. Richard Peck
- US Army Combat Capabilities Development Command (DEVCOM) Ground Vehicle System Center (GVSC) Cold Weather Operations—Dr. Michael Anderson
- US Army Combat Capabilities Development Command (DEVCOM) Ground Vehicle System Center (GVSC) SpaceDrip: Automated Wastewater Reuse and Treatment Systems—Dr. Michael Anderson
- ERDC Defense Installation Resilient Water Purification System (DIR-WPS “DRIPS”) and Relief Wells System: Decentralized Mobile Water

- Assessment, Purification, and Decontamination for Installation Resiliency—Dr. Clint Smith
- ERDC Source-Separated Graywater Pilots: Chemistry, Unit Operations, and Criteria Towards Reuse—Dr. Chris Griggs
 - TRC Companies Water and Wastewater Overview—Dr. Victor Medina
 - Individual Water Hydration Program Overview: DEVCOM Soldier Center—Eric Brack
 - Plasma Waters Water Production Technology, Chile—Dr. Alfredo Zolezzi

Breakout Sessions B and C focused on facilitating a full group discussion on potential project collaborations and the development of the PA. The group filled out the PA PowerPoint to prepare for the brief to the senior leaders on the final day of the workshop. Much of the discussion surrounded the need to create a broad problem statement that could accommodate the broad scope of activities that will be fully identified in the coming months. The full water/wastewater group did not meet together in Breakout Session D as this time was used for individual final preparations of the brief presentations.

Figure 1. Some members of the water/wastewater group.



3.3 International Perspective

As all of the foreign ICE-PPR country representatives joined the infrastructure and energy groups, the water/wastewater group largely used the breakout sessions to align US interests in the area. However, on the second day of the workshop, a representative from Norway (Mr. Anders Haavik-Nilsen) and Swedish officers provided overviews of the water/wastewater defense infrastructure in their respective countries and their perspective on future collaborations. They shared that they are not concerned about intentional poisoning and pollution and per- and polyfluoroalkyl substances (PFAS) in water/wastewater, and they are interested in the transferable learnings from Alaska. The Scandinavian representatives expressed interest in supporting collaborations with the US by offering the use of their water resources (lakes, rivers, and snow) if training activities were to take place in Norway or Sweden.

Workshop participants are currently engaging defense-community representatives from all of the ICE-PPR countries and are focusing on pursuing leads that have already been identified in Canada and Finland.

3.4 Workshop Outcomes

3.4.1 Problem Statement

The main challenge with water (freshwater and wastewater) in cold regions is keeping it from freezing. It is vital to work on temperature control and management and to further investigate how to maintain water as a liquid. Additionally, it is necessary to reduce energy consumption for liquid water production.

Other identified issues include infrastructure challenges (i.e., water storage and distribution), delivery issues (i.e., logistics and supply chain), decentralization, and concealment and management of heat signatures. Chemical, biological, radiological, and nuclear (CBRN) contamination challenges are also important to manage. Addressing these issues will require further knowledge of the partner nations' capabilities and identifying alternative water sources.

3.4.2 Objective

The objective is to identify and provide solutions on the management of water and wastewater distribution in a polar environment, considering infrastructure, the point of entry to consumption, and the end user.

3.4.3 Scope

The scope of work includes the following tasks:

Task 1. Develop systems for liquid logistics (storage, transportation, and distribution) from production to consumption and discharge or reuse in an austere environment.

Task 2: Optimize resource management associated with water and wastewater.

Task 3: Manage integration with energy and infrastructure.

Task 4: Identify opportunities to collaborate, exercise, compare, and standardize around doctrine, validation, standard operating procedures, and protocols for polar water and wastewater operations.

Task 5: Explore broader applications for these solutions (e.g., humanitarian assistance and disaster relief).

3.4.4 Task Details

Task 1: Develop systems for liquid logistics (storage, transportation, and distribution) from production to consumption and discharge or reuse in an austere environment, specifically regarding the following:

- Potable water from all indigenous water sources (all nations)
 - Low temperature plasma water purification
 - Decentralized mobile water purification and decontamination
 - Purification (removal of microbiological and chemical contaminants)
 - Desalination (reverse osmosis, ion concentration, polarization, etc.)
- Wastewater reuse (i.e., Canada, Denmark, New Zealand)
 - Graywater
 - Blackwater (i.e., Finland, United States)
- Alternative water sources

- Atmospheric water extraction
- Hydrogen fuel cells (i.e., Norway, United States)
- Water from exhaust
- Process comparison (all nations)
 - Share and demonstrate tactics, techniques, and procedures
- Handling of liquid water down to -40°C or below
 - Storage, transfer, and transport

Task 2: Optimize resource management associated with water and wastewater, specifically regarding the following:

- Heat management
 - Prevent freezing and maintain as a liquid.
 - Reduce heat signature.
 - Reuse and capture waste heat.
- Energy management
 - Optimize fuel efficiency.
 - Diversify energy sources.
- Logistical burden
 - Reduce the need to transport water.
 - Minimize requirements to transport water equipment.
 - Optimize capacity.

Task 3: Manage integration with energy and infrastructure, specifically regarding the following:

- Energy
 - Identify efficient energy solutions for melting ice or running treatments.
 - Reconcile water needs with the energy plan and capability.
 - Coordinate regarding energy interoperability within partner nations (generators, direct power, etc.).
 - Maintain common fuel sources.
- Infrastructure (i.e., Canada, United States)
 - Identify climate control to store liquid water (e.g., in tent, in snow or ice) depending on volume (i.e., Norway, Sweden).
 - Reconcile water needs with Infrastructure plan and capability.
 - Manage supply chain commonality of equipment (maintain and sustain).
 - Explore safety policies and concerns.

- Explore storage location concerns (e.g., ground insulation, air gap, etc.).

Task 4: Identify opportunities to collaborate, exercise, compare, and standardize around doctrine, validation, standard operating procedures, and protocols for polar water and wastewater operations, specifically regarding the following:

- Leverage where and how the US DoD is already using doctrine, organization, training, materiel, leadership and education, personnel, and facilities (DOTMLPF) (all nations)
- Train (i.e., Denmark, Finland, Norway, Sweden)
 - Conduct shared training (United States, i.e., Alaska).
 - Compare and collaborate.
- Identify shared definition of minimum water quality requirements (long term, short term, and emergency potable standards)

Task 5: Explore broader applications for these solutions (e.g., humanitarian assistance and disaster relief; All Nations), specifically regarding the following:

- Provide water after disasters (natural and postconflict).
- Support health and hygiene for remote populations.
- Find sources of water.
- Identify military applications to leverage here (e.g., minimize fuel usage, operate in austere environments).
- Ensure commercial availability.
- Develop procedures for collaborating and coordinating with authorities (e.g., validation protocols).
- Address climate change implications.
- Reduce water insecurity.

4 Energy

4.1 Preworkshop Synopsis

A core energy topic-area team consisting of Dr. Orian Welling (ERDC-CRREL), Dr. Caitlin Callaghan (ERDC-CRREL), Sheila Sklerov (Naval Postgraduate School) and Annie Kammerer (Headquarters, Department of the Army) planned the energy session. The planning team was led by ERDC-CRREL. The newly formed ICE-PPR Power and Energy Sub-Working Group was also consulted through the entire process and provided useful feedback to create a high-quality workshop. Many of the ICE-PPR Power and Energy Sub-Working Group members ultimately participated in the workshop. The following key activities occurred prior to the workshop to prepare for a productive facilitated discussion:

- Prepared a list of cold regions energy experts to invite
- Drafted workshop session objectives and schedule
- Provided prework PA training to invitees and to the ICE-PPR Power and Energy Sub-Working Group
- Sent a prework questionnaire to invitees along with draft objectives and a schedule
- Developed key hypotheses based on invitee prework responses
- Identified and resourced roles for facilitating the workshop

The list of potential invitees was developed by compiling cold regions energy S&T experts from the following sources:

- Lists of attendees at previous conferences and meetings (sourced through Dr. Callaghan and ERDC-CRREL technical directors)
- Input and contacts from the core energy session planning team
- International experts provided by ICE-PPR nation leads (sourced through Mr. John Woods, Office of Naval Research [ONR])
- International experts provided by defense attachés at each nation's US Embassy (Dr. Welling emailed requests to each embassy; the defense attaché contact list was provided by Ms. Maria Pruitt, Office of the Deputy Assistant Secretary of the Army for Defense Exports and Cooperation, and Dr. Catie Stephens, ERDC International Research Office.)

The session planning group then reviewed the invitee list to balance space and size constraints with a need for a diverse group of experts, developing a final invitee list.

Dr. Callaghan and Dr. Welling drafted the initial session design based on the stated workshop objectives of developing key material for PA objectives and scope. The design focused on collaborative, structured discussion of several operational focus areas, including sub-breakout sessions for each operational area. Full group presentations were limited to aligning and framing objectives for the workshop and background and additional training on the final Project Agreement end goal. Unlike many other S&T workshops, there were no technical presentations from researchers.

A short background on PAs and a prework survey were sent to participants three weeks before the workshop with a suspense of two weeks before the workshop. The planning team used the survey results to refine the list of operational focus areas for the sub-breakout sessions.

All aspects of the planning and design were also supported by Mr. Ray Chen and Mr. Brad Blevins of Forge Forward Inc.

4.2 Progress through Workshop Activities

The session leads were Dr. Orian Welling and Dr. Caitlin Callaghan (ERDC-CRREL), and the notetakers were Mike Stearns (ERDC-CRREL) and David Pogue (ERDC-CERL).

The first energy breakout session (afternoon of the first day, after the Plenary) was held with all energy session participants (approximately 35, fluctuating through the week) together in the same room. The goals of this full session were to prime all participants for good discussions, set expectations on how the sub-breakout operational area groups would function, and ensure all participants were aligned with the operational areas planned for the breakouts. Key activities included the following:

- Facilitated round-robin introductions
- Motivational overview of workshop goals and anticipated impact
- Consultant-led discussion of expectations and ways of working for each sub-breakout group, including assignment of notetakers and sub-breakout group leads

- Facilitated discussion on operational areas planned for the sub-breakout groups

Including the facilitated discussion on operational areas for sub-breakout groups instead of working with predetermined areas was ultimately very helpful for the workshop outcomes. Through the course of this discussion, the group determined that the original operational areas defined by the organizers were not sufficiently inclusive or sufficiently aligned with military operations to support actionable workshop outcomes and agreed to a new set of three operational areas. While no framework perfectly aligns with all S&T interests, the exercise of deciding as a group how to split operational areas to tackle the problem (developing a PA) allowed participants to voice and acknowledge concerns early. As a result, there was very little discussion about framework issues (e.g., though batteries are used in both deployed sensors *and* in small unit communication equipment, participants still split into separate groups because the operational issues are different for each). The following final operational areas were used for the sub-breakout groups:

- **Portable and mobile systems** (key need: man-portable sources of heat and power suitable for operation in polar environments for full mission duration)
- **Temporary, semifixed, and fixed systems** (key need: adaptive energy solutions for remote, geodiverse, on or off-grid, and extreme polar environments, with consideration for changing climate)
- **Unmanned and autonomous systems** (key need: technology to allow deployment of remote systems that are robust, maintainable, and consistent within a polar environment)

The energy session's subsequent sub-breakout groups discussed and drafted the objectives and scope for each operational area. Participants volunteered to lead individual sessions and notetakers were provided for each session. The sub-breakout group leads and session leads then compiled the results into an outbrief presentation that was shared with all energy session participants, then presented to workshop senior leaders on the final day of the workshop.

4.3 International Perspective

Dr. Giselle Amow (Defence Research and Development, Canada) participated in the full energy session and provided useful perspectives on challenges of powering remote unmanned sites in the far north of Canada. Considerations included reducing the frequency of trips needed for refueling or maintenance, strategies for autonomous refueling, and use of renewable and locally generated fuels.

Workshop participants from the Norway Defence Estates Agency participated in discussion at multiple points through the workshop.

4.4 Workshop Outcomes

As of December 2022, a PA titled “Energy Development for Polar Environments” has been drafted, and the draft scope has been shared with subject matter experts in all seven ICE-PPR nations and with the ICE-PPR Power and Energy Sub-Working Group for comment. A Summary Statement of Intent (US internal document outlining national interests in the PA) has also been drafted.

5 Conclusions and Next Steps

The workshop brought together a wide variety of subject matter experts to address issues across a range of topics and to identify paths forward in relation to cold regions defense infrastructure. The facilitated breakout sessions provided a venue to discuss challenges, to identify opportunities, and to assemble the basic elements of draft PAs for the three topic areas: infrastructure, water/wastewater, and energy.

The three topic working groups continue to develop the three PAs on the plan of action and milestones (POAM) schedule (Table 1).

Table 1. Plan of action and milestones (POAM) schedule.

Tasks	Responsible	Due Date	Notes
Workshop	Topic Leads	13–15 Sep	—
Share Workshop Outcomes	Topic Leads	22 Sep	Topic leads share with ICE-PPR nation executive officers via Mr. Woods
Feedback Due to Topic Leads	All Participants	6 Oct	Comments to outcomes due
Comments Consolidated	Topic Leads	13 Oct	Share updated version of the scope of work to topic participants
Topic Meeting 1	Topic Leads	20 Oct	No later than 20 Oct hold meeting with all interested parties
Topic Meeting 2	Topic Leads	17 Nov	No later than 17 Nov hold meeting 2 with all interested parties to continue drafting tech planning documents
Topic Meetings with Leadership	Topic Leads	1 Dec	PA leads provide updates on progress
Topic Meeting 3	Topic Leads	15 Dec	PA leads provide updates on progress
Tech Planning Docs Completed	Topic Leads	22 Dec	—

Appendix A: Workshop Poster

This appendix includes the workshop poster (Figure A-1) that was sent out to participants prior to the workshop.

Figure A-1. Workshop poster.

INFRASTRUCTURE | WATER/WASTEWATER | ENERGY

International Workshop on Cold Regions Defense Infrastructure

*Uniting engineers and scientists from international defense and research organizations to
identify and prioritize research gaps and facilitate future collaborations.*

13-15 September 2022
Hanover, New Hampshire USA
U.S. Army Cold Regions Research
and Engineering Laboratory
(CRREL)

Points of Contact:

Technical Dr. Tom Douglas Tom.Douglas@erdc.dren.mil	Registration & Travel Dawn Hathaway Dawn.E.Hathaway@usace.army.mil
General Site Access Orrian Welling Orrian.Z.Welling@erdc.dren.mil	Registration & Posters Lauren Bosche Lauren.V.Bosche@usace.army.mil


Co-Convened by ICE-PPR


ERDC
ENGINEER RESEARCH & DEVELOPMENT CENTER
U.S. Army Engineer Research & Development Center

Appendix B: Workshop Agenda

Figure B-1 and Figure B-2 show the agenda followed during the workshop. This includes the breakout sessions per group.

Figure B-1. Agenda for the first day of the workshop.



International Workshop on Cold Regions Defense Infrastructure

September 13 - 15, 2022

U.S. Army Cold Regions Research &
Engineering Laboratory
Hanover, NH

Tuesday, September 13

0800 - 0900	Registration Open	Lobby
0900 - 0915	Welcome to the Meeting from Dr. Corriveau, <i>Director, Cold Regions Research & Engineering Laboratory</i>	Abele
0915 - 0930	Workshop Kick Off and Charge Kevin Bjella, Tom Douglas, John Woods	Abele
0930 - 0945	DASD Arctic - Greg Pollock (virtual) <i>Principal Director and Senior Advisor, OSD</i>	Abele
0945 - 1000	G2 - Ken Quail (virtual) <i>HQDA ODCS, G-2, Middle East Desk</i>	Abele
1000 - 1015	Arctic Operational Context Discussion - Justin Putnam (ERDC)	Abele
1015 - 1030	Arctic Edge Briefing - LTC Booth (SOC North)	Abele
1030 - 1100	COFFEE BREAK	
1100 - 1200	International Briefs <i>Intro from John Woods</i>	Abele
1200 - 1300	LUNCH	Base Camp
1300 - 1305	International Brief - NZ (virtual)	Abele
1305 - 1330	Workshop Expectations - John Woods	Abele
1330 - 1730	Break Out Session A Infrastructure in Abele Energy in Base Camp Water/Wastewater in Gow Auditorium	
1730 - 1930	Cocktail Hour at Jesse's Steakhouse - Dinner on your own	

Figure B-2. Agenda for the second and third day of the workshop.

Wednesday, September 14

0900 – 1200	Break Out Session B <i>Infrastructure</i> in Abele <i>Energy</i> in Base Camp <i>Water/Wastewater</i> in Gow Auditorium
1200 – 1300	LUNCH
1300 – 1630	Break Out Session C <i>Infrastructure</i> in Abele <i>Energy</i> in Base Camp <i>Water/Wastewater</i> in Gow Auditorium
1630 – 1800	Reception with Poster Session and Demos in Ice Engineering <i>Light hors d'oeuvres and Drinks will be served</i>

Thursday, September 15

0900 – 1200	Breakout Session D <i>Infrastructure</i> in GIS Teaching Room <i>Energy</i> in Base Camp <i>Water/Wastewater</i> in Gow Auditorium	
0900 – 1200	Invite Only: Senior Leader Engagement and Security Roundtable	
1200 – 1300	LUNCH	
1300 – 1310	Introductions and Charge to the Group	Abele
1310 – 1350	Infrastructure Topic Briefs	Abele
1350 – 1430	Energy Topic Briefs	Abele
1430 – 1500	COFFEE BREAK	
1500 – 1540	Water/Wastewater Briefs	Abele
1540	Closing Remarks/Reflections from VIP's – Dr. Corriveau, Chair	Abele

Appendix C: Photos from the Workshop

Figure C-1. Photos taken during the workshop.



Appendix D: Workshop Prospectus

This appendix provides the workshop prospectus (per working group).



International Workshop on Cold Regions Defense Infrastructure

Date: September 13–15, 2022

Location: US Army Cold Regions Research and Engineering Laboratory;
Hanover, New Hampshire, United States

Contact: Dr. Thomas A. Douglas (Thomas.A.Douglas@usace.army.mil;
907-378-7900)

Purpose: The inaugural International Workshop on Cold Regions Defense Infrastructure will unite engineers and scientists of the United States DoD with defense representatives from the other nations comprising the International Cooperative Engagement Program for Polar Research (ICE-PPR): Canada, Denmark, Finland, Norway, Sweden, and New Zealand. Through the ICE-PPR Memorandum of Understanding, we will establish Project Arrangements (PAs) across the seven nations to share measurements, models, and access to research sites and facilities. The goal of this workshop is to develop specific PAs within three major topic areas. From a variety of meetings and activities, we have identified the following specific topic areas for which PAs will be developed.

Energy:

1. Stationary power, including microgrids, small modular reactors, and microreactors
2. Heat (thermal management and supply), including air-source heat pumps and insulation/waste heat materials
3. Mobile and portable power applications, including batteries and fuel cells

Water/Wastewater:

1. Arctic-capable water assurance, disinfection, and supply using decentralized energy
2. Portable desalination and low-temperature plasma water purification
3. Arctic integrated graywater treatment and reclamation technologies

Infrastructure:

1. Arctic-capable, soft-walled expeditionary shelters and materials
2. Arctic-capable, large-scale expeditionary shelter
3. ISO-compatible shelter mobility systems

Background: The Arctic region is a strategic national security concern. Operating in any of earth's polar and cold regions (the Arctic and Antarctic as well as Subarctic and seasonally frozen locations) remains an extremely challenging endeavor due to harsh and rapidly changing weather, austere infrastructure, and a general lack of operational experience. The polar defense engineering and scientific community recognizes these challenges and has identified capability gaps and launched strategic infrastructure and operational energy initiatives. ICE-PPR was established in 2019 to enable defense departments working in earth's polar regions to collaborate across a variety of research and engineering topics.

Workshop Format and Objectives: The three-day workshop will open with a short morning plenary session to outline the PA development efforts. The remainder of day 1, all of day 2, and half of day 3 will focus on developing multinational PAs, identifying specific needs and appropriate measurements and technologies. Outbriefs from the nine specific PAs will be finalized on the morning of the third day and briefed to the plenary group in the afternoon. We hope to have high ranking attendees at this outbrief to help identify resources and paths forward. Surveys conducted before and during the meeting will further identify emerging trends and needs. An evening poster session and social event will promote broader discussions.

Workshop Outcomes: An executive-style report will identify and describe the PAs developed within each focus area, detailing proposed efforts and identifying paths for resourcing. The services and ICE-PPR can leverage this report to identify resources to address requirements and emerging needs.

Appendix E: Attendees

Table E-1. Participating organizations for the International Workshop on Cold Regions Defense Infrastructure, 13–15 September 2022, Hanover, New Hampshire.

Workshop Leads
US Army Engineer Research and Development Center, Cold Regions Research and Engineering Laboratory (ERDC-CRREL)
US Navy Office of Naval Research
Senior Leaders
National Science Foundation
Northern Aerospace Defense and US Northern Command
Office of the Secretary of Defense
US Arctic Research Commission
US Army 11th Airborne Division
US Army Combat Capabilities Development Command (DEVCOM) Soldier Center
US Army Corps of Engineers (USACE)
US Army ERDC-CRREL
US Army North, Fifth Army (ARNORTH)
US Navy Office of Naval Research
Partner Nations
Defence Research and Development Canada
Defence Technology Agency, New Zealand Defence Force
Federal Office of Bundeswehr Infrastructure, Environmental Protection and Services
Forsvarsbygg
Norwegian Defence Estates Agency
Plasma Waters
Swedish Armed Forces
Swedish Defence Research Agency (FOI)
US Navy Office of Naval Research
Workshop Participants
109 Airlift Wing
354 Civil Engineering Squadron
377th Theater Sustainment Command
Alaska Center for Energy and Power
Alaska Army National Guard
Alaskan Command
Cold Regions Test Center
Dartmouth College
Defense Innovation Unit (DIU)
Headquarters, US Department of the Army, Office of the Chief of Engineers
Headquarters, US Department of the Army, Deputy Chief of Staff, G2

Table E-1 (cont.). Participating organizations for the International Workshop on Cold Regions Defense Infrastructure, 13–15 September 2022, Hanover, New Hampshire.

Workshop Participants
Headquarters, US Department of the Army, G-35
Massachusetts Institute of Technology Lincoln Laboratory
MITRE
Natick Soldier Systems Center
National Science Foundation
National Science Foundation International Programs
Naval Facilities Engineering and Expeditionary Warfare Center
Naval Facilities Expeditionary Programs Office
Naval Postgraduate School
Naval Special Warfare Center Crane
New Hampshire Army National Guard
Northern Aerospace Defense and US Northern Command
Northern Aerospace Defense and US Northern Command J8 Science and Technology
Office of the Assistant Secretary of Defense-Industrial Base Policy (Contractor)
Office of the Chief of Engineers, Pentagon
Office of the Chief of Engineers, US Army
Office of the Under Secretary of Defense for Acquisitions and Sustainment
Product Manager Force Sustainment Systems
Power and Energy Systems, Naval Special Warfare Center Crane
Product Manager Force Sustainment Systems
Special Operations Command North
Stantec Consulting Ltd.
Ted Stevens Center for Arctic Security Studies
TRC Companies
University of Alaska Fairbanks
US Air Force Civil Engineer Center
US Air Force Rapid Sustainment Office
US Air Forces Northern
US Army 11th Airborne Division
US Army 11th Infantry Division, Arctic
US Army 6th Brigade Engineer Battalion
US Army Armaments Center
US Army DEVCOM
US Army DEVCOM Americas
US Army DEVCOM Army Research Lab
US Army DEVCOM Ground Vehicle Systems Center
US Army DEVCOM Indo-Pacific
US Army DEVCOM Soldier Center

Table E-1 (cont.). Participating organizations for the International Workshop on Cold Regions Defense Infrastructure, 13–15 September 2022, Hanover, New Hampshire.

Workshop Participants
US Army ERDC
US Army ERDC Construction Engineering Research Laboratory (CERL)
US Army ERDC-CRREL
US Army ERDC Environmental Laboratory (EL)
US Army ERDC Geospatial Research Laboratory (GRL)
US Army ERDC Geotechnical and Structures Laboratory (GSL)
US Army Medical Test and Evaluation Activity
US Army Product Manager Petroleum and Water Systems
US ARNORTH
US Navy Office of Naval Research
US Navy Office of Naval Research Global
US Navy Office of Naval Research–Reserve Component
USACE
USACE Alaska District
Vermont Army National Guard
WaterStep
Workshop Facilitators
Forge Forward
US Army ERDC-CRREL
US Army ERDC Headquarters

Appendix F: Outbrief Slides

F.1 Infrastructure Outbrief Slides

The infrastructure group presented the following 14 slides.*

* PA = Project Arrangement, POAM = plan of action and milestones, S&T = science and technology, SME = subject matter expert, and XO = executive officer.

The background of the slide features a large iceberg floating in a blue ocean under a clear sky. The iceberg's tip is above the water, while its much larger, jagged base is submerged. In the top left corner, there is a circular logo for the 'ICE PPR' (International Cooperative Program for Polar Research) featuring various national flags. In the top right corner, there is a stylized snowflake logo containing icons for a person, a building, a battery, and a snowflake. The main text is centered over the submerged part of the iceberg.

Project Arrangement
15 September 2022

Infrastructure

Mr. Kevin Bjella
USACE-ERDC-CRREL

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International Workshop on Cold Regions Defense Infrastructure



Agenda



- ☐ Setting the Stage
- ☐ Problem Statements
- ☐ Challenges
- ☐ Objective
- ☐ Scope of Work





Setting the Stage



- 40 infrastructure experts diverse SME's
 - US (all services)
 - Norway
 - Sweden
 - Germany
 - Denmark



Problem Statements



- No common, extreme cold weather (ECW) testing location to conduct validation of emerging infrastructure solutions
- Current suite of expeditionary shelters do not meet the ECW conditions
- No shelters for fighter and support aircraft in ECW
- Current ground infrastructure cannot endure seasonal variations to sustain forces
- No common catalog for interoperable ECW infrastructure



Challenges



- Poorly defined temp requirements (-60°F/-65°F)
 - Suggestion: Three Tier Climate Operations Index
 - i.e. – Type I = Southern Arctic Coastline (infrequent cold, heavy snow, freezing precipitation)
 - Type II = Northern Arctic Coastline (moderate long duration cold, moderate snow, long duration high winds)
 - Type III = Interior continental (long duration deep cold, low wind, moderate to low snow loading)
- Freezing precipitation
- Freeze/thaw cycling
- Permafrost stability
- Darkness



Objective



Research and develop effective, survivable, and interoperable (Joint and Combined) ECW/Arctic infrastructure.



Scope of Work



1. Establish an international, environmentally-representative “proving ground” where equipment effectiveness and interoperability can be demonstrated and validated
2. Develop scalable ECW expeditionary shelters with reduced logistical burden
3. Develop ECW large-scale shelters for aircraft/vehicle and maintenance/warehousing operations
4. Enable rapid, enduring lines of communication for sustainment of forces
5. Create a common ECW infrastructure catalog



Scope 1



Establish an international, environmentally-representative training and evaluation center where equipment effectiveness and interoperability can be demonstrated and validated

- Arctic version of the ERDC's Contingency Basing Integration Training and Evaluation Center (CBITEC) at Fort Leonard Wood
- Combined S&T to 'shift left'
- Coalition involvement
- Diagnostic monitoring
- Field testing and training with military forces
- All-season arctic conditions
- Potential Sites
 - Camp Roedsmoen – NOR
 - Camp Setermoen – NOR
 - Kalixfors – SWE
 - Arctic Infrastructure Research Center (AIRC) – USA, ERDC





Scope 2



Develop scalable ECW expeditionary shelters with reduced logistical burden

- Modular
- Tactically transportable
 - Lightweight
 - Reduced signature
- Sustainable
 - Climate focused
- Adaptable





Scope 3



Develop ECW large-scale shelters for aircraft/vehicle and maintenance/warehousing operations

- Sustainable
 - Climate focused
- Adaptable





Scope 4



Enable rapid, enduring lines of communication for sustainment of forces

- Beddown (Expeditionary)
- Sustainable (Resupply)
- Recovery (Major repairs)
- Rapid geotechnical assessment
- Seasonal limitations
 - Permafrost, ice thickness/strength
 - Spring/summer thawing
 - Muskeg





Scope 5



Create a common ECW infrastructure catalog

- Based on Joint Construction Management System (JCMS) facility library
- Identification of current coalition ECW capable structures
- Planning considerations
 - Duration
 - ECW levels
 - Location (soils, proximity to urban)



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12



Welcome Questions



High Level POAM



- 1st DRAFT of PA: 31 October 2022
- 2nd DRAFT of PA: 31 January 2023
- Final Review of DRAFT PA: April 2023
- Final DRAFT: Mid-May 2023
- *Biweekly Virtual beginning Thursday, 13 October 2022 @ 1200 EST*

F.2 Water/Wastewater Outbrief Slides

The water/wastewater group presented the following 12 slides.



Project Arrangement
15 September 2022

Water and Wastewater

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International Workshop on Cold Regions Defense Infrastructure



Contents



Project Arrangement (PA)

- ☐ Three Subsets
- ☐ Problem Statements
- ☐ Objective
- ☐ Scope
- ☐ Tasks
- ☐ POAM



Three Subsets



Water



Wastewater



Doctrine/Protocols



- Infrastructure
- Point of Entry to Consumption
- End User



Problem Statement



How do we deal with...

- Temperature (control and management) - how to maintain water as a liquid?
- Energy consumption (reduce fuel use for liquid water production)
- Delivery issues (logistics/supply chain)
- Infrastructure challenges (water storage/distribution)
- Decentralization
- Concealment and management of heat signature
- Lack of knowledge of partner Nations' capabilities
 - "If it works in Polar, it can work anywhere in the world" NOR/SWE
- Lack alt. water sources – how do we identify water sources?



Objective



Identify and provide how to manage water and wastewater from/to infrastructure to an individual level in a Polar environment

Infrastructure

Point of Entry to Consumption

End User



“The life cycle of a block of ice”

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5 5



Scope of Work



1. Develop systems for liquid logistics (storage, transportation, and distribution) from production to consumption and discharge/reuse in an austere environment
2. Optimize resource management associated with water and wastewater
3. Manage integration with energy and infrastructure
4. Identify opportunities to collaborate, exercise, compare, and standardize around doctrine, validation, Standard Operating Procedures, protocols for polar water and wastewater operations
5. Explore broader applications for these solutions (e.g., humanitarian assistance and disaster relief)



Sharing of Tasks



1. **Develop systems for liquid logistics (storage, transportation, and distribution) from production to consumption and discharge/reuse in an austere environment**
 - **Potable water from all indigenous water sources (All Nations)**
 - Low temperature plasma water purification
 - Decentralized mobile water purification and decontamination
 - Purification (removal of microbiological and chemical contaminants)
 - Desalination (reverse osmosis, ion concentration, polarization, etc.)
 - **Wastewater reuse (i.e., CAN, DNK, NZL)**
 - Graywater
 - Blackwater (i.e., FIN, USA)
 - **Alternative water sources**
 - Atmospheric Water Extraction (AWE)
 - Hydrogen fuel cells (i.e., NOR, USA)
 - Water from exhaust
 - **Identify processes for comparison (All Nations)**
 - Share and demonstrate tactics, techniques, and procedures
 - **Handling of liquid water down to -40°C or below**
 - Storage, transfer, transport





Sharing of Tasks



2. Optimize resource management associated with water and wastewater

- **Heat management**

- Prevent freezing/maintain as a liquid
- Reduce heat signature
- Reuse/capture waste heat

- **Energy management**

- Optimize fuel efficiency
- Diversify energy sources

- **Reduce logistical burden**

- Reduce need for transportation of water
- Minimize requirements for transport of water equipment
- Optimize capacity





Sharing of Tasks



3. Manage integration with energy and infrastructure

- **Energy**
 - Identify efficient energy solutions for melting ice or running treatments
 - Reconcile Water needs with Energy plan and capability
 - Coordinate regarding energy interoperability within partner nations (generators, direct power, etc.)
 - Maintain common fuel sources
- **Infrastructure (i.e., CAN, USA)**
 - Identify climate control to store liquid water (e.g., in tent, in snow or ice) depending on volume (i.e., NOR, SWE)
 - Reconcile Water needs with Infrastructure plan and capability
 - Manage supply chain commonality of equipment (maintain and sustain)
 - Explore safety policies and concerns
 - Explore storage location concerns (e.g., ground insulation, air gap, etc.)



Sharing of Tasks



4. Identify opportunities to collaborate, exercise, compare, and standardize around doctrine, validation, Standard Operating Procedures, protocols for polar water and wastewater operations

- Leverage what the U.S. DoD is already using Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, and Facilities (DOTMLPF) (All Nations)
- Training (i.e., DNK, FIN, NOR, SWE)
 - Conduct shared training (USA i.e., Alaska)
 - Compare and collaborate
- Identify shared definition of minimum water quality requirements (long term, short term, and emergency potable standards)





Sharing of Tasks



5. Explore broader applications for these solutions (e.g., humanitarian assistance and disaster relief) (All Nations)

- Provide water after disasters (natural and post conflict)
- Support health and hygiene for remote populations
- Find sources of water
- Identify military applications to leverage here (e.g., minimize fuel usage, operate in austere environments)
- Ensure commercial availability
- Develop procedures for collaboration and coordination with authorities (e.g., validation protocols)
- Address climate change implications
- Reduce water insecurity





POAM



Tasks	Responsible	Due Date	Notes
Workshop	Topic Leads	13-15 SEP	Workshop
Share Workshop Outcomes	Topic Leads	22-Sep	Topic Leads share with ICEPPR nation XO's via Mr. Woods
Feedback Due to Topic Leads	All Participants	6-Oct	Comments to Outcomes due
Comments Consolidated	Topic Leads	13-Oct	Share updated Version of SOW, SOT to Topic Participants
Topic Meeting 1	Topic Leads	20-Oct	NLT 20 OCT hold meeting with all interested parties
Topic Meeting 2	Topic Leads	17-Nov	NLT 17 NOV hold meeting 2 with all interested parties to continue drafting Tech Planning Documents
Topic Meetings with Leadership	Topic Leads & Strausser	1-Dec	PA Leads meet with Strausser on updates
Topic Meeting 3	Topic Leads	15-Dec	PA Leads meet with Strausser on updates
Tech Planning Docs Completed	Topic Leads	22-Dec	
PA Drafts Meeting	Strausser	13-Jan	20 Jan?
PA Drafts Submitted	Strausser	27-Jan	17-Feb?

F.3 Energy Outbrief Slides

The energy group presented the following 11 slides.



The background of the slide features a large iceberg floating in a blue ocean under a clear sky. The iceberg's tip is above the water, while its much larger, jagged base is submerged. In the top left corner, there is a circular logo for the 'ICE PPR' (International Cooperative Program for Polar Research) featuring flags of the United States, Canada, Norway, Sweden, Finland, and the United Kingdom. In the top right corner, there is a stylized snowflake logo containing icons for a person, a brick wall, a wavy line, and a battery. The text 'VIP Outbrief' is written in large white letters on the left side of the submerged part of the iceberg, with '15 September 2022' in smaller white text below it. The word 'Energy' is written in large red letters on the right side of the submerged part of the iceberg. At the bottom center, the text 'DISTRIBUTION A: Approved for public release.' is written in small white letters. A black horizontal bar at the very bottom contains the text 'International Workshop on Cold Regions Defense Infrastructure' in yellow.

VIP Outbrief
15 September 2022

Energy

DISTRIBUTION A: Approved for public release.

International Workshop on Cold Regions Defense Infrastructure



Energy in the Arctic

Challenge to get it there (fuel, etc.)

Requires a lot to survive



Objective: develop energy systems that are
modular, ruggedized, transportable and
effective to meet current and future security
and combat missions of partner nations in
polar environments



Energy Challenges in the Polar Environment



- ➔ **Adversaries** are focused on exploitation and economic gain
- ➔ **Energy requirements** must meet tactical, prime power, and installation demands
- ➔ Overreliance on civil and commercial assets
- ➔ Seasonal /fragile **logistics**
- ➔ **Extreme weather** changes
- ➔ **Climate change** is altering plans as fast as we develop energy solutions (mitigation and adaptation)



Operational Levels



Key Needs

1

Portable & Mobile



Man-portable sources of heat and power suitable for operation in polar environments for full mission duration

2

Temporary, Semi-Fixed & Fixed



Adaptive energy solutions for remote, geo-diverse, on or off-grid, extreme polar environments (w/ consideration for changing climate)

3

Unmanned & Autonomous



Technology to allow deployment of remote systems that are robust, maintainable and consistent within a polar environment

1



Portable & Mobile Concepts



What are we going to do?

Provide **human-portable heating systems** fit for new range of arctic mission profiles

Improve **cold-weather reliability of power and re-charging systems** for man-portable communications and navigation



What will it take?

- Mission footprint analyses (e.g., heating need for 3-person vs. standard 10-person tent)
- Assessment of existing technology across partner nations
- Develop improved cold-weather energy storage (electrical or thermal)
- Portable, light-weight energy storage and recharging systems (e.g., from vehicles or portable renewables)



Temporary, Semi-Fixed & Fixed Facility Concepts



What are we going to do?

Analyze and adapt **existing technologies** (energy sources, storage and distribution)

Increase **energy efficiency** and **logistics optimization**

Develop new methods to **generate locally produced fuel** (e.g. hydrogen)

Develop new **polar resilient storage and distribution** technologies

Research and define current state, and role, of **humans in the loop** for arctic energy solutions

What will it take?

- Collaborative gap analysis of current energy technology (wind, solar, nuclear, heat pumps, geo-thermal, fossil fuels)
- Base improvements, hydrogen vehicles, additive manufacturing, etc.
- Explore and develop co-generation system maturation (heat for food production, water, etc.)

- Batteries, thermal, hydrogen, systems integration, micro-grids, etc.

- Improve human training/learning; human augmentation analysis; cold specific job PPE, reduce maintenance touch points

3



Unmanned & Autonomous Concepts



What are we going to do?

Increase **battery durability** and **energy density** to lengthen operability of sensors to include sea bottom sensors and on ice sensors

Explore development of polar capable **autonomous vehicle refueling system** for unmanned remote systems

Modeling & Simulation, Test & Evaluation of alternative energy sources and energy storage technologies

What will it take?

- New battery chemistry (cold resistance)
 - Improved battery temperature control
 - Battery management system power reduction
-
- Analyses of limitations of current and potential emerging hybrid technologies
-
- Collaboration between partner nations on modeling & simulation, feasibility studies, and test & evaluation site locations
 - Leveraging the unique assets of each partner nation



Energy Seams & Connections



- Gap analyses and sharing of information
- Continuous data collection (common energy data sets, attributes, etc.)
- Vehicles
- Logistics & Operations
- Sources / conversion / storage / distribution / transmission
- Safety & Security
- Environmental resiliency (climate change) for all energy and materiel developments





Next Steps



- Solicit feedback from all ICE-PPR Nations
- 1st Draft PA
- 2nd Draft PA
- Final review by ICE-PPR Nations
- PA draft to legal (NIPO/etc.) by 5.31.23



Thank You!

Abbreviations

AFCEC	Air Force Civil Engineer Center
AIRC	Arctic Infrastructure Research Center
AIRG	Arctic Infrastructure Research Group
ARNORTH	US Army North, Fifth Army
BEAR	Basic Expeditionary Airfield Resources
CBITEC	Contingency Basing Integration Training and Evaluation Center
CBRN	Chemical, biological, radiological, and nuclear
CERL	Construction Engineering Research Laboratory
CRREL	Cold Regions Research and Engineering Laboratory
CXXM	Expeditionary Engineering Division, Modernization Branch
DEVCOM	US Army Combat Capabilities Development Command
DIRWPS	Defense Installation Resilient Water Purification System
DIU	Defense Innovation Unit
DOTMLPF	Doctrine, organization, training, materiel, leadership and education, personnel, and facilities
ECW	Extreme cold weather
EL	Environmental Laboratory
ERDC	Engineer Research and Development Center
EXWC	Engineering and Expeditionary Warfare Center
FP	Force Provider

FOI	Swedish Defence Research Agency
GRL	Geospatial Research Laboratory
GSL	Geotechnical and Structures Laboratory
GVSC	Ground Vehicle System Center
ICE-PPR	International Cooperative Engagement Program for Polar Research
ISO	International Organization for Standardization
JCMS	Joint Construction Management System
LAMS	Large-area maintenance shelters
NAVFAC	Naval Facilities
ONR	Office of Naval Research
PA	Project Arrangement
PFAS	Per- and polyfluoroalkyl substances
POAM	Plan of action and milestones
S&T	Science and technology
SME	Subject matter expert
XO	Executive officer

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