State of Alaska
Arctic Offshore Mooring Program
Engineering Considerations

Andrew T. Metzger, Ph.D., P.E.

Alaska University
Transportation Research Center
INTRODUCTION

Alaska Deep Draft Arctic Ports Charette

- Planning meeting for a possible deep draft port in AK (May 16-17, 2011)
- Results
  - Stakeholder requirements may necessitate an Arctic Marine Transportation System
  - Large capital project(s)
  - Long-term development plan
INTRODUCTION

- Alaska Deep Draft Arctic Ports Charette
  - Is there any “low-hanging fruit”?
    - Element of an Arctic Marine Transportation System
    - Not large capital project
    - Completion in near-term
    - Will benefit the State of Alaska
    - Ideally, benefit local stakeholders as well
INTRODUCTION

- Proposition: Alaska Offshore Mooring Program
  - Provide a network of offshore moorings for vessels
    - Locate in areas of “safe harbor”
    - Sheltered from weather
    - Near supplies, resources or activities
    - Doesn’t require construction of a conventional “port”
  - Offshore Fuel Terminal
INTRODUCTION

- Alaska Offshore Mooring Program
  - Offshore Fuel Terminal(s)
    - Fuel and food supplies limit duration of marine operations in the Arctic
    - Offshore fuel terminals could extend time-on-site – effectiveness of operations
    - Possible economic benefit for coastal communities

www.lonely planet.com
INTRODUCTION

- Alaska Offshore Mooring Program
  - “Build-it-and-we’ll-use-it” sentiment from Federal agencies
    - NOAA
    - USCG
    - USN
  - Reiterated last month at:

www.lonely planet.com
INTRODUCTION

- Remainder of this presentation:
  - Engineering concerns for arctic offshore mooring facilities
    - Current Practice
    - Adaption to the Arctic
    - Engineering design criteria for Alaska
      - Site-specific environmental conditions
  - How INE/ AUTC can assist the State
CURRENT PRACTICE

- Designing an offshore vessel mooring to support operations

- Consult the “Handbook”:
  - UFC 4-159-03 - Design: Moorings
CURRENT PRACTICE

- Designing an offshore vessel mooring

- Type of Mooring?
  - Relatively economical
  - Readily deployed/ retrieved
  - Low maintenance
  - High reliability
  - Simplistic
  - “low hanging fruit” project
CURRENT PRACTICE

- Designing an offshore vessel mooring to support operations

- Type of Mooring?
  - Recommendation:
    - Single-point mooring
    - Drag-type Anchors
CURRENT PRACTICE

- Designing an offshore vessel mooring
  - E.g.:

UFC 4-159-03 - Design: Moorings;
Figure 7-2
CURRENT PRACTICE

- Designing an offshore vessel mooring to support operations

- Drag-anchor
  - To suit bottom conditions
  - Design Vessel??? + Environmental Conditions

- Sinkers
  - As-needed
  - Attenuate vessel motion
  - Reduce scope

- Chain/ Cable to suit vessel and wind/ current conditions
CURRENT PRACTICE

- **Buoy**
  - Standard buoys available
  - Size (buoyancy) to suit vessel and site conditions
  - Are standard buoys suitable in the Arctic?

- **How do we mitigate the effects of Sea-ice?**
  - Remove moorings before onset of ice?
  - Sink the buoy? (interesting possibility...)
  - Ice-capable buoy? (no apparent off-the-shelf versions for this application)
CURRENT PRACTICE

- Standard buoy

12-FOOT BUOY

BUOY SHACKLE
TENSION BAR
RAIL
FLEXIBLE FOAM
URETHANE SHELL - WHITE
RADAR REFLECTOR - OPTIONAL
RIGID FOAM
Adaption to Arctic

- **Alternative: Spar Buoy**
  - Natural tendency to damp vessel motion
  - Possibly good choice for exposed areas
  - Spar-type mooring buoys have been proposed to mitigate ice
    - Design so lowest portion of buoy is lower than deepest anticipated ice
    - Ice could potentially ride-over buoy (with no vessel tied up)
Adaption to Arctic

- Alternative: Spar Buoy
- E.g.: Ice-capable spar buoy

Adaption to Arctic

- **Fuel Mooring**
  - It has been done...

René Raaijmakers, Business Development Manager, Bluewater Offshore Production Systems (USA) Inc., Texas, USA
Adaption to Arctic

- Fuel Mooring
  - It has been done...

René Raaijmakers, Business Development Manager, Bluewater Offshore Production Systems (USA) Inc., Texas, USA
Adaption to Arctic

- **Fuel Mooring**
  - Specialized equipment
  - Most often used in petrochemical industry
  - Probably require a scaled-down version
  - Recommendation:
    - Develop performance specifications for a site in Alaska
    - Hire a consultant/manufacturer to design/fabricate to suit
    - Consideration of subsea pipeline burial depth in land-fast ice zone
Engineering Considerations

- Design of Mooring systems in the Arctic
  - Planning Level Discussions...
  - Who are the customers?
    - Federal Agencies
      - NOAA
      - USCG
      - USN
    - Industry
      - O&G
      - Mining
      - Local (Alaska) shipping interests
Engineering Considerations

- Design of Mooring systems in the Arctic
  - Planning Level Discussions...
    - Identifying Customers will help identify the: *Design Vessel(s)*
      - Vessel Type (cargo, barge, etc.)
      - Length
      - Draft
      - Displacement
Engineering Considerations

- **Design of Mooring systems in the Arctic**
  - Require appropriate design criteria to design reliable engineered systems
  - We don’t design for the mean, we design for the extreme
  - “Reliable”: low probability of failure
  - What are the extreme environmental conditions in the Arctic? – i.e., low probability of exceedance
Engineering Considerations

- Design of Mooring systems in the Arctic

- Challenges in the U.S. Arctic:
  - Environmental parameters needed for engineering design are not readily available
  - Need engineering design criteria for the U.S. Arctic
Engineering Considerations

- Design of Mooring systems in the Arctic
  - Must identify extremes of:
    - Wind
    - Current
    - Sea-ice conditions
    - Soil Conditions

...for each site
Engineering Considerations

- Design of Mooring systems in the Arctic
  - How do we identify extremes?
    - Site-specific measurements coupled with...
    - Forecast/ Hindecast techniques
    - Until we have decades of data, this is the most rational option we have....
How AUTC can help

**Planning level:**

- Planning support
  - Technical
  - Technical
  - Administrative

- Assist in identifying potential site(s) for moorings

- Feasibility/ Economics of a fuel mooring
Engineering Design Criteria

- Design of Mooring systems in the Arctic
  - Engineering Design Criteria
    - Collect site-specific data
      - Recording Doppler Current Profiler (RDCP) studies
      - Current velocity monitoring
  - Wave Conditions
  - slides to follow...
Engineering Design Criteria

- Design of Mooring systems in the Arctic
  - Engineering Design Criteria
  - RDCP

Aanderaa: www.aadi.no
Engineering Design Criteria

- Design of Mooring systems in the Arctic
  - Engineering Design Criteria
  - Collect site-specific data - Wind, wave and currents (see website)
Engineering Design Criteria

- Design of Mooring systems in the Arctic
  - Engineering Design Criteria
  - Collect site-specific data
    - Wind monitoring
      - Off-the-shelf anemometer
    - Sea-ice monitoring
      - Off-the-shelf marine radar
  - Radar has been successfully used for this purpose (Barrow) (see website)
Design of Mooring systems in the Arctic

Proposal A – Engineering Design Criteria

1) Assemble an environmental monitoring package
   - RDCP
   - Anemometer
   - Marine Radar
Engineering Design Criteria

- Design of Mooring systems in the Arctic
  - Proposal A – Engineering Design Criteria
    - 2) Deploy Instrumentation at candidate site during “ice-free” season
      - Collect soil sample during deployment
        - Sampling bucket
Engineering Design Criteria

- Design of Mooring systems in the Arctic
  - Proposal A – Engineering Design Criteria
    - 3)
      - Retrieve Instrumentation
      - Redeploy to next site
Proposal A – Engineering Design Criteria

4) Analyze data

Provide design recommendations

- Wind
- Current
- Sea-ice considerations
Engineering Design Criteria

- Design of Mooring systems in the Arctic
  - Proposal A – Engineering Design Criteria

  - Site-specific results could be applied to a conventional mooring or fuel mooring

  - Fuel mooring would require additional specifications related to fuel transference requirements

  - Instrumentation package, once acquired, could be deployed at multiple sites
Engineering Design Criteria

- Design of Mooring systems in the Arctic
  - Proposal B – Mitigating Sea-ice
    - 1)
      - Identify possible methods for mitigating sea-ice
        - Fixed, ice-hardened structure
        - Removable mooring
        - “Sinkable” mooring
        - Ice-capable buoy (e.g., spar buoy)
Engineering Design Criteria

- Design of Mooring systems in the Arctic
  - Proposal B – Mitigating Sea-ice
    - 2)
      - Conceptual Designs
    - 3)
      - Analyses
        - Engineering
        - Costs
    - 4)
      - Provide Recommendations to State
      - Prototype development
Engineering Design Criteria

- Design of Mooring systems in the Arctic
  - Proposal C – Multimodal Planning Study
  - *Expansion of fuel mooring concept*
    - Basis
      - **Fuel and Supplies (food)** are two limiting factors for US Arctic Maritime Operations
      - **Fuel mooring**
        - Fuel supply along route to the Arctic
        - Periodic bulk fuel shipment from sea to shore side facility via fuel mooring
        - Potential economic benefits for coastal community and State
          - Lower fuel costs for community?
          - Create jobs?
Engineering Design Criteria

- Design of Mooring systems in the Arctic
  - Proposal C– Multimodal Planning Study
    - Basis
      - Fuel and Supplies (food) are two limiting factors on cruises to the US Arctic
      - Resupply (food)
        - Resupply point along Arctic route
        - Food/supplies could be flown to site
        - Lighter supplies to vessels offshore
        - Lightering from beach – no port needed
        - Additional Potential economic benefits for coastal community and State
Engineering Design Criteria

- Design of Mooring systems in the Arctic
  - Proposal C – Multimodal Planning Study
    - Combined fuel and resupply facility will be, by definition, a multimodal transportation hub
    - Will greatly expand operational capabilities in the Arctic
  - State owned/operated?

www.lonelyplanet.com
College of Engineering and Mines
Institute of Northern engineering
Alaska University Transportation Research Center
University of Alaska Fairbanks

Andrew T. Metzger
atmetzger@alaska.edu
907.474.6120