Sandia National Laboratories

SAND2018-9555PE

Arctic Infrastructure Resilience and Arctic Research at Sandia National Laboratories

06 Sep 2018

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Sandia National Laboratories

History

…"exceptional service in the national interest"

Research and Development of National Needs

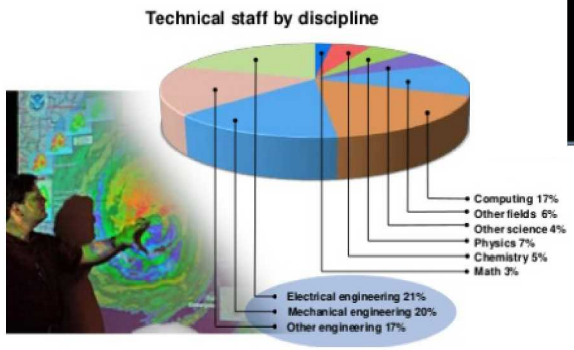
Synergistic Defense Products

Missions since 1950s now include all things nuclear, cyber security, sensors, chem/bio security, treaty verification, space systems, economic competitiveness, critical infrastructure security, global modeling, decision analysis, etc… and energy systems.

Broad Technical Capabilities and Talent

2018 workforce:

12,400+ *(52% perform R&D work)*



Locations:

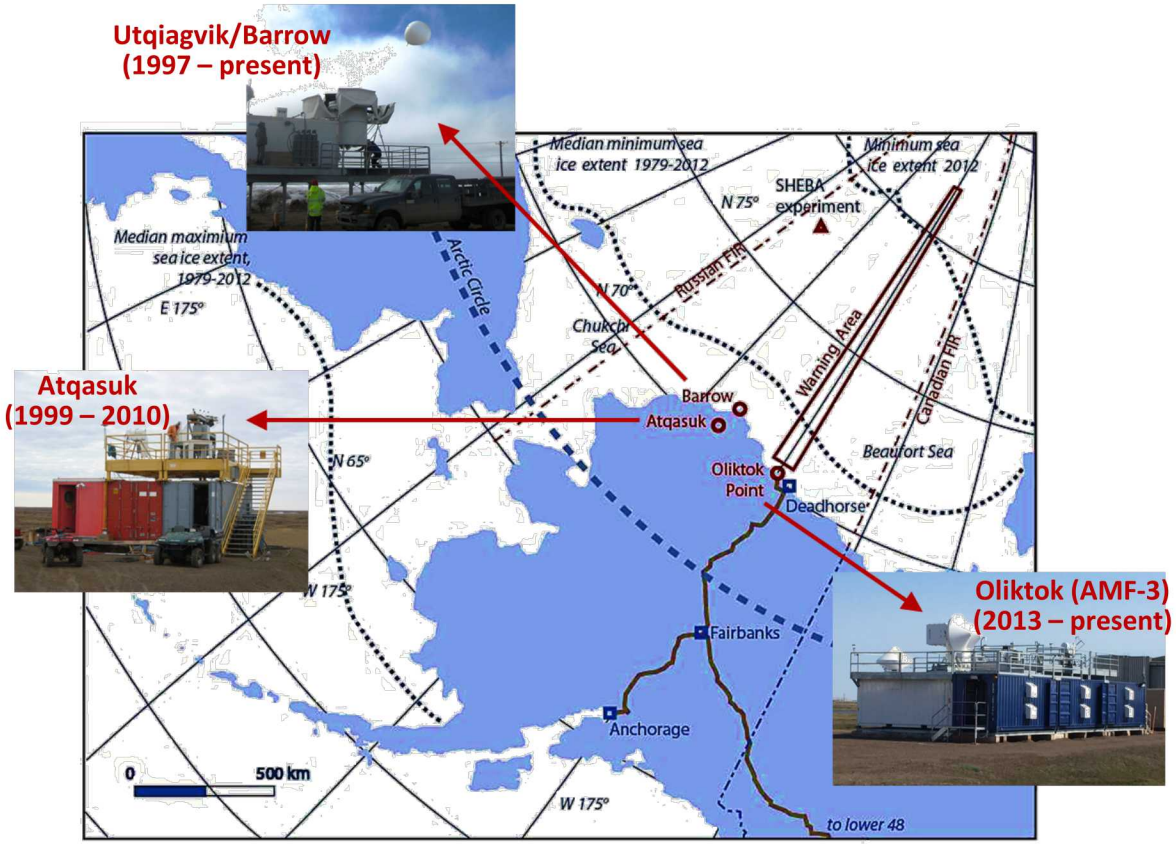
Collaboration

We conduct ~$3B annually:

Partners include Government Agencies, Industry, Academia, and others.

Sandia Labs Arctic Presence

Sandia Labs has maintained a consistent operational research presence and capability in the Alaska High Arctic for over 20 years; where the Sandia Atmospheric Sciences group has supported measurement systems and field campaigns for the DOE Atmospheric Radiation Measurement program since 1997. As such, Sandia has seen first hand the extent of change for the Arctic landscape and the impacts of those changes on the environment, communities, industry, and security conditions – with national - and global consequences. Efforts to fill research and technology gaps are greatly needed to protect national interests.



Sandia Arctic-Related Work

Energy projects for Alaska villages and research

- **Venetie** microgrid optimization study
- **Kodiak** energy storage analysis project
- **Cordova** flywheel energy storage resilience project
- **St. Mary's/Pitka's Point** DOE/DOD grid-bridging for energy storage and renewables
- **Bifacial PV** panels at high latitudes study
- **Sandia advanced sensors** DOE grid modernization project

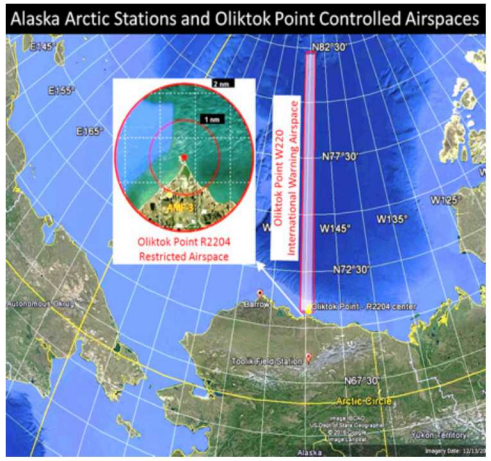
Polar operations and data collection

- 20 years of climate measurement at DOE ARM sites
- Utqiagvik/Barrow, Oliktok Point, and Atqasuk
- Use of unmanned aerial vehicles (UAVs/drones and tethered balloons)
- Seismic sensing of permafrost active layer
- Nuclear materials management for Air Force
- Airborne radar for crevasse detection in ice sheet

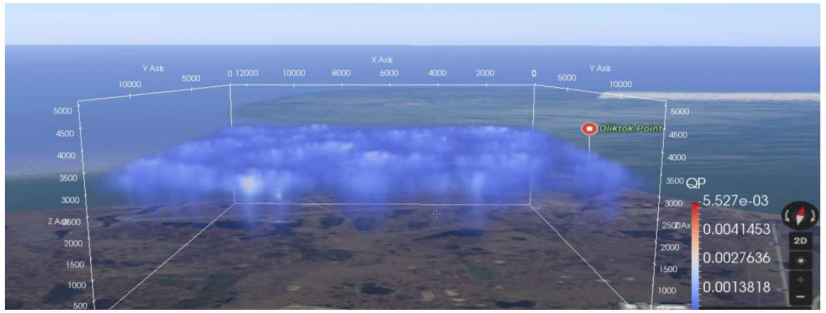
Controlled Airspaces in High Arctic

- FAA approved, DOE Sandia managed
- 2nm radius around Oliktok Point
- 40x700nm from Oliktok Point toward North Pole
- Search & Rescue drill with Coast Guard using UAVs in Oliktok Point controlled airspaces
- Regular use of UAVs (drones) and tethered balloons

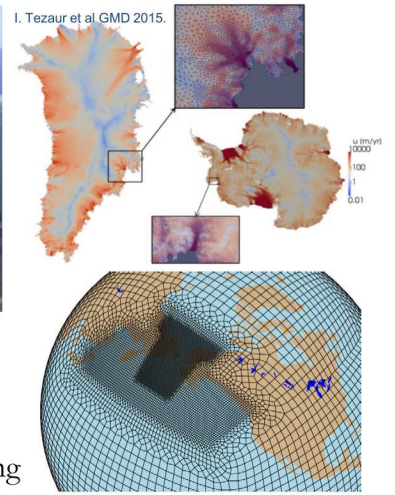
Credit: USCG Petty Officer 2nd Class Grant DeVuyst



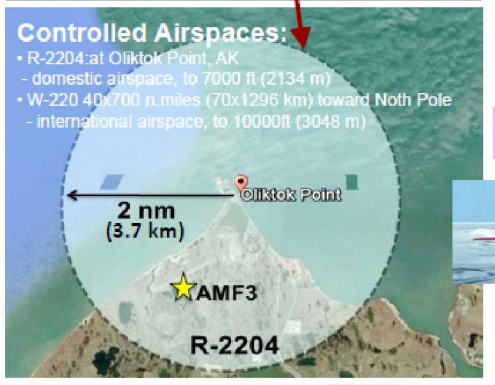
Climate Modeling

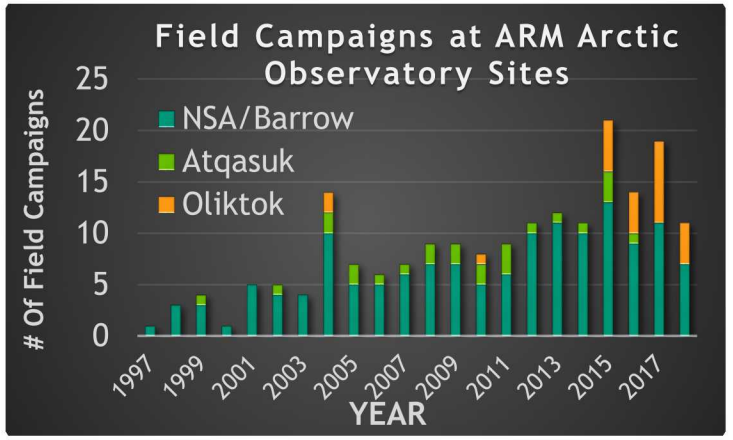


- Integrated measurements and atmospheric models
- Cloud-resolving model large eddy simulations
- Computer model of melting of Greenland ice sheet
- Variable resolution for high-resolution Arctic + global modeling



Sandia Arctic: Unmanned Aerial System Campaigns



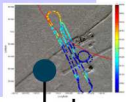


2015-16; Barrow + Oliktok:
Inaugural Campaigns for ARM Research with Unmanned Systems (ICARUS)
- using multiple TBS platforms and sensors
- *with Sandia Labs*

2015; Oliktok:
First concurrent TBS and DH platforms flights
- *with CIRES/CU-Boulder*

2016-17; Oliktok:
DataHawk Test flights
- *with PNNL*

2015-16; Oliktok:
Evaluation of Routine Atmospheric Sounding Measurements w/ Unmanned Systems (ERASMUS-I,-II)
- using DataHawk and Pilatus platforms
- *with CIRES/CU-Boulder*



2018; Oliktok:
Profiling at Oliktok Point to Enhance YOPP Experiments (POPEYE)
- using DataHawk and TBS platforms
- *with NOAA and PNNL*

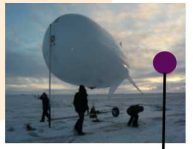
2015; Oliktok:
Arctic Shield Search & Rescue exercise
- using ScanEagle platform
- *with USCG, C-P, Insitu, NOAA, FAA, NSB and Era*

2014; Oliktok:
Coordinated observations of the Arctic lower atmosphere (COALA)
- using DataHawk platform
- *with CIRES/CU-Boulder*

2016-17; Oliktok:
Radar calibration sphere on TBS
- *with PNNL*

2002; Barrow:
Simultaneous Aerosonde-Radiosondes
- *with ANL and NSF*

2010; Oliktok:
Arctic Lower Troposphere Observed Structure (ALTOS)
- using SPEC He-filled balloon;
- *with SPEC, PSU, Scripps and UAF*



2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018

2001; Barrow:
First UAV flights on North Slope AK
- *using Aerosonde*
- *with NSF*

2004; Barrow, Atqasuk, Oliktok, Toolik Lake:
Mixed-Phase Arctic Cloud Experiment (M-PACE)
- using Vaisala sondes and ARM-Proteus UAV
- *with UAF, PSU, UIUC, UND, UWisc, PNNL and NOAA*

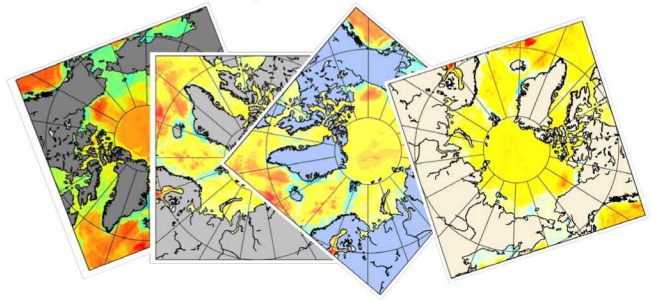
2012; Oliktok:
UAS Test Maneuvers
- using BAT-3 and Aeryon Scout
- *with NMSU*

2013; Oliktok:
Marginal Ice Zone Observation & Process Experiment (MIZOPEX)
- using Sierra, Datahawk and ScanEagle
- *with NASA, UAF and CU-Boulder*

Sandia Arctic: Sandia-funded Projects

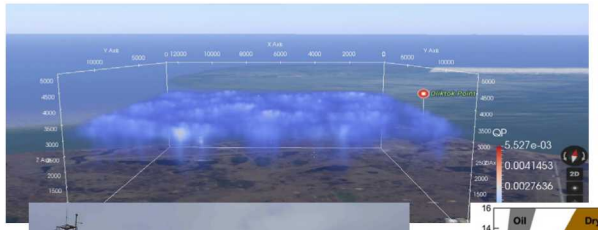
Permafrost Thaw

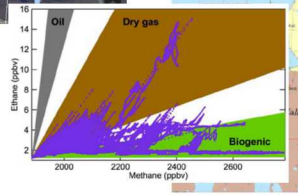
- Forecasting Marine Sediment Properties On and Near the Arctic Shelf (to generate probabilistic maps for the best estimates of Arctic seafloor properties to date)
- Permafrost in Active Layer Seismic Interferometry (PALSIE) (to monitor active layer thickness change with seismic measurements at Poker Flat)

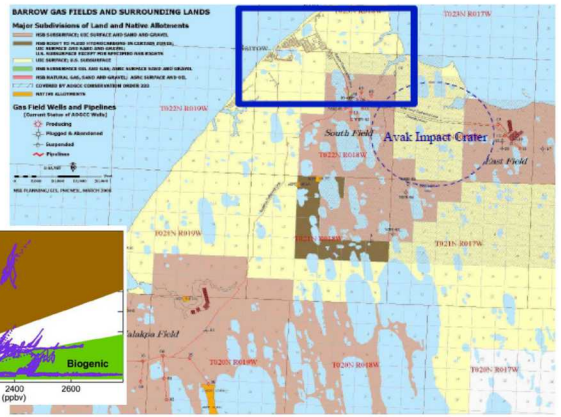


Climate Modeling

- High Resolution Atmospheric Measurements + Ultra-High Resolution Modeling in the Arctic
- Arctic Methane, Carbon Aerosols and Tracers in the Arctic (longest continuous measurements of these on North Slope Alaska)
- Attribution of Methane Emissions (comparisons between Utqiagvik and Prudhoe Bay)
- Fugitive Emissions Sensor Networks Optimization (develop methods and software to optimize sensor placement)

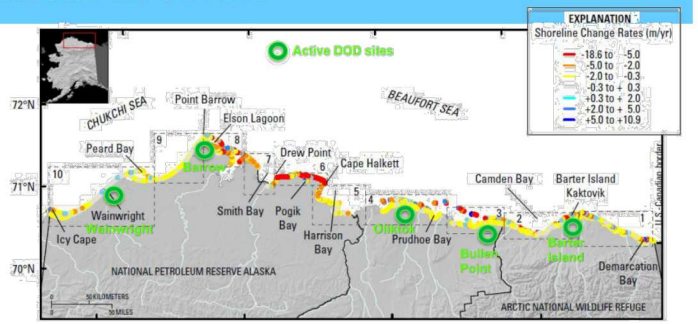






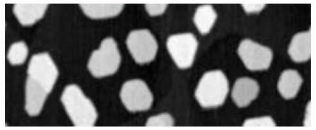
Coastal Erosion

- A Predictive Model for Arctic Coastal Erosion (field research and analysis at Drew Point)



Ice Migration

- Deciphering Atmospheric Ice Nucleation Using Molecular-Scale Microscopy

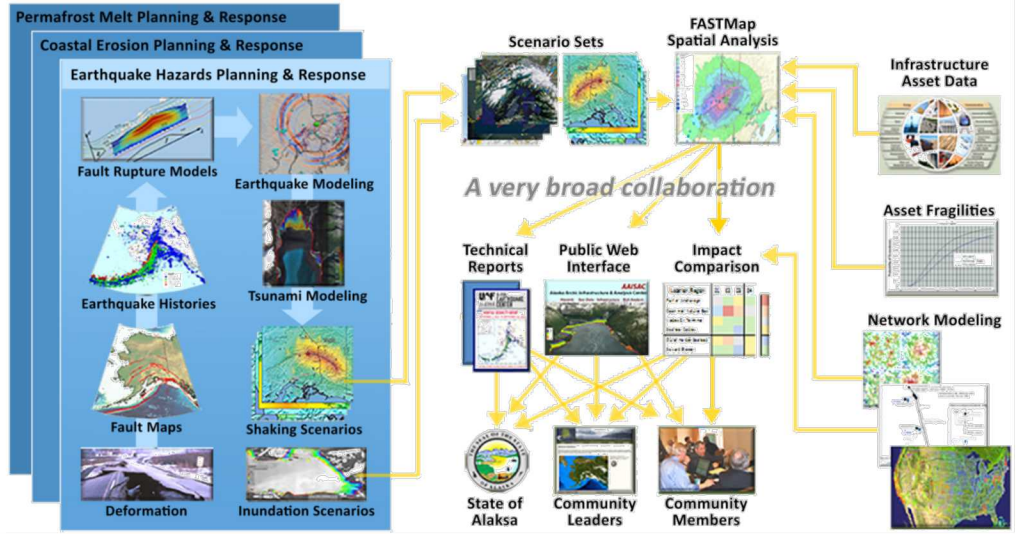


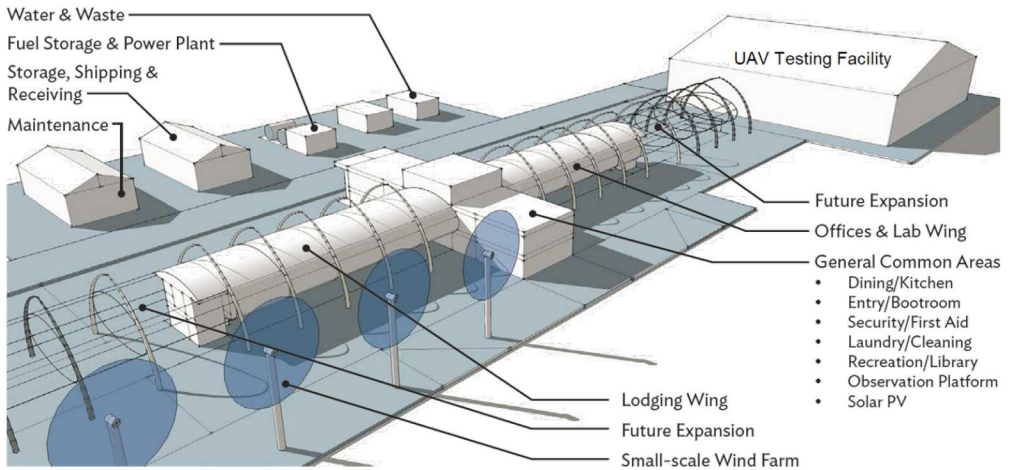
Observation Capabilities

- Tethered Balloon Systems (TBS) Maritime Operations (with sensors and fiber optic system)
- Evaluating High Altitude Infrasound Heliotropic Platforms in the Arctic (use 24-hr solar to provide simple, inexpensive long-term high-altitude flight with sensors)
- Joint UAV and Balloon Arctic Operations (JUBA) (sensors integration and calibration, preparations for icing tests for UAV flight safety)

Sandia Arctic Science & Security Initiative

- Conceived to exploit Sandia expertise in science and technology to meet and anticipate the challenges from an evolving Arctic over the long-term future. The intent is an Arctic program to:
  1. understand, anticipate and resolve emerging national security challenges,
  2. innovate and develop technologies,
  3. create solutions that solve national security challenges, and
  4. inform the national debate for technology policy.
- Our deep science and engineering experience enables us to discuss technical challenges and solutions for Arctic security concerns.
- Sandia is partnering with the University of Alaska Fairbanks (UAF) and the Wilson Center Polar Initiative to leverage the unique capabilities, assets, and networks of each. We are currently focused on two major programs:
  1. The Arctic Infrastructure Simulation Analysis Center
  2. US High Arctic Research Center





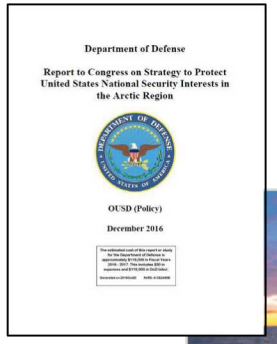
UNIVERSITY OF ALASKA FAIRBANKS

Wilson Center

The Arctic Infrastructure Simulation Analysis Center

Infrastructure: A complex system upon which people depend for livelihoods, security, and safety.

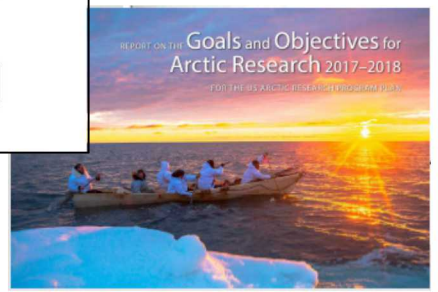
- Infrastructure in Alaska, with growing use of the Arctic
  - *"Relying on or supplementing from the few existing population centers for operations of any size would likely overwhelm the civil infrastructure and adversely affect the local communities, which are wholly dependent upon this limited infrastructure."*
    - Report to Congress on Strategy to Protect US Interests in the Arctic Region, December 2016
  - *"Compromised infrastructure increases risks to human health, safety and well-being and results in economic impacts on the scale of billions of dollars in Alaska alone."*
    - Report on the Goals and Objectives for Arctic Research 2017-2018, from the US Arctic Research Commission
- UAF, The Wilson Center, and Sandia collaboration to increase resilience across Arctic infrastructure and natural systems through modeling and analysis; to include:
  - **Disaster planning**: to enhance planning and response.
  - **Increased resilience**: to improve understanding of risks, adaptation, and engineered and social systems in Alaska and the Arctic to increase resilience.
  - **Long-term planning**: to adapt to changing climate and environmental conditions, new activities and land uses, and community transitions.


Department of Defense

Report to Congress on Strategy to Protect United States National Security Interests in the Arctic Region

OUSD (Policy)

December 2016



Arctic Infrastructure: Hazards Happen

Oil spills, Valdez

Ice-jam Flood, Galena

Wildfire, Nulato

Ice overflow, Dalton Hwy

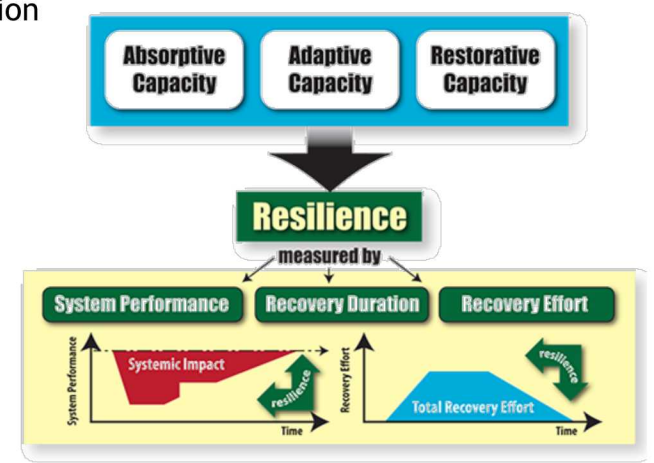
Storm Surge, Newtok

Tsunami (local), Seward

Mass flow: Slow (Dalton Hwy & Alyeska Pipeline, left), Fast (Sitka, right)

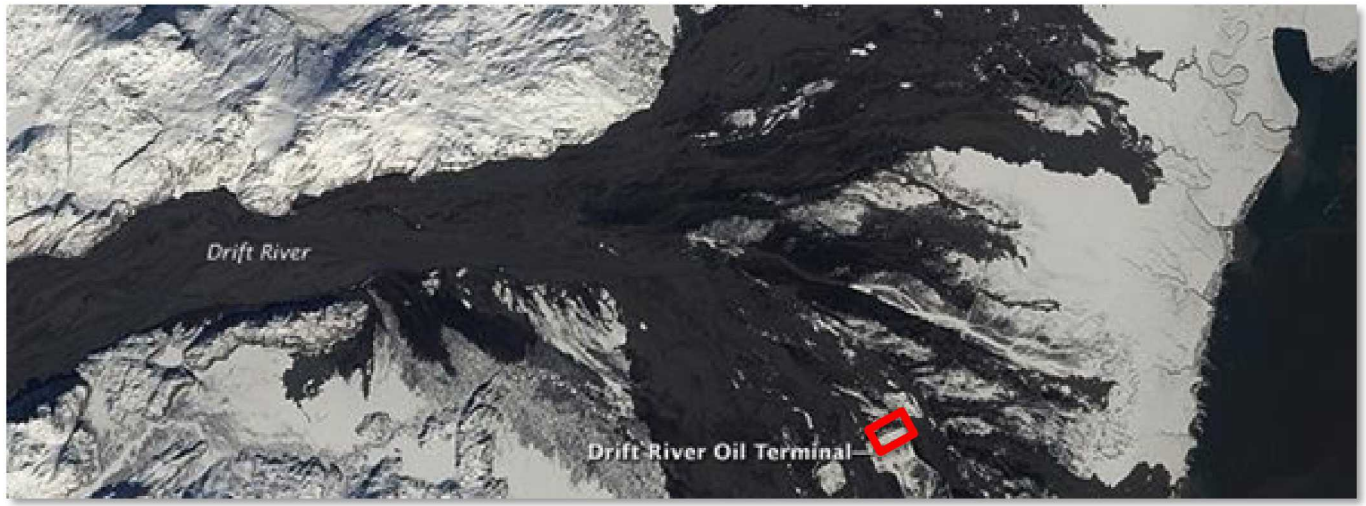
Extreme Precipitation, Fairbanks

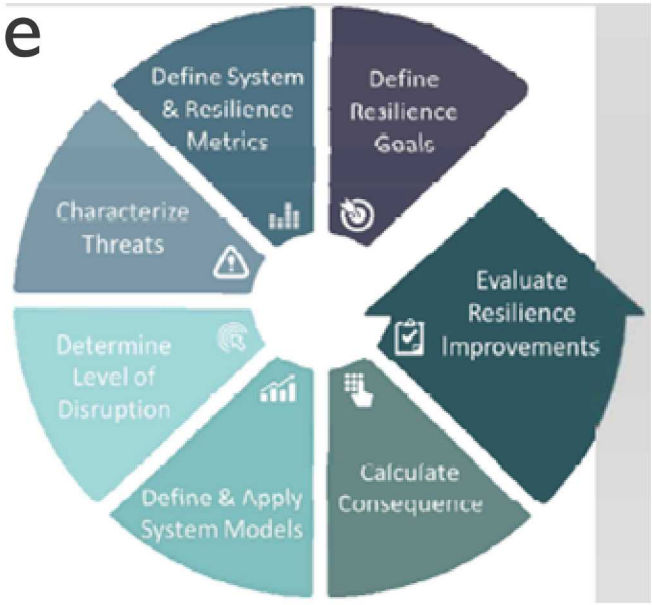
Coastal Erosion



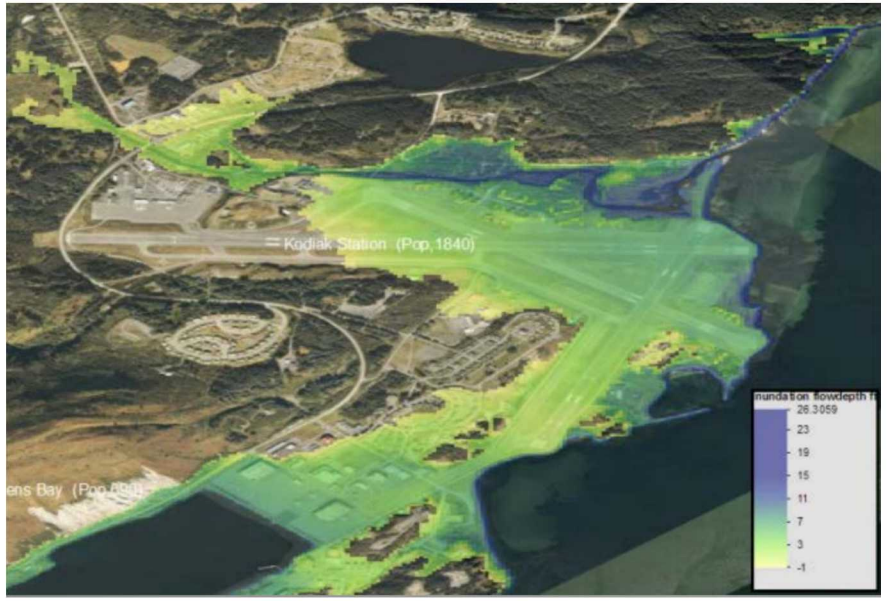
- Infrastructure Modeling Simulation and Analysis
  - To understand impacts and consequences from insults to our infrastructure.
- Risk = consequence times probability
  - Use real data from past events to develop trends and scenarios for future events
  - Broad spectrum of consequences (economic, community, public health, environment, etc.)
  - Severity of event may impact stakeholders differently
- Resilience = Ability of infrastructure and community to withstand, adapt and recover from an event

Arctic Infrastructure: Plan for Resilience



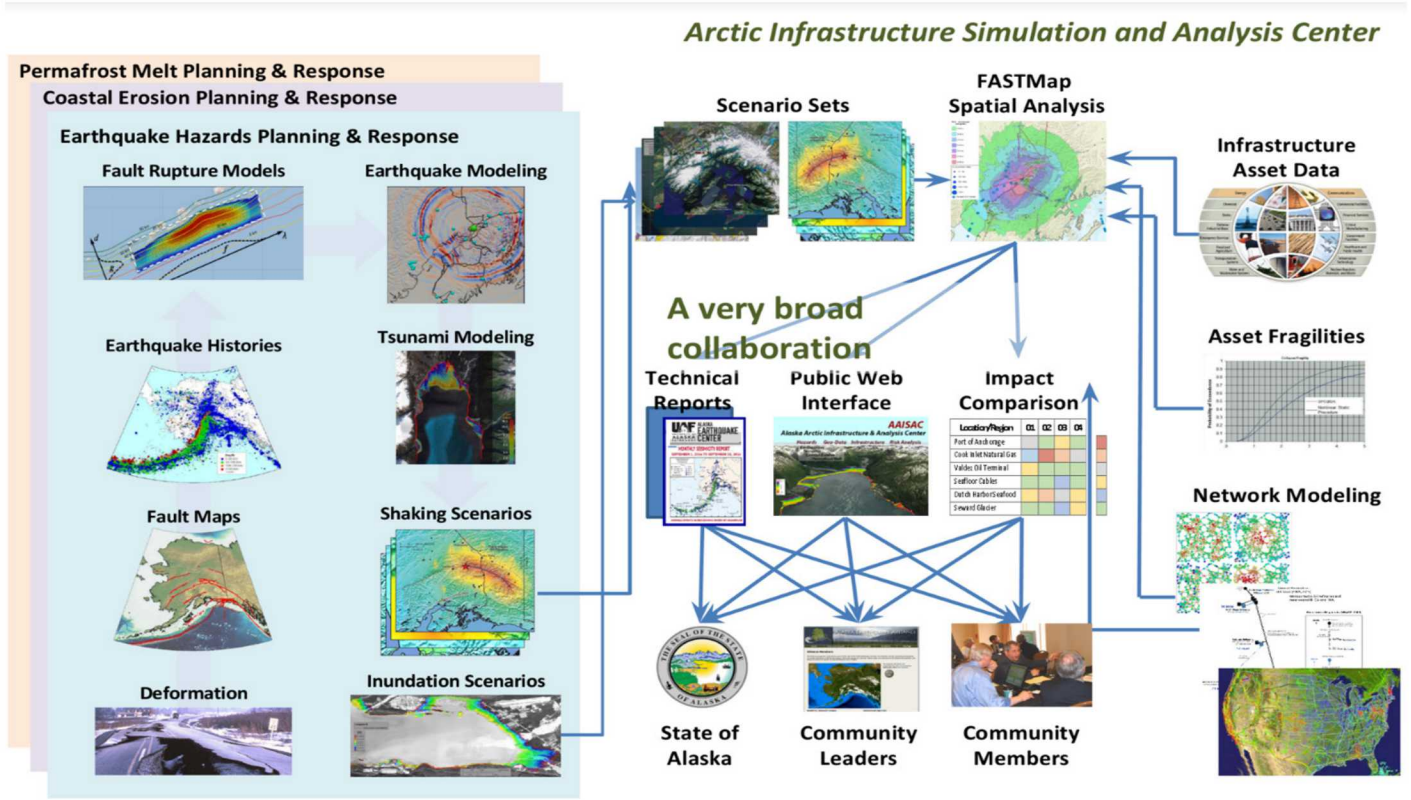


- Don't create vulnerability (plan ahead)!
  - Example: Major oil storage facility on west shore of Cook Inlet. Built on delta formed by volcanically triggered mudflows. Hit twice in half a century. Event probability: 5%/yr
- Mitigate vulnerabilities (move, protect or ignore)
  - Risk-based decision making
  - Kodiak Earthquake example: M9.2 followed by tsunami:
    - Significant loss of life
    - Hundreds of millions of dollars in damages
    - Cascading impacts (e.g. shipping and transportation networks, response, and regional food security)



Inundation maps from Kodiak complex disaster scenario, Michael West UAF-GI, Elena Suleimani, UAF-GI, Sandia National Labs

The Arctic Infrastructure Simulation Analysis Center



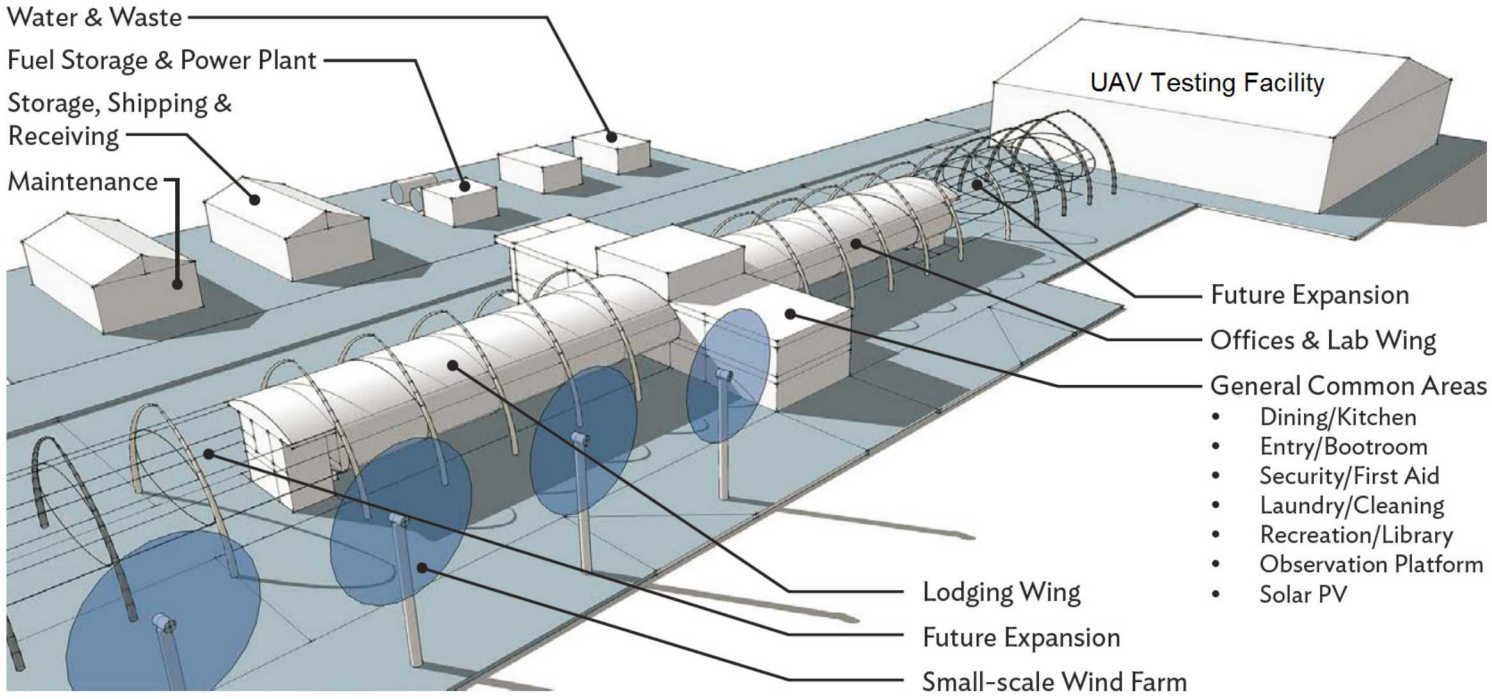
We work with communities, governments and tribal agencies, businesses, and NGOs to apply innovative natural and social science and engineering for limiting future losses due to major hazards. We provide up-to-date information and analysis to co-develop options and empower stakeholders toward making informed choices for achieving greater infrastructure resilience for sustainable development.

Sandia Arctic Science & Security Initiative

U.S. High Arctic Research Center (USHARC)

Vision: USHARC shall be a shared national asset to support a comprehensive Arctic science and security program that addresses the needs of Arctic stakeholders to include Federal and State government, industry, Arctic communities, and researchers. Stakeholder collaborations and establishment of an Arctic station network (with Utqiagvik/Barrow and Toolik Lake) will advance U.S. understanding of the Arctic to improve environmental stewardship, security and economic opportunity.

Purpose: To pursue research of Arctic infrastructure, emergency response, search and rescue, domain awareness, environmental change, and technologies that support these; leading to positive economic development, environmental protection, and national security improvements.

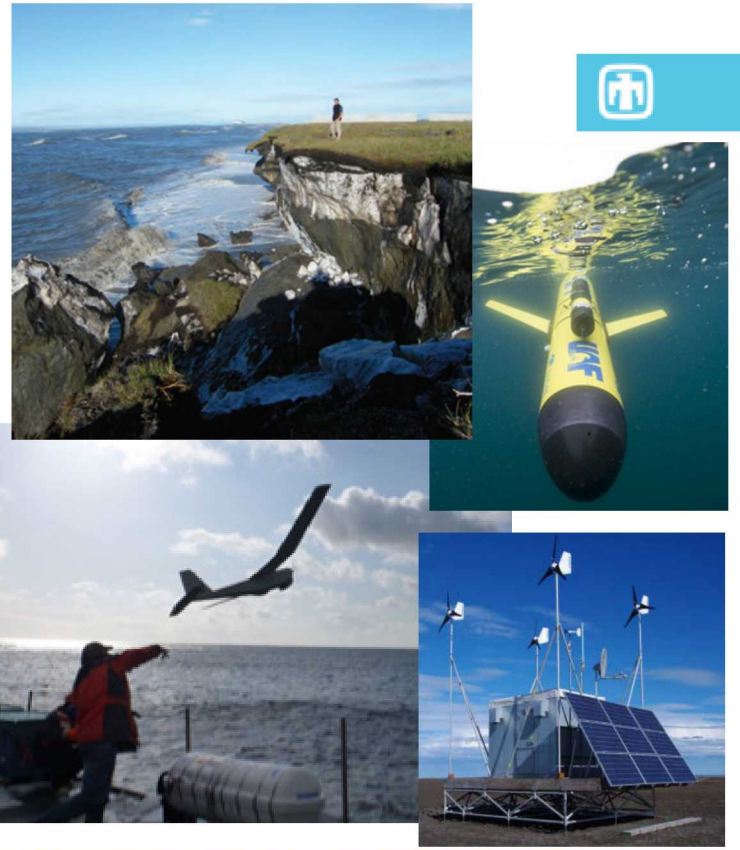


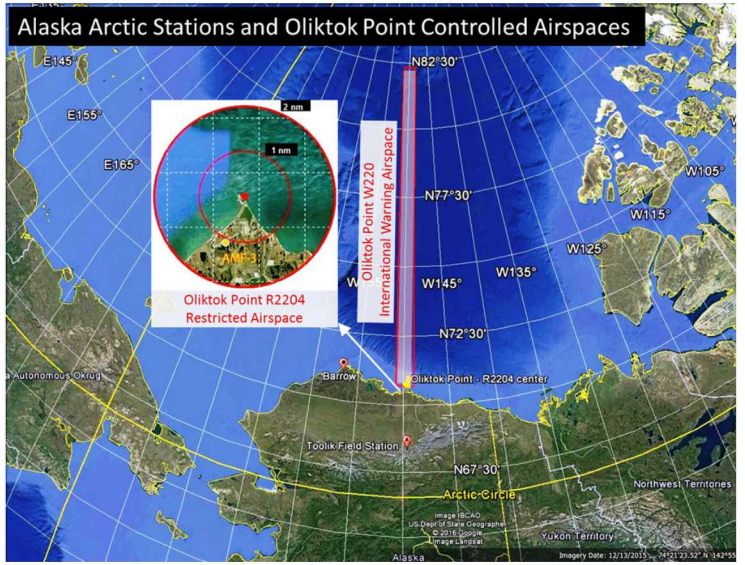
Sandia Arctic Science & Security Initiative

U.S. High Arctic Research Center (USHARC)

USHARC will support 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.

- World-class Arctic research requires year-round access and facilities. The Station will include labs for research, testing and technology development, a center for UAS and autonomous platform operations, staff and researcher lodging, operational support infrastructure, and spaces for teaching and training.
- Research, testing and exercise personnel will be able to focus on successful high-quality work by utilizing the combined experience of UAF, Sandia and partners, along with the assets and infrastructure of the Station.
- USHARC at Oliktok Point: The opportunity exists to take advantage of existing assets and infrastructure, controlled airspace, an active unmanned aircraft systems (UAS) program and local partnerships to develop the existing facilities currently operated by Sandia into a multi-disciplinary, year-round facility; where Arctic conditions and human activity intersect.






Thank You