Welcome to ADAC’s Annual Meeting
9-10 November 2016
Alexandria, Virginia
ADAC’s Annual Meeting…overview of the next two days

• **Current Center Overview** by ADAC leadership

• **Strategic reflections** from DHS S&T OUP Director, DHS Arctic Strategy and USCG Deputy Commandant for Operations

• **Project by project review** of ADAC’s current portfolio
  • Remote project presentation by Co-PI
  • Time scheduled for questions on each project

• **Opportunity to network** via lunch breaks, and no-host social this evening.

• **In-person and remote participation.** ADAC welcomes the participation of an extensive number of remote collaborators

• **Opportunity for ADAC Researchers** to gain insights from ADAC’s customers and DHS Program Management

• **In summary,** this Annual meeting is an important milestone in the Center’s ongoing development
ADAC...at a Glance:

ADAC is hosted by the University of Alaska, with work conducted at UA campuses in Anchorage and Fairbanks...and conducts research across a growing network of academic and industry partners.

Vision: The DHS Center of Excellence, providing networked and mission-focused support to the USCG Operator in the High North. The vision includes efforts to transition ADAC into a National Center.

Mission: To develop and transition technology solutions, innovative products and educational programs to improve situational awareness and crisis response capabilities related to maritime challenges posed by the dynamic Arctic environment.

Strategy: The Center’s strategy is to advance knowledge in relevant science and technology through conducting research and development in close collaboration with mission agencies’ end users. The Center also develops future leaders for the DHS enterprise through structured and well-led programs.

ADAC’s principal customer: USCG...in support of Arctic Search and Rescue, Humanitarian Assistance and Disaster Response.

ADAC works with an array of federal, state, local, tribal, industry and academic partners to advance domain awareness of the Arctic region.

ADAC’s Leadership
- Douglas Causey, PhD, Principal Investigator, University of Alaska, Anchorage (UAA)
- Larry Hinzman, PhD, Research Director, University of Alaska Fairbanks (UAF)
- Randy Kee, Maj Gen (Ret) USAF, Executive Director (UAA)
- Heather Paulsen, MBA, Finance Director (UAA)
- Clarice Conley, MFA, Education Outreach and Workforce Development Director (UAA)
- LuAnn Piccard, MSE PMP, Project Management Director (UAA)
ADAC: A networked team advancing S&T + R&D to meet Arctic operator needs:

- **Supporting** POTUS, DHS and USCG Arctic Strategy and IARPC’s 5 Year plan.
- **Establishing** a growing collaboration with Canadian government and academia
- **Partnering** with NOAA & NWS and advancing cooperation across the U.S. federal family
- **Developing** new research through Arctic Incidents of National Significance (IoNS) workshops...a CANUS forum.
- **Creating** education and professional Arctic mariner courseware

• **Advancing** DHS strategic goal of Long frame analysis through Arctic Information Fusion Capability project

• **Conducting** research to create an Operationally capable Community-based Observer network in Arctic Alaska.
  - Leveraging austere environment technology to provide “Fusion Forward”...connecting on-scene knowledge to USCG & other command centers.

• **Envisioning** a future as a U.S. National Center of Arctic R&D.
ADAC: is a Center of Maritime Research...focused to advance domain awareness...Pan-Arctic

One illustration...of it like a basic algebra equation of environmental factors: In simplest terms:

\[ a + b + c + \ldots, \text{ etc.} = \text{“Approximate” Domain Awareness} \]

Note...each environmental factor variable is changing, at an increasingly dynamic rate ...all across the High North!
Data from Low Cost Sensor Arrays

CBON-SA

Arctic Oil Spill Calculator

ICECON

Storm Surge and Coastal Erosion Modeling

Sea Ice Hazards

External to ADAC Arctic Data

Arctic Information Fusion

USCG Decision Makers

Relevant data generated from new ADAC Projects

Data from Long Range Autonomous Under Water Vehicles
• **ADAC’s Principle Investigator**
  Dr. Douglas Causey, University of Alaska, Anchorage

• **ADAC’s Research Director**
  Dr. Larry Hinzman, University of Alaska, Fairbanks

• **Acknowledgements to**
  • **ADAC Finance Director**, Heather Paulsen, MBA, UAA
  • **ADAC Education Outreach and Workforce Development Director**
    Clarice Conley, MFA, UAA
  • **ADAC Project Manager** LuAnn Piccard, MSE, PMP, UAA
  • **ADAC Communications and Administration officer**, TBA
Partnerships...the core of ADAC’s “Research Network”

**From Academics:**
- Maine Maritime Academy
- University of Idaho
- University of Washington
- Woods Hole Oceanographic Institute
- US Coast Guard Academy and their Center for Arctic Study and Policy
- Texas A&M University
- University of New Mexico *
- University of Texas El Paso *

**From Industry:**
- Axiom Data Science
- Alaska Marine Exchange
- Dubay Business Services
- NOVA DINE-Kestrel **
- ASRC Federal Mission Solutions **

* Federally Designated Minority Serving Institutions (MSI)
** Federally Designated Tribal Organizations (FDTO)
ADAC’s Partnering and Collaborating Organizations

- NOAA & National Weather Service
- Canadian DND and Canadian Academic Researchers
- USCG Headquarters, USCG Pacific Area, USCG Research & Development Center, and District 9 and 17
- DoD Alaska Command and Alaska NORAD Region
- Alaska Ocean Observation System
- NASA-OSD Arctic Collaborative Environment

- DHS Centers of Excellence at Rutgers University, Stevens Institute and University of Houston
- National Ice Center
- National Science Foundation
The Science of Data Fusion for Decision Support in the Arctic

**AIFC:** A new approach to information fusion in austere environments, to greatly advance a system already in use by USCG: *Arctic ERMA*

A network of inputs through partnerships and access from the tactical edge;
- Connects CBONs via Multi-media/multi-lingual field reports, easily accessible;
- Simple and open standards data & system exchange
- Works anywhere (Cellular/WiFi/SATCOM)
- Tasking from HQ to the field
- Advances cutting-edge

**AIFC:** “Super” ERMA

Data Interoperability Decision Support for Operators:
- Use case/scenarios
- Fine scale actions
- User defined
- Array of data...from authoritative sources
- Macro and Micro Fusion
- Internet and Austere comms
- Building from ERMA
- Artificial Intelligence (in later stages)

Improve forecasting and anticipation
- Infrastructure
- Risks/Opportunities

Sociocultural and Economic Indicators Weighted

Outputs Over Time Define Indicators for Use in Decision Support

**Biophysical and Infrastructure Capability Indicators Weighted**

Reduce risk to people and resources

**Micro-scale Human Behaviors**

**Macro-scale SAR/HADR operations**

**SAR/HADR:** Weather, Sea State, Ice, Debris, Erosion, AIS, Currents, Subsistence Activities

CBONS...a capable forward network: Developing to be Capable to support

**MONITORING**

**COMMUNITY MAPS**

Changing Arctic Ecosystems

**MONITORING**

**Community Maps**

Changing Arctic Ecosystems

**Biophysical and Infrastructure Capability Indicators Weighted**

**Sociocultural and Economic Indicators Weighted**

**Arctic Information Fusion Capability**
1) “Fusion Central”...scenario specific, operator driven multi-source data and modeled information for agile decision support
2) “Fusion Forward”...enable user defined operational decision views and criteria, which connects “on-scene” to “command”...critical in austere communications environments.
Knowledge from the tactical edge:

- **Connecting** and leveraging with Arctic information via DataONE
- **Developing** austere and low cost sensors
- **Building** Autonomous Platforms
- **Advancing** Modeling such as:
  - Storm Surge,
  - Sea Ice Forecasts,
  - Coastal Erosion,
  - Arctic Oil Spill Calculate

**Spotlight: 2-3 Nov 16:** *Field test* for ADAC’s LRAUV sensors package at WHOI
Community Based Observing Networks and Systems (CBONS) are high fidelity observers (HFOs) who submit quality assured and coordinated observations on biophysical variables that can be integrated with data from other observing systems. Connected to USCG Command via Austere environment comms, CBONS data adds to Arctic Fusion...from the tactical edge.

Spotlight: Streaming data from Tin City AK beach to JBER Exercise Command Center in USCG Arctic Chinook
“Arctic Operator driven research”

- Workgroup from USCG and Canada Coast Guard discerns under researched area that applies to mission areas.
- ADAC collects research and researchers to present the body of information.
- Workshop delivers shortfalls in science and technology.
- ADAC seeks research via RFP.
- ADAC’s 1st IoNS (Summer 2016):
  - 20 Research questions,
  - 13 Research proposals.
  - Proposal selection and Workplans to follow
ADAC Annual Meeting Agenda

November 9, 2016: Day 1

9:00-9:30: Center Overview, presentation by ADAC PI, Dr. Douglas Causey, University of Alaska Anchorage (UAA), Research Director, Dr. Larry Hinzman, University of Alaska Fairbanks (UAF), and Executive Director, Randy Kee, UAA.

9:30-10:30: DHS Strategic Reflections.
Dr Matt Clark, DHS S&T OUP Director.
Mr. Sean Moon, Senior Advisor to the Assistant Secretary Borders, Immigration & Trade, DHS Policy.

10:30-10:45: Break.

10:45-11:30: Arctic Oil Spill Modeling, Dr.'s Thomas Ravens, UAA and Scott Socolofsky, Texas A&M—College Station (remotely participating).

11:30-12:15: Ice Conditions Index for the Great Lakes Region (ICECON), Dr.’s Thomas Ravens, UAA and Andrew Mahoney, UAF.

12:15-1:15: Lunch.

1:15-2:00: CBON-SA, Dr. Lilian Alessa, University of Idaho.

2:00-3:15: AIFC, Dr. Mock, UAA, Mr. John DeLaurentis, Mr. Thomas Mogck, Mr. Mark Rowan, Mr. Eric Velte, ASRC Federal Mission Solutions, LLC., Mr. Brian Conroy, Nova-Dine, and Mr. Leo Naboyshchikov, Kestrel.

3:15-3:30: Break.

3:30-4:15: Storm Surge, Coastal Inundation and Erosion, Dr.’s Thomas Ravens, UAA and Craig Tweedie, University of Texas El Paso.

4:15-5:00: Sea-Ice Hazards, Dr. Andrew Mahoney, UAF.

5:00-5:05: Wrap-up.

6:00-7:00: No-Host Reception, Hilton Lounge, located on the premises.

10 November 2016 Annual Meeting Day 2

9:00-9:05: Welcome.

9:05-9:50: Sensors, Dr. Martin Cenek, UAA.

9:50-10:00: Break.

10:00-10:30: Guest speaker, VADM Charles Ray, Deputy Commandant for Operations, HQ USCG.

10:30-11:15: LRAUV, Dr. James Bellingham, Woods Hole Oceanographic Institution.

11:15-12:00: HIOMAS Modeling, Dr. Jinlun Zhang, University of Washington.

12:00-1:00: Lunch.

1:00-1:45: Arctic Education in Training, CAPT Ralph Pundt, Maine Maritime Academy.

1:45-2:00: Break.

2:00-2:45: Education Outreach and Workforce Development, including Minority Serving Institution Internship and Career Development Scholars/ADAC Fellows. Ms. Clarice Conley, UAA, Mr. Kyle Alvarado, ADAC Fellow, and Mr. James Matthews, ADAC Fellow.

2:45-3:00: Wrap-up reflections.

3:00-3:15: Break

Onwards to the meeting!
Arctic Oil Spill Modeling

Dr. Thomas Ravens, University of Alaska Anchorage
Dr. Scott Socolofsky, Texas A&M
**Project Title: Arctic Oil Spill Modeling**

**FOA/NOFO Research Question(s):** Topic 1a, Maritime Risk & Threat Analysis; Topic 2a Coastal and Marine Critical Infrastructure development; Topic 2b, Coastal and Marine Modeling and Analysis. **Specific research question:** Topic 2b. question 3.

---

### Project Objectives:
- In order to support USCG deliberate and crisis planning, assist NOAA Office of Response and Restoration with the development of an Arctic-capable GNOME oil spill model.
- Develop and transfer algorithms for determining the movement and spreading of oil released (a) near the surface, accounting for the presence of sea ice and (b) under ice, accounting for under-ice roughness.

### Potential Impact:
- The research contributes to the development of an Arctic-capable oil spill model referred to as GNOME-2.
- Project also feeds Arctic Information Fusion Capability.

### Key Milestones/Deliverable Schedule:
- **Project Start**…………..Jan 15
- Review of 23 Arctic oil spill studies ……………………Jun 15
- Completed “Diagnostic Save Files”…………..…Jun 16
- Successful runs of GNOME model using high resolution & conventional Diagnostic Save Files………Jun 16
- Algorithms for oil spreading in icy seas………………Jun 17
- Project end date…………………………………..Jun 19

### Performance Metrics:
- Number of studies reviewed (target of 10 to 30) – 23 reviewed. ✓
- Resolution of GNOME model (target 2 km) – 6 km resolution GNOME model achieved (note, project tied to High Resolution Sea Ice and Currents project). ✓

### Key Accomplishments:
- Guidance to NOAA on how to account for ice in oil spreading algorithms. The guidance was incorporated into GNOME-2.
- Demonstrated that HIOMAS Ocean / Sea Ice model output can be used to drive GNOME oil spill model.
- Successful adaptation of TAMU plume model (for well blowouts) to the Arctic Ocean with ice cover.
- Identified an approach for estimating the movement and spreading of oil released under ice, accounting for the roughness of the under side of the sea ice.

### Funding:
- Expended to Date by End of Year 2 ..........$96,130.65

### Program Champions:
- LT R. Brooks, HQ USCG CG-MER.
- Mr. J. Popiel, USCG D-9.
- Mr. H. Blaney, HQ USCG CG-255.

### Stakeholders:
- HQ USCG, USCG RDC, USCG Pac Area and USCG D-17.
- NOAA Office of Response and Restoration (ORR).

### Points of Contact:
- Tom Ravens, UAA, Project Principal Investigator.
- Scott Socolofsky, TAMU, Project Principal Investigator.
Arctic Oil Spill Modeling – Baseline and Preliminary Work

**Baseline:**
The US Coast Guard relies on the GNOME oil spill model and NOAA for guidance and expertise in the event of an oil spill.

[GNOME = Generalized NOAA Operational Modeling Environment]

Three years ago, at the start of this project, the GNOME model was not Arctic – capable.

**Preliminary Work:**
Engagement with the NOAA Office of Response and Restoration.
Review of 23 Artic Oil Spill studies.
Guidance/suggestions to NOAA on simple ways to incorporate ice into the GNOME model.
Arctic Oil Spill Modeling – Guidance/suggestions to NOAA

**On movement of oil on surface:**

Oil moves with winds and currents if ice concentration is less than 20%.

Oil moves with ice if ice concentration is greater than 80%.

For ice concentrations between 20% and 80%, linearly interpolate.

**On spreading of oil on surface with different concentrations of ice:**

Rate of oil spreading with increasing ice

---

![Graph comparing the total area of a spill in open water as it increases over time for different spill volumes.](image)

To calculate the spill area when ice is present, the open water area of the spill is multiplied by the fraction of open water.

Ex: for a 1,000 m$^3$ spill, after 30 hrs (roughly 1 day) the open water spill area is 10 km$^2$. If the ice concentration is 6/10, the actual area of the spill is $10 \times (1-0.6) = 4$ km$^2$. 
Arctic Oil Spill Modeling – Algorithms for predicting oil movement and spreading

Random-walk algorithms for spreading of oil on the surface based on the Arctic Oil Spill Calculator (AOSC) and based on GNOME.

Agreements indicates that ADAC was able to reproduce the GNOME spreading projections (case shown assumes no ocean current, no wind, and a diffusion coefficient of $10^6 \text{ m}^2/\text{s}$)
Arctic Oil Spill Modeling – Demonstration of the use of the HIOMAS model for driving the GNOME oil spill model in Arctic.
Arctic Oil Spill Modeling – Demonstration of the use of the HIOMAS model for driving the GNOME oil spill model in Arctic (cont.)
Arctic Oil Spill Modeling – Demonstration of the use of the HIOMAS model for driving the GNOME oil spill model in Arctic (cont.)
Texas A&M Oilspill Calculator (TAMOC)
- Comprehensive spill modeling system for subsea oil spills

**Simulation Start-up**
- Initial Conditions
  - Particle Size Distribution
  - Chemical Composition of Phases
  - Mass Fluxes

**Simulation Modules**
- Single Bubble Model (BPM)
  - Slip velocity
  - Mass/heat transfer
  - Ambient conditions
- Stratified Plume Model (SPM)
- Bent Plume Model (BPM)

**Properties Computed Every Time Step**
- Ambient Module
  - $T, S, C_i$
  - $z$

**Discrete Bubble Model (DBM)**
- Equations of State
- Physical Properties of Bubbles, Drops, and Particles
Validation of TAMOC

• We validate TAMOC to:
  • Laboratory data for single- and multiphase plumes in the literature
  • New laboratory data from the Socolofsky research group
  • Deep spill field experiment
  • Field measurements during the Deepwater Horizon
  • Field measurements from cruises by the Gulf Integrated Spill Research (GISR) consortium, funded by the Gulf of Mexico Research Initiative

• Documentation:
  • Socolofsky et al. (2008) *JHE*, **134**(6), 772-783.
  • Gros et al. (2016) *ES&T*, **50**(14), 7397-7408.
  • Numerous manuscripts in review and preparation: expected publication dates of 2017 and 2018.
Movies of Laboratory Experiments

Intrusion Formation in Stratification

Oil and Gas Separation in Crossflow
Validation of TAMOC Trajectory in a Crossflow

See Jirka (2004)
TAMOC Simulation of Laboratory Crossflow with Stratification

- Predicted plume (BPM)
- Predicted particle path (BPM)
- Measured plume edge (Socolofsky et al., 2013)
- Measured particle path range (Socolofsky et al., 2013)
TAMOC Validation to the Deep Spill Experiment

Measured (hot colors) and predicted trajectory (dashed lines) of diesel release
Validation to Field data from the Deepwater Horizon

A

$F_{\text{benzene}}$ at 900-1300 m depth

B

$F_{\text{removed at the sea surface}}$
Field Data for Methane Dissolution inside Hydrate Stability Zone

Data from Rehder et al. (2009)
Multibeam result from Fledermaus for Sleeping Dragon in MC 118
Validation to Rise Height of Natural Seeps

Measured Rise Height

TAMOC Prediction

GISR Data at GC 600; Wang et al. (2016).
Conducted preliminary simulations of a blowout for a light, sweet crude in the Beaufort Sea

Release characteristics set to those in the API Model Intercomparison Study (Socolofsky et al. 2015, MPB, 96(1-2), 110-126.

Release Details:
- Depths (m): 350, 100, 50, and 25
- Orifice Diameter (m): 0.3
- Flow rate (bpd): 25,000
- GOR: 2,000
- Temperature (°C): 150
Salinity and Temperature Profiles for Arctic Simulations

- From ice tethered profiler-21 (WHOI)

August 2008

February 2009
Sample TAMOC Result: Deepwater

August 2008

February 2009
Sample TAMOC Result: Shallow Release

August 2008

February 2009

Depth (m)

Q (m³s⁻¹)

S (psu)

T (deg C)
Ambient Current Profiles

\[\text{Depth (m)}\quad \text{u velocity (cm/s)}\]

\[\text{Depth (m)}\quad \text{v velocity (cm/s)}\]
Bent Plume Model Simulation: Centerline Trajectory

August 2008

February 2009
Bent Plume Model Simulation: Detailed Results

August 2008

February 2009
Summary of Arctic TAMOC Simulations

• Model structure is complete and appropriate for expected ambient forcing (stratification and currents)
• TAMOC has been validated to available laboratory and field data
• Preliminary simulations show that significant amounts of oil and gas will reach the ice in reasonable discharge scenarios
• TAMOC provides to the oil/ice module:
  • Heat flux of released oil and gas to the ice
  • Mass flux of oil by pseudo-component
• Next step: Nearfield ice interaction module
Preliminary density current modeling based on output of TAMU plume model \((Q, \Delta \rho)\)
Case 1: stagnant water/ice and smooth ice

\[ g' = \frac{\Delta \rho}{\rho} g \]

\[ \frac{U}{\sqrt{g'h}} = Fr \approx 0.7 \]

\[ Q = UA = U \, 2\pi rh \]

\[ h(r) = \left[ \frac{Q}{2\pi r(0.7)\sqrt{g'}} \right]^{2/3} \]
Case 2: Stagnant water and ice with under-ice roughness

Assumptions:

- Density current moves radially from its center, filling the cavities in the under-side of the ice.

- Effective depth of under-side of ice subject to oil flow:

  \[ d = \frac{V_{\text{void}}}{\text{Area}} \]

- Effective fluid velocity:

  \[ U = \frac{Q}{2\pi rd} \]

- If \( d < h \), calculate \( U \) based on \( h \) instead.
Case 3: Moving ice, with rough bottom

**Assumptions:**
- fluid velocity = 0,
- ice velocity = $U_{ice}$,

$d = \text{ave. oil thickness under ice.}$

**stagnation point analysis:**

$$U_{fluid} = U_{ice} = \frac{Q}{2\pi rd}$$

$$b = \frac{Q}{2\pi dU_{ice}}$$

$$L = \frac{Q}{dU_{ice}}$$
Where we are going (short term)

Develop algorithms for situations with non-zero ocean currents.

Continue to develop the use of output from the TAMU plume model to provide initial conditions for the density current model – both for the well blowout scenario and for the marine pipeline rupture scenario.

Examine NOAA/Canadian databases and translate the available oil property data into the required input parameters in the TAMU plume model (TAMOC) and eventually GNOME2.

Identify and run test cases for a range of meteorological conditions and locations to demonstrate the robustness of our tool and to demonstrate the range of potential impacts.

Conduct a sensitivity analysis of model input parameters.

Deliver a complete set of algorithms for oil movement/spreading due to surface / under-ice releases to the NOAA Office of Response and Restoration for inclusion into GNOME2.
Where we are going (longer term)

• Examine the heat transfer associated with well blowouts and project any sea ice thaw that might occur in the aftermath of a blowout event.

• Estimate gas release due to well blowouts.

• Explore the extent to which under-ice roughness and void volume can be estimated based on surface features sensible by satellites.

• Develop algorithms for oil movement and spreading due to under-ice releases when ice concentration is less than 100%.
Ice Conditions Index for the Great Lakes Region
(ICECON)

Dr. Thomas Ravens, University of Alaska Anchorage
Dr. Andrew Mahoney, University of Alaska Fairbanks
Project Title – Ice Condition Index (ICECON) for the Great Lakes.

FOA/NOFO Research Question: Topic 2.c.1.i: What are the best ways to provide communications and information in congested maritime regions and waterways.

**Project Objectives:**
- Work in collaboration with the US Coast Guard, NOAA, and others to develop an ice condition index (ICECON) for the Great Lakes.
- Use available data to forecast ICECON up to 3 days into the future.

**Potential Impact:**
- The system will help the US Coast Guard provide guidance and decision support to vessels (of a given class) which are planning a given transit.
- The system will also help the US Coast Guard manage its icebreaker fleet.

**Key Milestones/Deliverable Schedule:**
- Project Start……………………………………….Nov 2016 ✓
- Finalized ICECON approach………………………..Jun 2017 ✓
- Forecasting of ICECON…………………………Jun 2018 ✓

**Performance Metrics:**
- Accuracy of forecasted ice conditions (thickness, concentration, and type). It is expected that 80% of the surface area of the Great Lakes will have accurate ice thickness and ice concentration calculations (thickness and concentration projections within 1 thickness/concentration class of the ice chart thickness/concentration class). It is expected that 70% of the forecasted ice type data is in agreement with the ice chart ice type data.
- Consistency of ICECON assessment/ship performance.

**Key Accomplishments:**
- The ADAC team has engaged with the US Coast Guard and other stakeholders and is working with the Coast Guard to organize a “Council of Experts” to convene in Cleveland on Mov. 29, 2016.
- The Council will review a few contending approaches to an ice condition index, and suggest the best pathway forward.

**Funding:**
Expected for Year 3 ………………………………. $145,393

**Program Champions:**
- USCG Office of Waterways Management (CG-WM).

**Stakeholders:**
- USCG
- NOAA National Weather Service

**Points of Contact:**
- Tom Ravens, UAA, Project Principal Investigator
- Andy Mahoney, UAF, Project Principal Investigator
Where we were – Arctic Ice Regime Shipping System (Transport Canada 2003)

Step 1: Define the Ice Regime based on ice conditions

**Ice Regime**
- Ice Concentration
- Stage of Development
  - Thickness
  - Age
- Stage of Decay
- Ice Roughness

---

**Thin First-year Ice (FY)**
First-year ice that is 30 to 70 cm thick

**Medium First-year Ice (MFY)**
First-year ice that is 70 to 120 cm thick
Where we were – Arctic Ice Regime Shipping System (Transport Canada 2003), cont.

Step 2: Define Vessel Classes and Ice Multipliers

(A set of Vessel Classes and a set of class-dependent Ice Multipliers are defined – with positive Ice Multipliers indicating the vessel class is sufficient to handle the ice condition and with negative multipliers indicating that the vessel class was insufficient).

<table>
<thead>
<tr>
<th>Vessel Class</th>
<th>Maximum Allowable Ice Type</th>
<th>Ice Thickness (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAC1</td>
<td>No Limit</td>
<td>no limit</td>
</tr>
<tr>
<td>CAC2</td>
<td>Multi-year</td>
<td>no limit</td>
</tr>
<tr>
<td>CAC3</td>
<td>Second-year</td>
<td>no limit</td>
</tr>
<tr>
<td>CAC4</td>
<td>Thick First-year</td>
<td>&gt; 120</td>
</tr>
<tr>
<td>Type A</td>
<td>Medium First-year</td>
<td>70-120</td>
</tr>
<tr>
<td>Type B</td>
<td>Thin First-year (stage 2)</td>
<td>50-70</td>
</tr>
<tr>
<td>Type C</td>
<td>Thin First-year (stage 1)</td>
<td>30-50</td>
</tr>
<tr>
<td>Type D</td>
<td>Grey-white</td>
<td>15-30</td>
</tr>
<tr>
<td>Type E</td>
<td>Open Water / Grey</td>
<td>10-15</td>
</tr>
</tbody>
</table>

Vessel classes and allowable ice type/thickness

<table>
<thead>
<tr>
<th>Ice Types</th>
<th>Type Vessels</th>
<th>CAC</th>
</tr>
</thead>
<tbody>
<tr>
<td>MY Multi-Year Ice</td>
<td>-4 -4 -4 -4 4 -4 -1</td>
<td>3</td>
</tr>
<tr>
<td>SY Second Year Ice</td>
<td>-4 -4 -4 -4 -3 -1</td>
<td>1</td>
</tr>
<tr>
<td>TFY Thin First-Year Ice, 70-120 cm</td>
<td>-3 -3 -3 -3 -3 +1</td>
<td>2</td>
</tr>
<tr>
<td>MFY Medium First-Year Ice, 50-70 cm</td>
<td>-2 -2 -2 -1 -1</td>
<td>2</td>
</tr>
<tr>
<td>FY Thin First-Year Ice, 30-50 cm</td>
<td>-1 -1 -1 -1</td>
<td>2</td>
</tr>
<tr>
<td>GW Grey-Water Ice</td>
<td>1 1 1 1 2 2</td>
<td>2</td>
</tr>
<tr>
<td>G Grey Ice, 10-15 cm</td>
<td>1 2 2 2 2 2</td>
<td>2</td>
</tr>
</tbody>
</table>

Ice Multipliers (IM’s) for a range of Ice Types and Vessel Types (IM’s become negative if ice thicker than capacity)
Step 3: Calculate the Ice Numeral (IN)

Ice Numeral is a weighted average of the Ice Multipliers, which in turn relate directly to the ice-capability of vessels (negative if conditions exceed capability of the vessel, positive otherwise).

Step 4: Decide whether to proceed based on Ice Numeral.

IN ≥ 0, proceed.

IN < 0, do not proceed, find alternative route.
Where we were – Arctic Ice Regime Shipping System (Transport Canada 2003), cont.

ADAC review
AIRSS boils down to:

Ships should not proceed if their ice capability is inadequate for the ice condition (mainly ice thickness) – though there is some accounting for ice concentration, ice roughness, and ice thaw.

Approach does not explicitly take into account:

- Surface temperature,
- Ice pressure (whether converging or diverging ice field),
- Snow depth (which would slow transport)
- Heat transfer

All affect ice condition, all can be forecasted for Great Lakes.
Where we were – assessment of the Great Lakes Environmental Research Lab (GLERL) and their forecasting products

Surface (water) temperature

Air temperature
Where we were – assessment of the Great Lakes Environmental Research Lab (GLERL) and their forecasting products

Wind speed and direction

Water currents
Where we were – assessment of the Great Lakes Environmental Research Lab (GLERL) and their forecasting products

Ice concentration (historic ice chart shown – no ice forecasts currently available)

Ice thickness

Ice velocity

[forecasts not currently available]

Short-term Forecasts: GLERL has added an ice forecasting component to its existing Great Lakes Coastal Forecasting System (GLCFS), which uses a computer model to predict ice formation and break-up. This model is used by the National Weather Service to forecast short-term (5-7 day) ice concentration, thickness, and velocity as well as improving winter wave forecasts, as ice cover significantly affects how surface waves behave. A new GLCFS product under development is a sea spray vessel icing potential that will aid mariners late in the Great Lakes shipping season. GLERL is also developing a Great Lakes Ice-Circulation Model (GLIM) for all five Great Lakes.
Where we are – Methodology for Year 3

**Task 1.** Develop algorithm/decision tree for determining the ICECON as a function of ice type, ice thickness, temperature, pressure, ice concentration, and snow depth.

**Task 2.** Identify, adopt, or define a system of vessel types similar to that used in the Arctic Ice Regime Shipping System (AIRSS).

**Task 3.** Use available ice-encounter data from Great Lakes vessels from previous year or two and other data to help develop and validate ICECON. Define the vessel types (classes) in terms of their ability to transit through different types of ice as characterized by ICECON.
Task 4. Use the GLERL numerical models and ICECON decision tree (Task 1) to provide now-casted and forecasted ICECON.

Task 5. Develop algorithms that allow us to use the “now-time” and forecasted data on icebreaker activity to adjust the now-casted and forecasted ICECON distribution, and identify the entity that will enter the icebreaker activity and operate the ICECON decision support tool.

Task 6. In “beta” test mode and in partnership with District 9, demonstrate the use the ICECON forecasting system to provide decision support to vessels (of a given class) who are considering transit from A to B over a given time period.
**Task 1.** Develop algorithm/decision tree for determining the ICECON as a function of ice type, ice thickness, temperature, pressure, ice concentration, and snow depth.

Assess proposed approaches for ICECON (USCG District 9):

Three different ICECON values for 2 ft of brash ice under different winds and air temperatures
Where we are – Task 1 (cont.)

Assess National Ice Center (NIC) point system approach:

Points are assigned based on 5 parameters:

Ice concentration, Ice thickness, Temperature, Wind conditions, Ice features

**Ice Concentration**: Given in percentage of coverage, typically to the nearest 10th. (10%, 20%, 30%, etc.)

- 00 – 10% : 0 pts - Minimal coverage, waterways are open and navigable
- 11 – 39% : 5 pts - Ice present, many leads and polynyas provide ease of navigation
- 40 – 69% : 10 pts - Moderate ice coverage, areas of open water allow vessels to maneuver.
- 70 – 99% : 20 pts - Heavy ice coverage, vessels will continually be moving through ice.
- 100% : 25 pts - Heavy ice coverage, no openings present.

**Ice Thickness**: Given in inches (centimeters).

- 0-2 inches : 2 pts - New ice, minimal resistance to vessel traffic. (<5 cm)
- 2-6 inches : 10 pts - Thin ice, easily broken, little resistance to more ice-capable vessels. (5-15 cm)
- 6 – 12 inches: 15 pts - Medium ice, easily broken, little resistance to more ice-capable vessels. (15 – 30 cm)
- 12 – 28 inches: 20 pts - Thick ice, approaching upper limit of light icebreakers. (30 – 70 cm)
- 28+ inches : 25 pts - Very thick ice, light icebreakers must back and ram. (70+ cm)
USCG District 9 has adopted this approach on a trial basis.

Ship captains are collecting data on ice parameters, and assigning points and a provisional Ice Classification.

The Impacts to Vessels is assessed in the field and compared to the Impacts to Vessels that is suggested by the provisional system (above).
Where we are - next steps

• Waiting on a Notice of Award.
• Planning a Council of Experts meeting which is scheduled for Nov. 29.
Questions?

Tug stuck in the ice at the Soo Locks. March 20, 2014. Credit: NOAA