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Advantages of a Proposed U.S. High Arctic Research Center in the Context of a North American Arctic Facility Collaborative Network

PRESENTED BY

Jasper Hardesty Mallory Stewart, Lori Parrott, Mark Ivey

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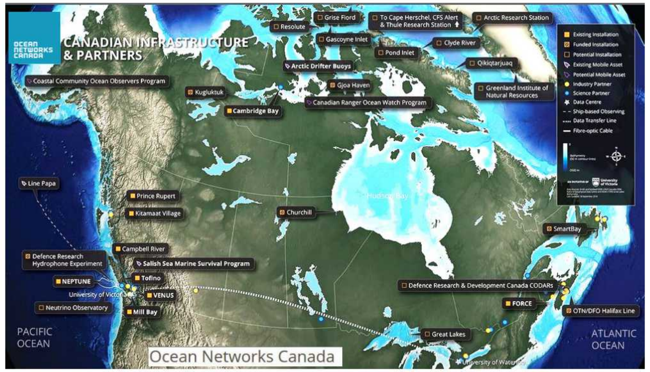
Existing Arctic stations, facilities, and networks



Ocean Networks Canada

AOOS
Alaska Ocean Observing System

Polar Knowledge Canada
Savoir polaire Canada

INNOVATION.CA
CANADA FOUNDATION FOR INNOVATION
FONDATION CANADIENNE POUR L'INNOVATION

NATIONAL SCIENCE FOUNDATION
ARCTIC PROGRAM

Arctic Research Icebreaker Cons.
ARICE

FORUM OF ARCTIC RESEARCH OPERATORS
FARO
faro-arctic.org • faro-arctic@bios.au.dk

IASC

R-ArcticNet:
Pan-Arctic river discharge

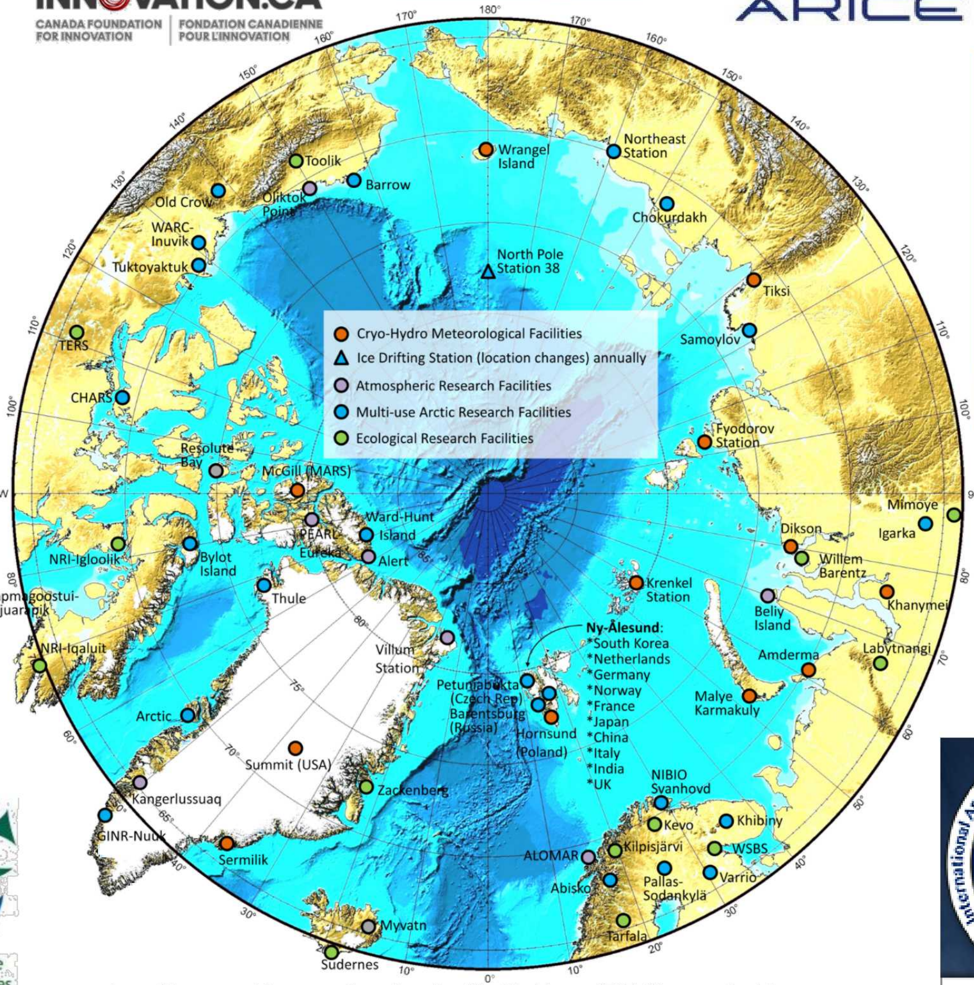
Polar Continental Shelf Program

Ecological Monitoring and Assessment Network

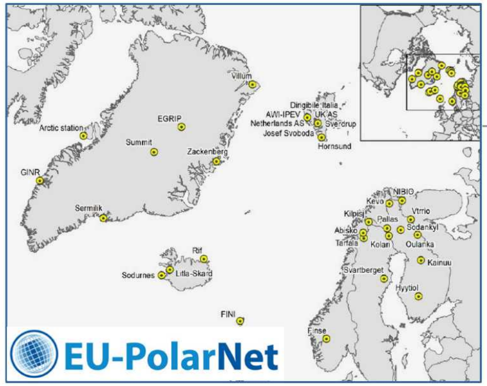
"EMAN: Monitoring Biodiversity in Canadian Forests", Environment Canada, 2001.

CANADIAN NETWORK OF NORTHERN RESEARCH OPERATORS

North American Ice Service
National Ice Center
International Ice Patrol
Canadian Ice Service
Service canadien des glaces



Locations and types of major Arctic Stations [2016] compiled from multiple sources (e.g. INTERACT, US Agencies, NSF, FARO, POLAR-Canada)



1. South and East Hudson Bay
2. Nelson
3. Northwest Hudson Bay
4. Mackenzie
5. Yukon
6. Anadyr Kolyma
7. Lena
8. Yenisei
9. Ob
10. Barents, Norwegian Sea

SAON
SUSTAINING ARCTIC OBSERVING NETWORKS

INTER ⇄ ACT

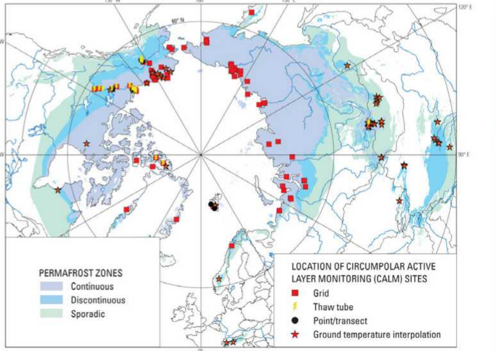
INTERNATIONAL COOPERATIVE ENGAGEMENT PROGRAM FOR POLAR RESEARCH

Greenland Ice Sheet Monitoring Network
GLISN

Greenland Climate Network
GC-Net
PARCA: Program for Arctic Regional Climate Assessment

Greenland Institute of Natural Resources

International Arctic Systems for Observing the Atmosphere
IASOA



CALM/Circumpolar Active Layer Monitoring Sites
USGS Professional Paper 1386-A, Chap A-5, Fig 39; 2012; (https://pubs.usgs.gov/pp/p1386a).

Existing Arctic stations, facilities, and networks

Arctic Observations Organization or Network	Region	Scope	Domain				Basis	Notes
			Terr.	Mar.	Cryo.	Bio.		
Agreement on Enhancing International Arctic Scientific Cooperation	Pan-Arctic	Programs support	x	x	x	x	International Agreement, Arctic Council Science Ministerial	Enhance cooperation in Scientific Activitie;s Support access to terrestrial, coastal, atmospheric, and marine areas.
FARO: Forum of Arctic Research Operators	Pan-Arctic	Logistics	x	x	x	x	Country membership non-profit organization via an MOU	Cooperation among operators of research infrastructure in the Arctic. 21 member countries with national points of contact.
ARICE: Arctic Research Icebreaker Consortium	Pan-Arctic	Logistics		x	x	x	International collaboration under AWI via EU Horizon 2020 research and innovation program	To provide scientists with icebreaker capacities for the Arctic, to address research knowledge gaps.
INTERACT	Pan-Arctic	Logistics, Programs	x		x	x	Cooperative network under auspices of SCANNET MOU and EU Horizon 2020 research and innovation program	86 terrestrial field stations in 16 countries; to build capacity for Arctic research. Stations work together for efficient coordinated research, monitoring and logistics by sharing experiences and harmonizing activities.
IASC: International Arctic Science Committee	Pan-Arctic	Programs support	x	x	x	x	International scientific NGO Governed by a Council of rep's for each member country	Encourage and facilitate cooperation in all aspects of Arctic research; Working Groups provide forums for developing IASC scientific programs and activities.
NAIS: North American Ice Service	North America	Sea Ice, ice bergs		x	x		MOU between NOAA and Envir. Climate Change Canada	Canadian Ice Service, US National Ice Center and International Ice Patrol; to enhance Health, Safety and economic prosperity.
ACGF: Arctic Coast Guard Forum	Pan-Arctic	Research support, safety		x	x		Informal. Joint Statement signed by coast guards of Arctic nations	To foster safe, secure, and environmentally responsible maritime activity in the Arctic. All Arctic countries are members.
ICE-PPR: International Cooperative Engagement Program for Polar Research	Pan-Arctic	Logistics, Programs		x	x	x	Multi-lateral MOU for Mil-Mil and Mil-GOV cooperative Research	US Navy international research program to address challenges in polar regions; research, demonstrations, testing, data sharing.
PAIL: Pan Arctic Inuit Logistics	N. America	Logistics support	x				Wholly owned by the Inuit	Formed to attain M&O contracts for the North Warning System.
CNNRO: Canadian Network of Northern Research Operators	Canada	Logistics, shared use	x	x	x	x	A federally incorporated non-profit organization; via Polar Commission (CPC) and Aboriginal Affairs and Northern Development (AANDC)	Support facilities with technical services for scientific research in Canada Arctic and sub-Arctic; with ocean vessels, observatories, field stations, and remote monitoring installations; FARO rep.
ECSP: Extended Continental Shelf Project	Canada	Logistics, Shared use	x	x	x		US-Canada Cooperative Agreement	US-Canada collaboration to map Arctic Ocean and establish the limits of the ECS; via USCG Healy and CCG Louis S. St-Laurent.
Ocean Networks Canada	North America	Logistics, Programs		x	x	x	network by Univ. of Victoria; support by Innovation Canada	Observatory at Cambridge Bay collecting data the entire year, partners with Fisheries and Oceans for data from ice drifter buoys.
AOOS: Alaska Ocean Observing System	US/Alaska	Logistics		x	x	x	Memorandum of Agreement among federal, state, tribal, and private institutions	Network of critical ocean and coastal observations, data and information that aid our understanding of Alaska's marine ecosystem and environment.
SCANNET: Scandinavian/North European Network of Terrestrial Field Bases	EU	Logistics, Programs	x		x	x	Country membership non-profit organization via an MOU	Network of field stations, managers, and users; to improve observation and access to inform on environmental change in the North.

Why have a collaborative network for North American Arctic research facilities?

- PCSP: sharing makes sense, saves costs…

  "It's all about sharing at the end of the day and having the ability to maneuver. *It's expensive to work in the Arctic and sharing resources makes sense.*"

  [Mike Kristjansen; Logistics Manager, Canada Polar Continental Shelf Program
  (site shared with Armed Forces Canada Arctic Training Center)]

- ECS programs for the U.S. and Canada: Pooling resources, filling gaps…

  "Four years in a row, we actually did a two-ship operation with the Canadian icebreaker Louis St. Laurent [and USCG Healy]. They collected information which allows us to look deeper into the seafloor structure"… and we mapped "with multibeam sonar, so we worked together. Canada has collected seismic data for (the U.S.) this year, so we are dredging and mapping for them. Pooling resources and coordinating research with our neighbor saves both countries a tremendous amount of cost and effort, and that's why we can work together and share information."

  [Layer Mayer; director of the Center for Coastal and Ocean Mapping, on joint US-Canada research of Arctic continental shelf extents]

Mutual interests…

A framework to enhance collaboration and partnership of Arctic assets could benefit North Americans:

- planning for a roadmap of a sustainable North American Arctic observing system.
- address environmental and security issues that affect each countries' Arctic territories and Northern populations
- complementary and synergistic research and resource allocation;
- joint use of facilities to efficiently and effectively serve scientific, safety, environmental, and security needs;
- joint programming of infrastructure for more complex projects and to fill gaps;
- increased knowledge of, and access to, expanded capacities and facilities; and
- efficient collection and sharing of information to enhanced problem-solving of North American-specific concerns.

Science & Technology

- Collaborative international and multi-generational education and sharing of knowledge
- Coordinate the design, development and implementation of a comprehensive and sustained NA-Arctic research infrastructure network.
- Identify mutual needs and coordinate to reduce observational gaps in the Arctic.
- Enhance community-based observing programs.
- Improve understanding of Arctic processes and impacts of Arctic change on the Global system.
- Regional transitions of "Observing Change" to "Understanding Change" to "Responding to Change".
- Use facilities more coherently and effectively to deliver the highest quality Arctic research.
- Coordinated technology development, testing, and regulation (e.g. INTERACT drone development).

Safety, Security, Environment

- Greater opportunities for joint collaboration with Russia and other Arctic nations.
- Risk management and mitigation strategies for Arctic operations.
- Improve management, protection and sustainment of environments.
- Maintain cultures and promote healthy adaptations of Arctic communities.
- Share lessons to balance resource management and environment with economic and community development.

Coordinated Presence and Operations to Support Arctic Research, Technology, Environment, and Security

Source: Brian Glass, "NASA: Mission Ames", NASA, Posted August 5, 2014; https://blogs.nasa.gov/mission-ames/author/bglass/

Credit: Sebastian Saarloos, April 2016; https://www.army.mil/article/166773/sled_to_transport_equipment_tested_in_alaskan_cold

Source: Polar Continental Shelf Program Arctic Operations Manual, Natural Resources Canada, Aug. 2016

Why have a collaborative network for North American Arctic research facilities?

Approaches for use and sharing of Indigenous knowledge and Western science information:
Example: per (J. Kendall- BOEM, "Use of Traditional/Indigenous Knowledge and Science in Resource Management Decisions", Arctic Science Summit Week 2017):

- treat indigenous knowledge and science as distinct and complementary knowledge systems .
- focus on applying indigenous knowledge within the decision-making process.
- examples of how BOEM has used indigenous knowledge in decision making in Alaska:
  1) to design, plan, and conduct scientific research;
  2) applying both knowledge systems at the earliest opportunity;
  3) in environmental impacts assessment;
  4) consulting with indigenous leaders at key decision points; and
  5) applying traditional knowledge at a programmatic decision level.
- Win-win: Shared use of indigenous knowledge and science can allow for more complete and inclusive decisions for mutual benefits.
  - facilitates openness and enhances perspectives
  - co-produces new knowledge
  - garners understanding, acceptance, and trust
  - informs locals and researchers for safe and productive activities

Coordination between countries and communities

- Example: Implement support to coordinate research activities CHARS and Polar Knowledge Canada for mutual benefits to countries and local peoples.

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Conducting Research with Northern Communities

Documented Practices and Resources for Productive, Respectful Relationships Between Researchers and Community Members

Scientific research in the Arctic necessitates good communication and cooperation with northern communities. The following list is a compilation of resources, recommendations, and "best practices" from a variety of organizations. This webpage is intended to be a living resource and will be updated as new information becomes available. Each community has a unique set of requests for researcher conduct and level of desired inclusivity. As such, direct communication and relationships with community leaders should be the highest priority.

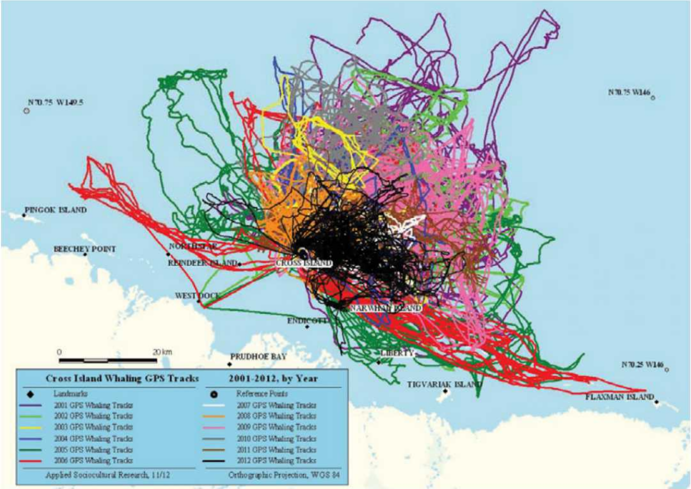
Please contact Lisa Sheffield Guy (lisa@arcus.org) or Helen Wiggins (helen@arcus.org) with:

- Comments or additional resources for this page;
- Suggestions for tools or activities that would foster collaboration between researchers and Arctic community members;
- Ideas to advance inclusion of Indigenous communities in research; or
- Help finding contacts and representatives in northern communities.

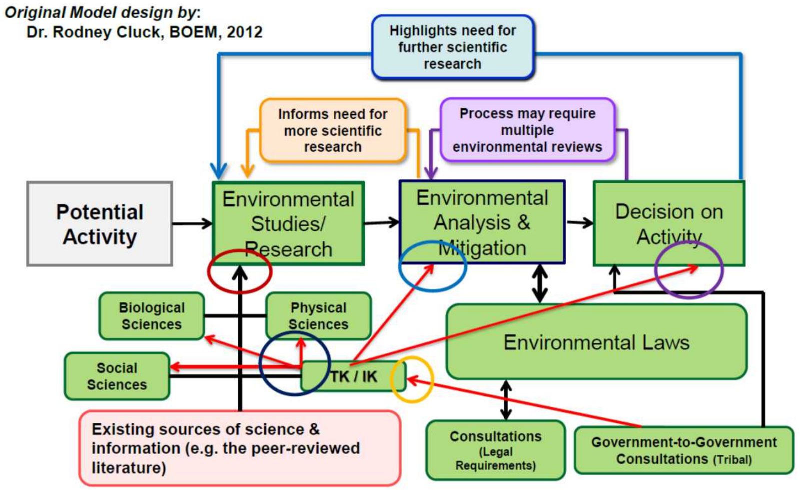
We are grateful to the following people for providing feedback and additional resources: Carolina Behe (Inuit Circumpolar Council - Alaska), Vera Metcalf and Julie Raymond-Yakoubian (Kawerak, Inc.), Karen Pletnikoff (Aleutian Pribilof Islands Association, Inc.), and Kaare Erickson (UIC Science, LLC).

Jump to Section

1. Documented Practices and Resources: Across Northern Communities
2. Documented Practices and Resources: Alaskan Communities
3. Documented Practices and Resources: Canadian Arctic Communities
4. Resources for Community-Based Monitoring
5. Resources from Outside the Arctic



Whaling tracks recorded with GPS. 2001-2012 (*Galginaitis, 2014*).
Source: J. Kendall, et.al.; Czech Polar Reports, V. 7(2): 151-163, ASSW 2017

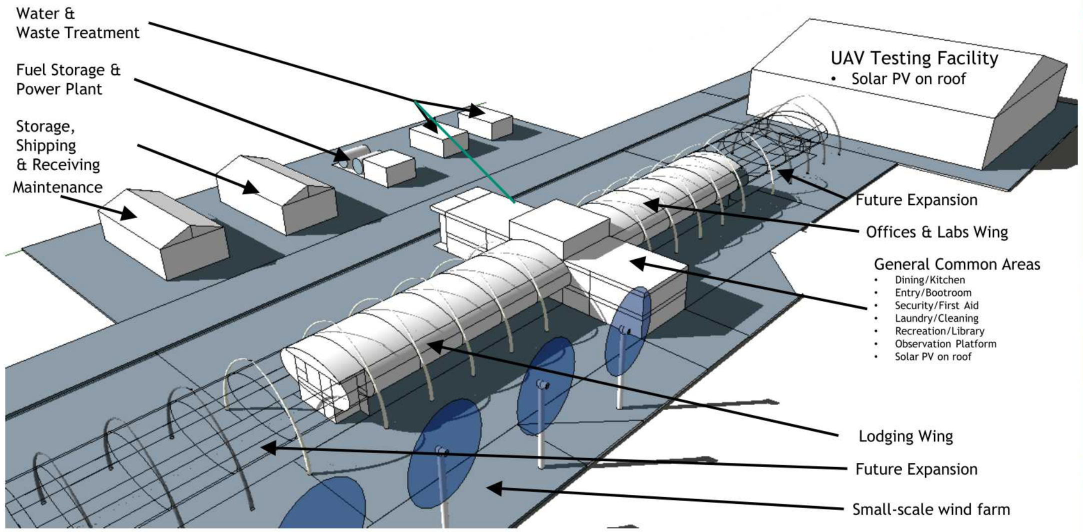


Circles represent areas where indigenous knowledge is used by BOEM.
Source: J. Kendall, et.al.; Czech Polar Reports, V. 7(2): 151-163, ASSW 2017

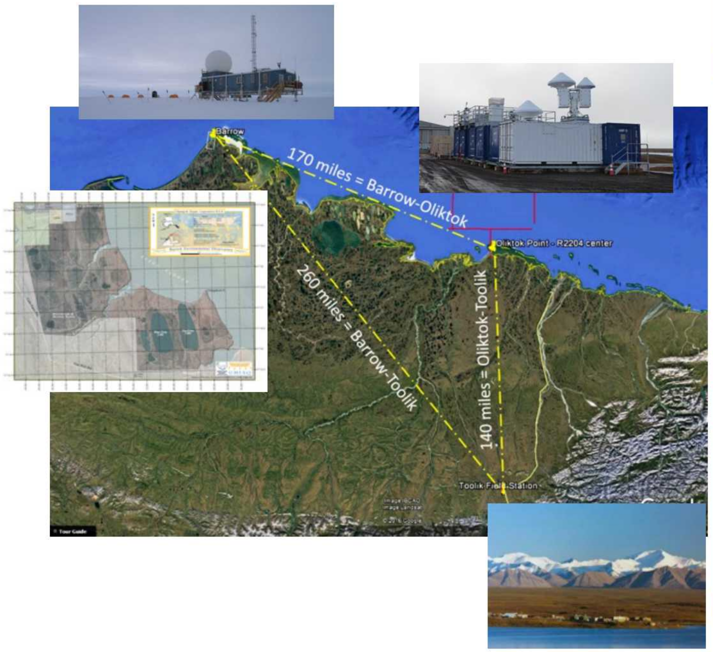
US High Arctic Research Center Concept

U.S. High Arctic Research Center (HARC) Concept

HARC will support comprehensive cooperative research, identify appropriate Arctic technologies, and conduct field tests and exercises to enable advances in the development, resilience, preservation and stewardship of Arctic resources, communities and environment.



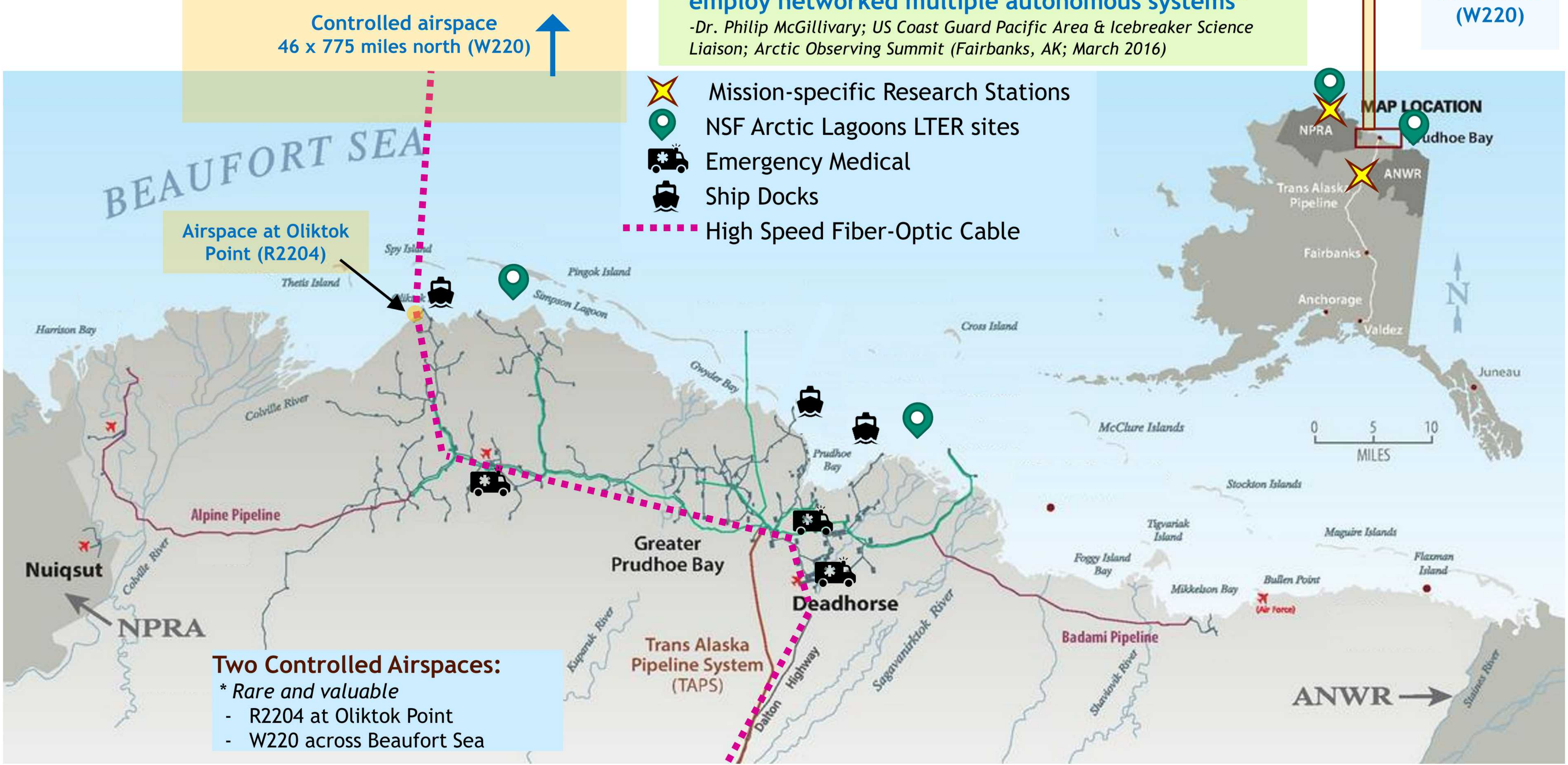
- **<u>Purpose</u>**: Science and research are critical to inform national policy and responses to rapid Arctic change. UAF-Sandia partnership is kick-starting the HARC concept to connect need and opportunity… to promote development of a comprehensive multi-agency US High Arctic research Center (HARC) as a national asset.
- **<u>Need and Opportunity</u>**: The rapidly changing Arctic will change the world… physically, economically, politically, and in many ways. As competing nations are well positioned to take advantage of these changes, national interests will be increasingly vulnerable. To respond as a secure and resilient nation, a proper research infrastructure is required.
- **<u>Vision</u>**: HARC shall be a national asset to support a comprehensive Arctic science and security network to address the needs of many stakeholders to include Federal, State, and Tribal governments, industry, Arctic communities, and researchers. HARC will enable research of Arctic infrastructure, emergency response, search and rescue, domain awareness, environmental change, and the technologies that support these – leading to economic development, environmental protection, and national security improvements.



Prudhoe Bay: Unique Infrastructure and Assets

"We need *a U.S. Arctic location* for exercises to employ networked multiple autonomous systems"

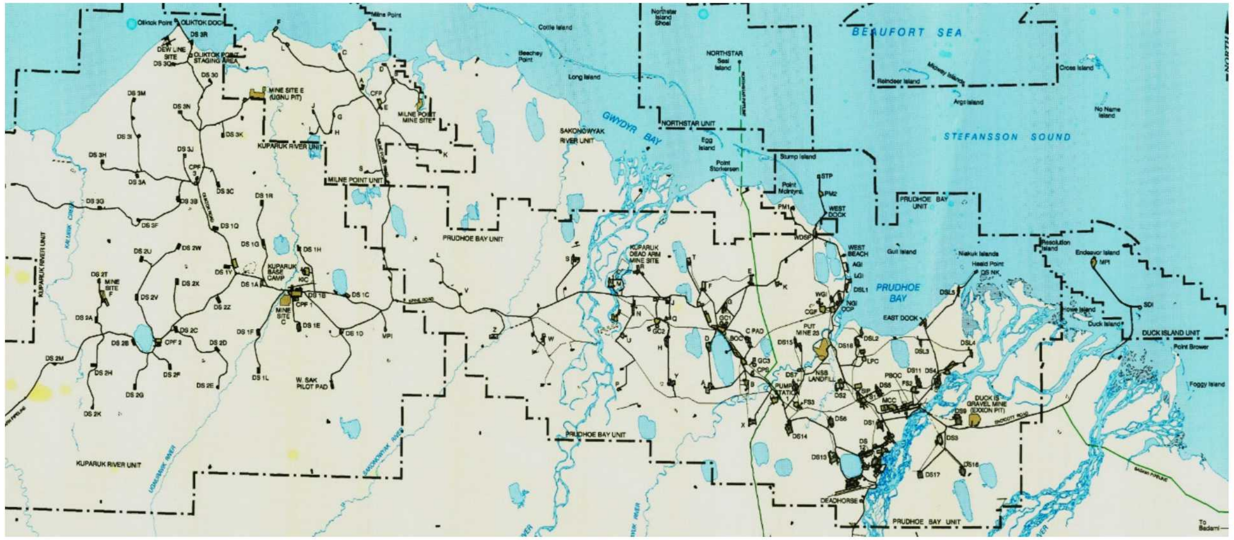
-Dr. Philip McGillivary; US Coast Guard Pacific Area & Icebreaker Science Liaison; Arctic Observing Summit (Fairbanks, AK; March 2016)



Prudhoe Bay: Unique Infrastructure and Assets

Industry-developed infrastructure could be leveraged to accommodate research infrastructure

- Transportation:
  - Roads (land access);
  - airports (flight access);
  - docks (marine access)
- Controlled airspaces (shore and ocean)
- Electrical power facilities and distribution
- Communications and high-speed fiber-optic cable
- Water and waste treatment facilities
- Fuel facilities and distribution
- Medical, Fire, and Emergency services
- Gravel pits (State of AK)
- Other support: Warehousing and storage, technical maintenance, housing, food service, shipping and supplies, etc.
- Opportunity to "jump start" HARC from agreements to use existing vacant or underutilized facilities?



Intersection of Human activity and Arctic Change

"If you melt it, they will come."

- Industry, researchers, people, tourists, invasive species, pollution, noise… "development"
- Impacts on local/Arctic communities
  - Mutual benefits of research for sustainable development
  - Gaps in research and technology
  - Integration of traditional and local knowledge with Western research
  - Community health, One health, food supply, safety
  - Protection measures (AK Clean Seas, NSB
- Impacts on the Environment
  - Physical (geology, limnology, permafrost, atmosphere, hydrology, geomorphology, marine sediment, etc.)
  - Wildlife (fish, marine mammals, terrestrial mammals, birds, etc.)
  - Ecosystems (microorganisms, benthic systems, flora/vegetation, invasive species, etc.)

Prudhoe Bay provides for research to understand how major activity can impact Arctic regions, how to balance the benefits and impacts, and learning how key natural processes are affected and development practices can be developed to minimize risk and maximize benefits.

Photo Credit: USCG Petty Officer 2nd Class Grant DeVuyst

Arctic Shield 2015: The **Oliktok site and controlled airspaces** were used to conduct this public-private search & rescue exercise. A drone (UAV) was launched from Oliktok, then "handed off" to the USCG cutter Healy to locate "survivors" in ice-covered waters. Manned aircraft and rescue personnel were then dispatched.

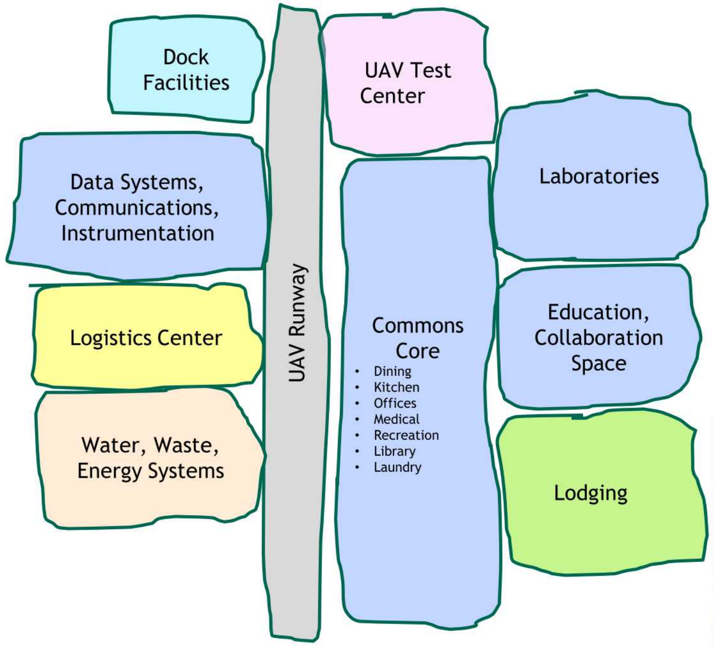
Phased Development of HARC

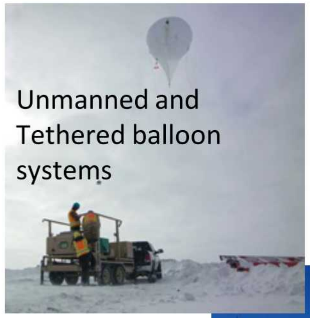
HARC is intended to adapt and evolve through phased development. One approach is outlined below, considering seasonal constraints for Arctic construction:

HARC: **Phased Adaptation** (*conceptual scheme)*

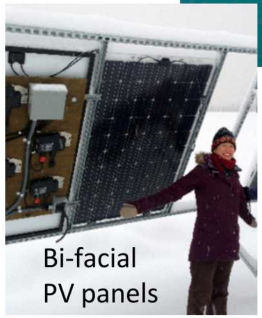
The optimal time for coordination of facilities is during planning, to provide the most efficient infrastructure for Arctic research and operations that also fill critical gaps in research and protection of vital natural systems.

- Master Plan: Phased development to align investments with priorities and allow adaptive planning for evolving needs
- Phase 1: Master Plan; construct roads, pads, infrastructure
- Phase 2: Core facility for basic year-round capability of small scale operations:
  - Commons core, Lodging, Lab, UAS Center, Maintenance & Support Center: Approx. 50,500 sq.ft. total
- Phase 3: Update Master Plan; expand facility scale, systems, and capabilities:
  - Marine dock and support facilities, marine vessels, portable lab trailer, portable shelter(s): Approx. 14,000 sq.ft. added building area, new pads
- Phase 4+: Future phases
  - Dictated by needs and priorities as established in subsequent evaluations and Master Plan revisions





miniSAR radar system

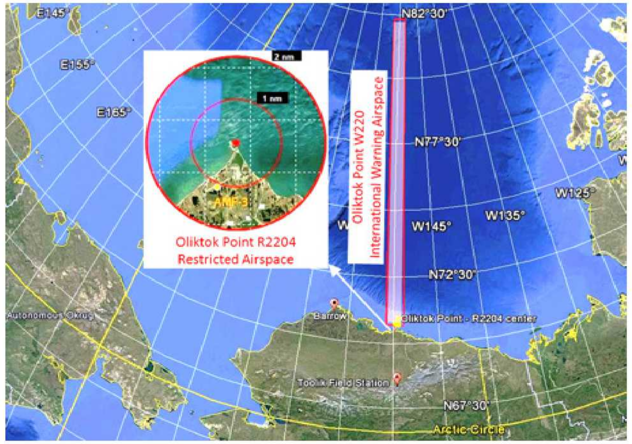


DRAFT/Summary Findings of recent Workshop and steps forward

The following key science drivers were identified:

- Beaufort has many gaps in observations and monitoring of terrestrial, atmospheric, and oceanic environments
- Impacts of (and on) human activities are poorly understood
- Higher resolution measurements are needed to support higher resolution modeling
- Many new technologies, including unmanned aerial systems and state-of-the-art sensors, are available to support Arctic science and research
- Seasonal transitions, or shoulder seasons, are both challenging and scientifically interesting

Each of four key science areas identified more specific needs (outlined in next slide).



DRAFT/Summary Findings of recent Workshop and steps forward

Table 1. Science Gaps Identified during HARC Workshop

Area	Science Gaps
Atmosphere	• Understanding/predicting change; data and measurements ▪ Methane emissions on/offshore ▪ Rain events during the winter – measurements and modeling ▪ Beaufort high pure atmospheric – measurements and modeling ▪ Sea ice – Chukchi versus Beaufort comparison studies ▪ Location may offer coastal/terrestrial impacts study opportunities ▪ Shoulder seasons; regional and large-scale collections ▪ Sea ice loss connected to mid-latitude during extreme weather • Human activity impacts: oil and gas, offshore liquefied natural gas (LNG), transportation • Weather forecasting improvements ▪ Ocean/atmosphere interaction with or without ice ▪ Precipitation/moisture exchange with respect to sea ice ▪ Origin of precipitation on North Slope • Disaster search-related response • Ocean/atmosphere interactions ▪ Fog – more river water, open water ▪ Cloud physics
Arctic Ocean and Ice	• Time series needed for all parameters • Ocean data/unique geography/marine biology/ecology ▪ Arctic barrier island ▪ Coastal erosion ▪ Bathymetry ▪ Sub-seafloor permafrost (presence, properties) ▪ Clathrates (methane hydrates) • Scientific collaboration: academic/industry/research stations/defense department • Dynamic coastal conditions ▪ Pacific Ocean stratification (thermal, salinity), mixing sea waters ▪ Sea ice conditions/changes (freezing, breakup) • Nearshore and sea floor changes • Massive shift in nearshore biology/ecology • Understanding impacts from development ▪ Research associated with resumption of commercial fishing ▪ Deep sea mining (future mineral extraction in seafloor as waters recede)
Terrestrial	• Carbon Flux from Permafrost ▪ Biogeochemical fluxes associated with hydrology ▪ Snow (and relation to permafrost, habitat, sea ice) ▪ Rates of change/baseline and special variability ▪ Gas and aerosol observations ▪ International visitors • Distribution of ice in permafrost • Scale of permafrost changes, high-resolution and abrupt change • Surface and subsurface hydrology change • Synchronization among components of the Arctic system ▪ Hydrology; Breakups; Ecology; Land-ice • High-resolution permafrost models and ground
Observations and Technology	• Sea ice dynamics and atmosphere-ice-ocean interactions in high Arctic • Baseline – human activity impact • Baseline – coastal erosion • Soil characteristics - ground ice, salinity • Spatial distribution of permafrost changes • Terrestrial/ocean floor permafrost dynamics • Representation of thin clouds, mixed phase clouds and aerosols in models

Table 2. Capability Needs Identified during HARC Workshop

Area	Capability Needs
Atmosphere	• Atmosphere physical and chemistry via unmanned aerial systems (UAS) over wide areas • Oceanic (as above) • High resolution temporal/spatial leverage • High data bandwidth • Extended range options (marine terrestrial)
Arctic Ocean and Ice	• Ocean Data ▪ Small research vessels ▪ Dock facilities ▪ Sample storage (cold) ▪ Core samples/drilling ▪ Biogeochemical analysis (jointly with industry) ▪ Adapting to changing future conditions • Airspace needs (remote sensing) ▪ Bathymetry systems • Data management (information technology needs) and how much do we want to do onsite ▪ Real-time users • Autonomous systems ▪ Aerial ▪ Underwater ▪ Surface water • Tracking marine mammals and organisms (numbers, species change, migration patterns) • Moorings that can survive freezing and method of communication beneath the sea ice • Access to nearshore environment • Rudimentary lab capabilities, sample storage facility • Sampling through the ice • Moorings – expansion of ocean acidification (OA) and paralytic shellfish poisoning (PSP)
Terrestrial	• Year-round, HUB, lab access, lab-facilities • Gas and aerosol observations baseline • Space weather observations (have international visitors) ▪ Need better distribution of permafrost observations ▪ Access to industry data on permafrost and hydrology ▪ Initiation of abrupt permafrost change ▪ Engineering lab for High Arctic and education ▪ High-resolution digital elevation model (DEM) ▪ Long term hyperspectral observations ▪ Having testing site near Alaska with permits to use land areas, ocean and lakes.
Observations and Technology	• Fine resolution data on thin clouds, mixed phase clouds, and aerosols • Information on sea ice in the high arctic region – ice thickness, movement, snow information (depth, snow water equivalent, distribution), wave information (height, frequency), water conditions • Determine subsurface soil properties without drilling (i.e., gather truth data for remote sensing, perhaps develop required equipment and methodologies) • Forecast of operating conditions, provide accurate bathymetry, etc. • Support operations in the High Arctic – tourism, commercial fishing, mining, oil and gas

Table 3. Instrumentation and Technology Identified during HARC Workshop

Area	Instrumentation and Technology
Atmosphere	• Tethered balloons • Radiosondes • Smart cables • Unmanned aerial vehicles (UAVs) for National Oceanic and Atmospheric Administration (NOAA) weather • Space weather sensors • Mobile launch • Measurement of rain during winter – that needs to be different or have someone there for upkeep • Standard suite of atm trace gas measurements • Expand/leverage MOSAIC • Baseline measurements capability needed • What is industry doing • Tide gauge – for ice covered regions • Prudhoe Bay, Canada, Dog Mine • Ground penetrating Radar (GPS) to get sea surface • Changing bathymetry – predictions • New Oliktok Long Range Radar Site (LRRS) capabilities • Opportunities to measure earth characteristics • Birds for instrumentation
Arctic Ocean and Ice	• Sounders • Remote sensing • Temperature profiles/sensors • Wave measurements • Marine geophysical equipment • Multi-beam sonar/bathymetry lidar • Buoys – hydrophones, acoustics • Hyperspectral instrumentation • CubeSats • Communication through the ice (development need) • Multi-beam sonar/bathymetry lidar • Buoys – hydrophones, acoustics • Hyperspectral instrumentation • Support U.S. Coast Guard and security training and operations
Terrestrial	• Unmanned aerial vehicles (UAV) ▪ InSAR and bistatic GPS ▪ GPS on UAVs (drones) • Remote Sensing ▪ Abrupt permafrost change ▪ Shrubs, snow, vegetation, normalized difference vegetation index (NDVI) • Cyber-Infrastructure • InSAR products and ground truthing and reference points • Ways to complement and add value to exist data streams from National Ecological Observatory Network (NEON) and Next-Generation Ecosystem Experiments (NGEE) • Need new engineering codes "Old Code" problem • U.S. Air Force interest in permafrost and erosion
Observations and Technology	• UAVs, tethered balloons, sounding rockets • UAV-synthetic aperture radar (SAR) for sea ice and ocean measurements • UAV-compatible radars and lidars (various wavelengths) • Sensors to measure sea ice thickness and snow thickness from UAVs and light aircraft? • Flexible facilities able to adapt to various research campaigns • Ground-based radars with reliable /affordable local power for monitoring coastal regions • Electromagnetic determination of soil/ground ice/groundwater properties

HARC: Steps Forward

- Broader outreach to Stakeholders:
  1. Native and local communities
  2. Industry partners
  3. International collaborators

- Build partnerships
  1. Government (Federal, State, Tribal)
  2. Local communities
  3. Industry

- Generate a proposal to relevant agencies
  1. For facility planning and site selection options
  2. Work with all stakeholders

- Obtain funding to construct facility
- Work with stakeholders to coordinate program development


Thank You