ARCTIC

Dynamic Positioning in Ice Conditions

Nils Albert Jenssen – Kongberg Maritime
Suman Muddusetti – Shell
Doug Phillips – *DP Expertise*
Klaus Backstrom – *Frontier Drilling*

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Dynamic Positioning Committee
Marine Technology Society

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DP in ice conditions

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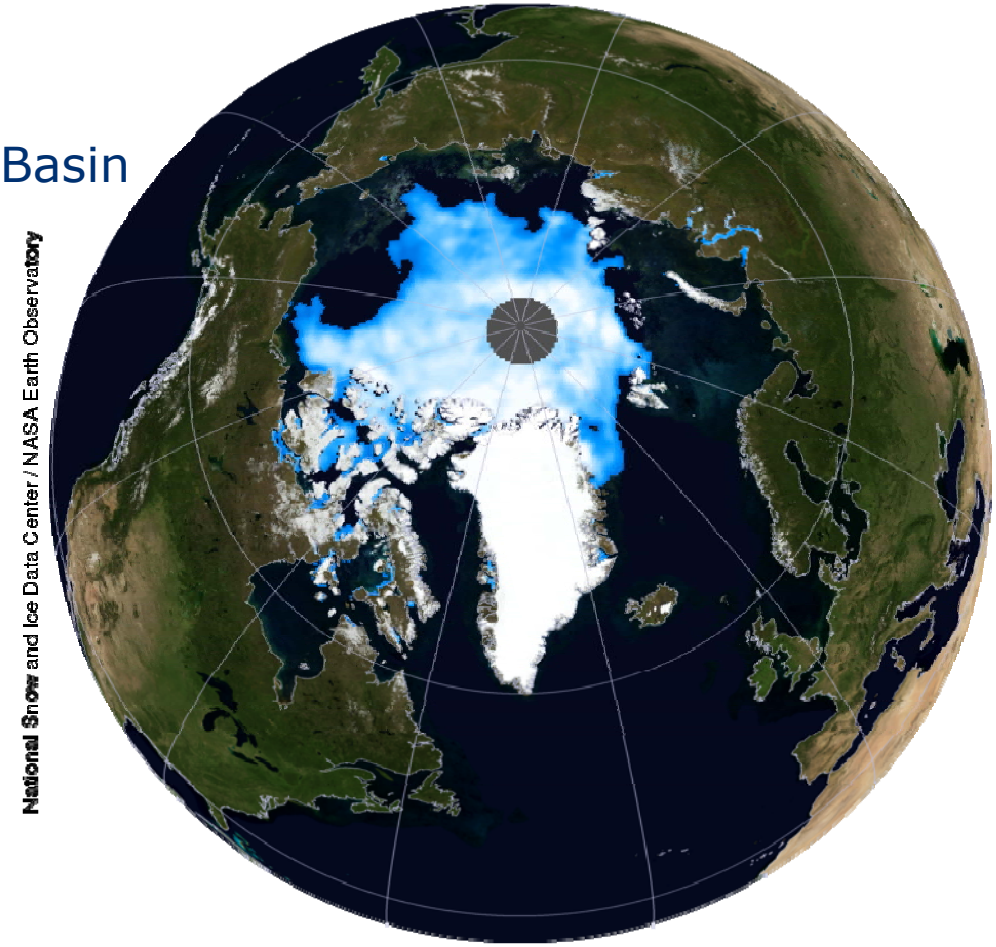
Scope

1. DP in Arctic Regions
2. The Bully Drill Ship
3. Lessons Learned in Ice Model Basin
4. Operational Aspects
5. Design of DP Control System
6. Conclusions



DP in Arctic Regions

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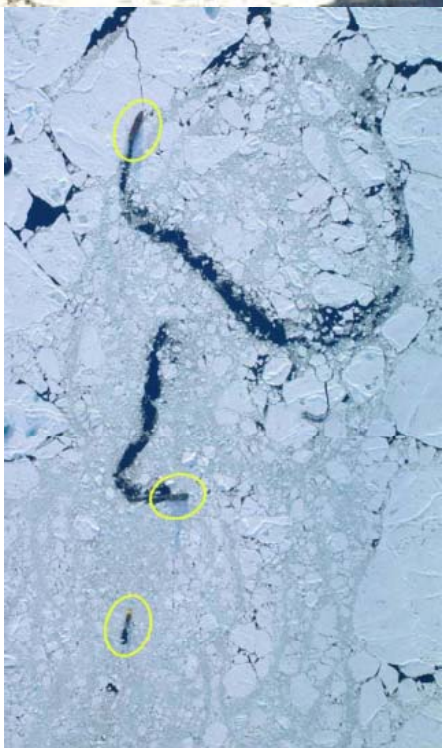
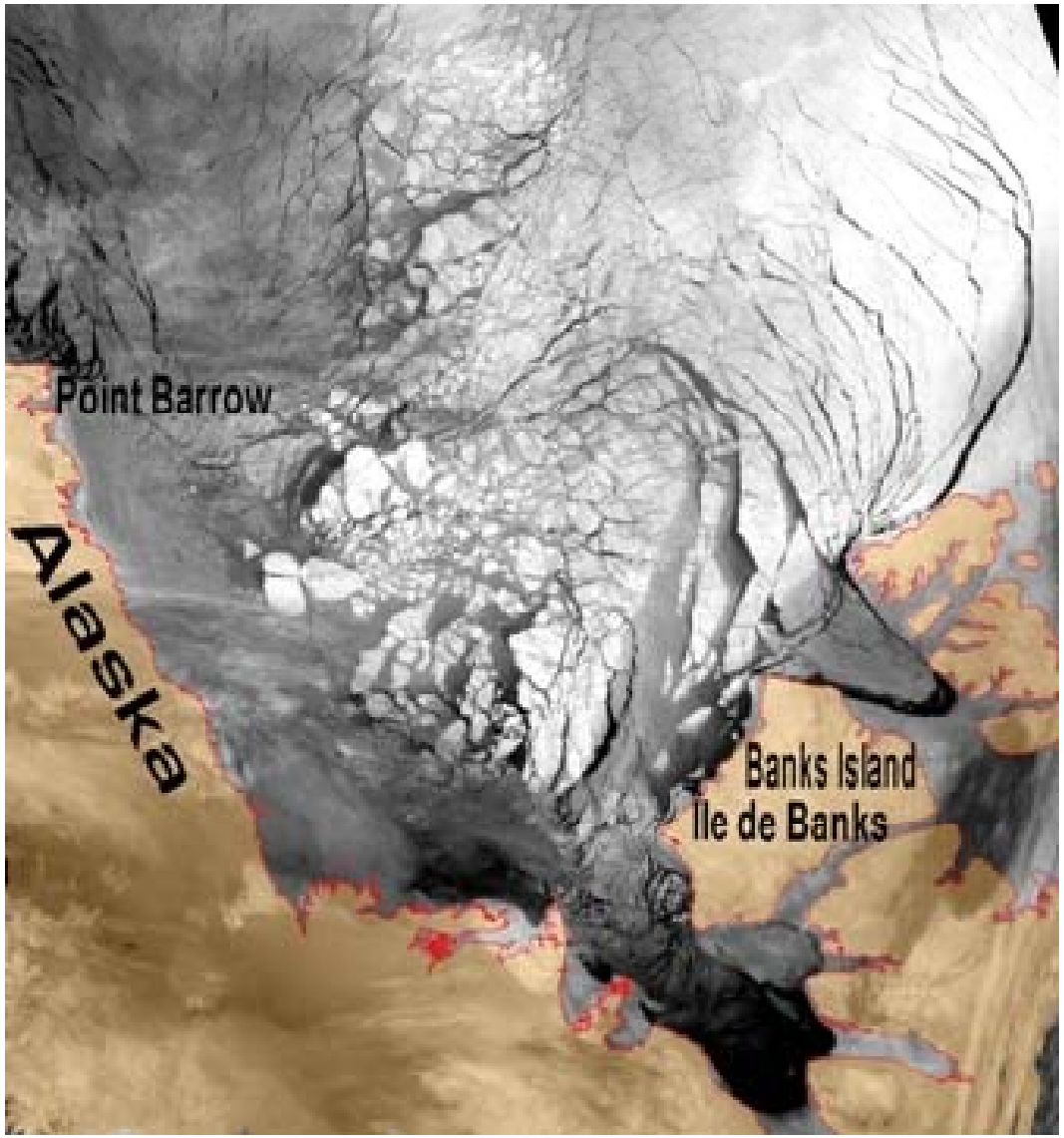
- Practically no real experiences
  - Sakhalin, CSO Constructor, 1999
  - IODP Expedition 302, Vidar Viking, 2004
  - Greenland, Vidar Viking, 2008
- Ice forces different from wind and waves; depend on
  - ice thickness and material property
  - concentration and ice floe size distribution
  - ice drift speed and direction
  - vessel motion
- Ice under the hull
  - thrusters
  - moon pool
  - hydro acoustics
- Ice management essential
  - ice concentration
  - size of ice floes



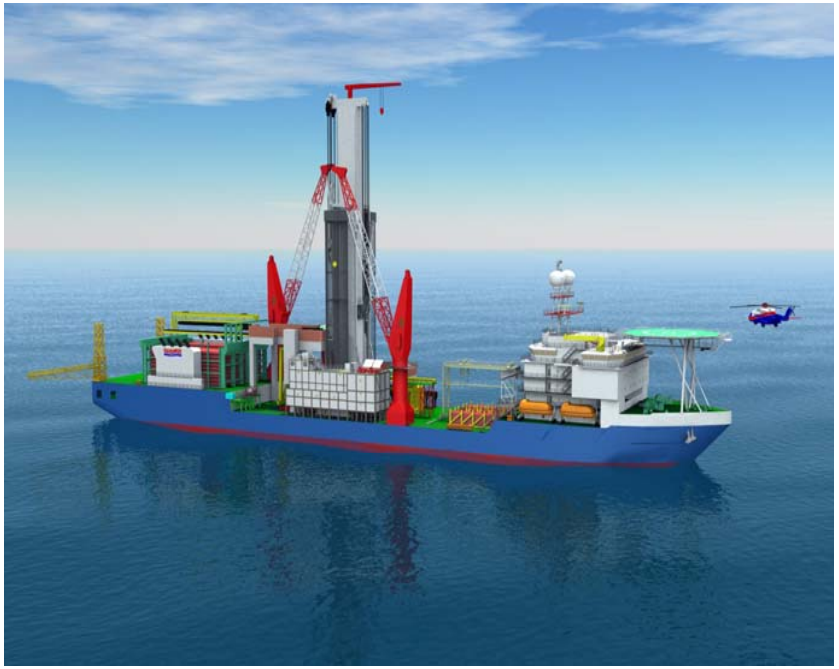
The Beaufort Sea Area



Beaufort Sea Summer 2008

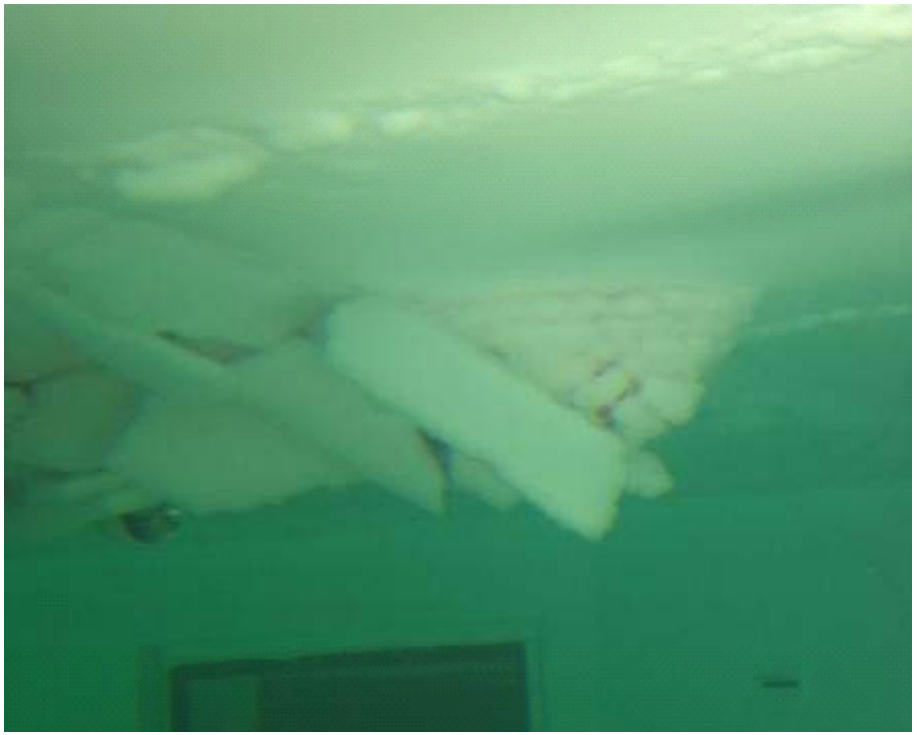
Bully Drill Ship

- Bow of an icebreaker capable of breaking ice floes as well as avoiding ice floes coming under the hull
- Constructed from an ultra-flexible grade of steel to protect the hull from shattering in extreme cold
- Special heating systems installed along piping and to protect the ballast tanks
- Engine vents widened and warmed to keep ice from building up
- Design developed by Frontier in cooperation with Shell's deepwater experts



Lessons Learned in Ice Model Basin

- Shape of hull essential



Before built-in ice management

Lessons Learned in Ice Model Basin

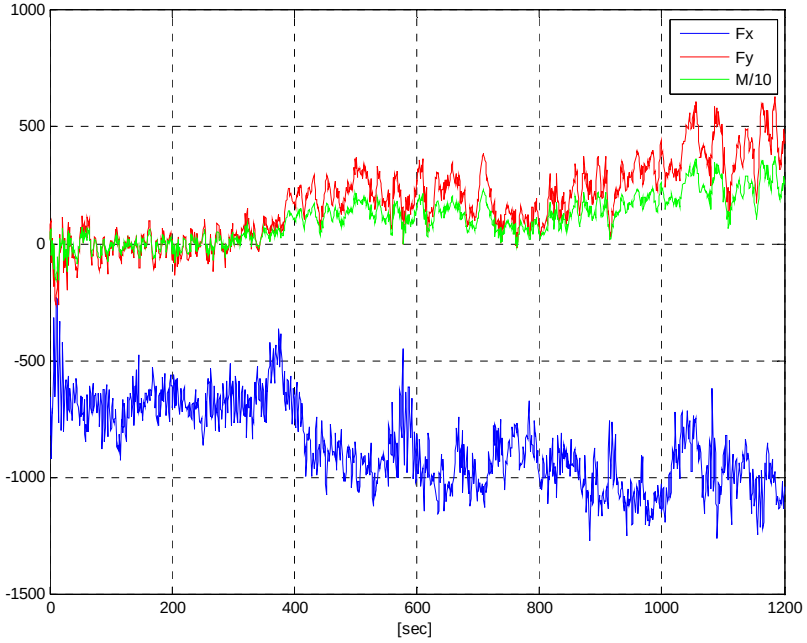
- Shape of hull essential

After built-in ice management

Lessons Learned in Ice Model Basin

- Ice load may be very high in average
- Very rapid, high peaks of considerable duration

Ice coverage 8/10th, flow size 10-20m, drift speed 1.5 knots, angle 0 deg

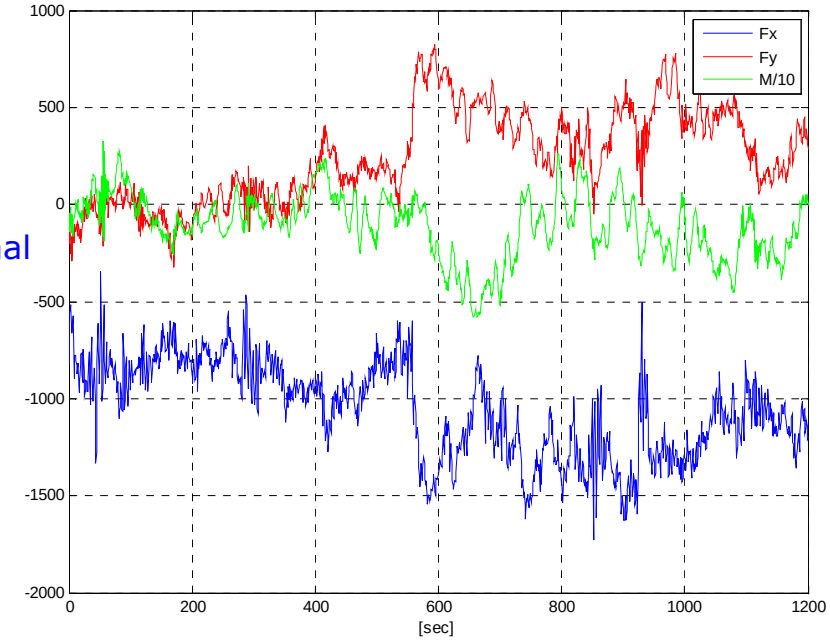


Ice thickness 0.8 m

Longitudinal

Lateral

Moment



Ice thickness 1.2 m

Lessons Learned in Ice Model Basin

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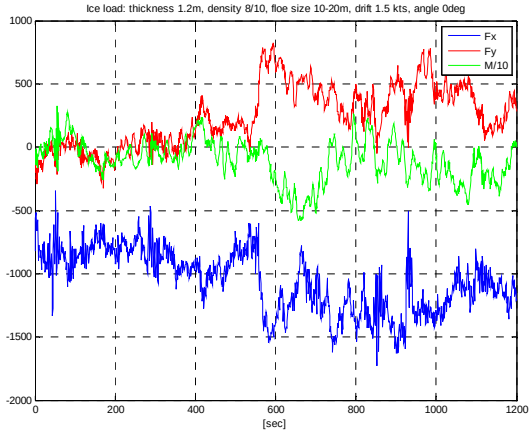
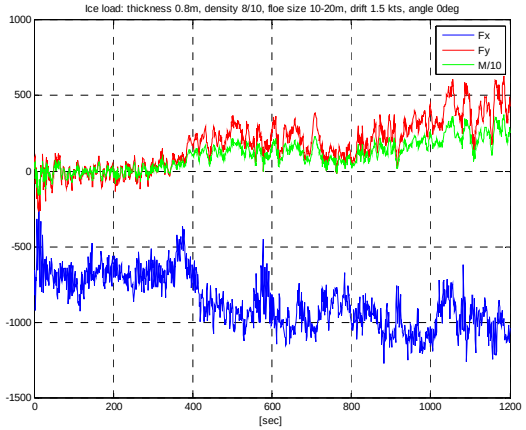
- Even though the vessel is moving directly towards the ice, the build up of ice on the port and starboard sides of the vessel is different resulting in a significant lateral force as well
- A turning moment builds up
- Turning moment from ice may be either stabilizing or destabilizing the vessel heading and will change over time
- Increasing forces are the result of ice building up around the hull



Longitudinal force

Lateral force

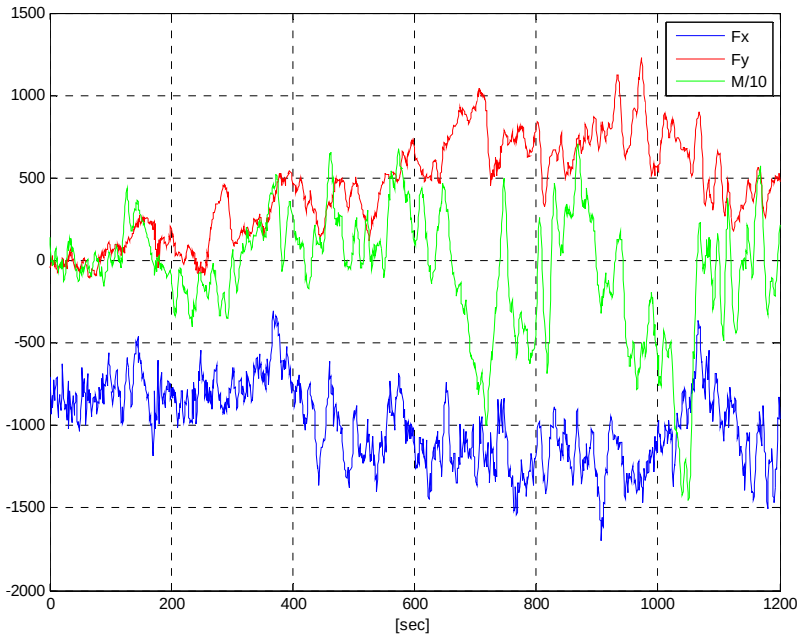
Turning moment



Lessons Learned in Ice Model Basin

- Increasing the ice concentration and floe sizes
  - average level of the ice forces increase
  - dynamic (stochastic) components increases

Ice coverage 10/10th, flow size 20-30m, drift speed 1.5 knots, angle 0 deg

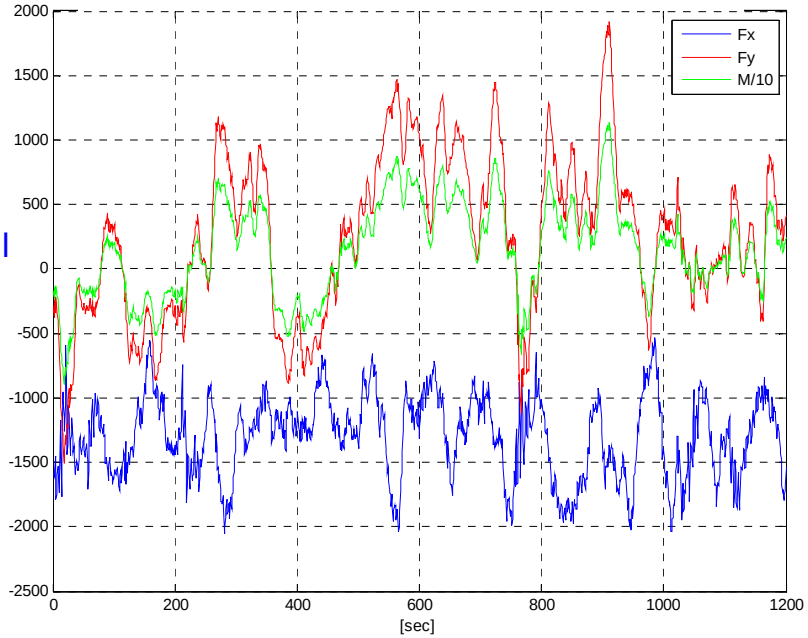


Ice thickness 0.8 m

Longitudinal

Lateral

Moment



Ice thickness 1.2 m

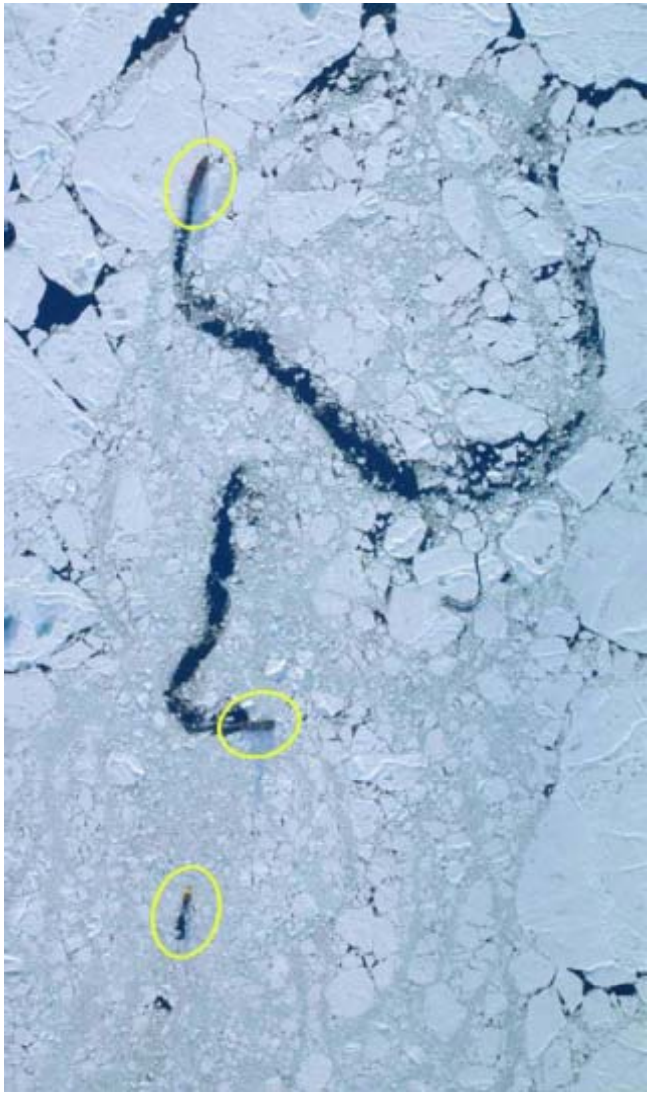
THE FULL PICTURE

Operational Aspects

- Ice management will be of utmost importance to facilitate DP operations

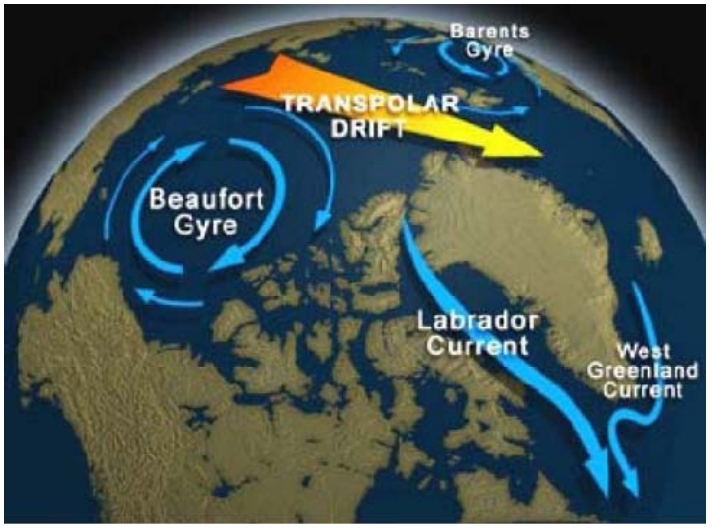
Ice Management

The use of ice breakers to reduce the ice loads and potential impacts on the station keeping abilities of the vessel being supported - typically achieved by breaking the ice floes into smaller floes and/or deflecting the floes



Operational Aspects

- The ice drift direction changes with time
- In the polar area the drift direction will change each 12th hour similar to the tide
- The changing of drift direction is one of the most challenging aspects of DP operations in ice conditions
  - drill rig has to head up towards the drift all of the time
  - the ice drift will continue rotate in the same directions
  - special ice management means must be implemented to enable the vessel to rotate back to "neutral" to avoid wind up of umbilicals and kill/choke line hoses



THE FULL PICTURE

Design of DP Control System

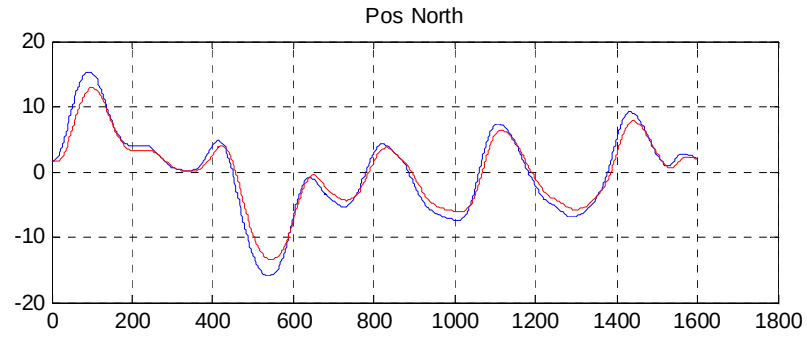
- Ice model tests
  - Model is moved on a straight line with fixed speed through the ice
  - A DP vessel in real life will not move that ideally relative to the encountering ice
  - Reasonable to believe that peak forces recorded in the model basins are above what could be expected at sea

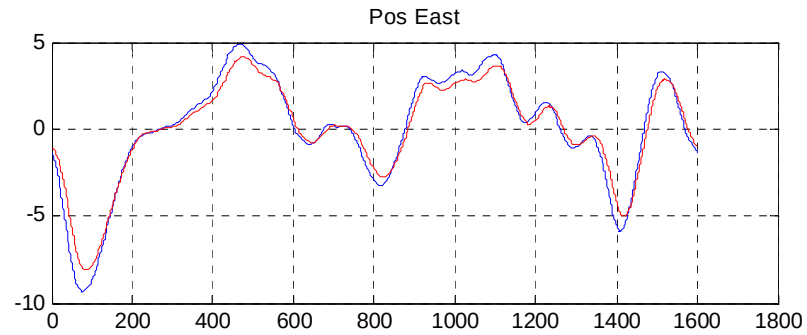
- No analytical tools available
  - simulation models
  - force calculation schemes
  - capability analysis tools

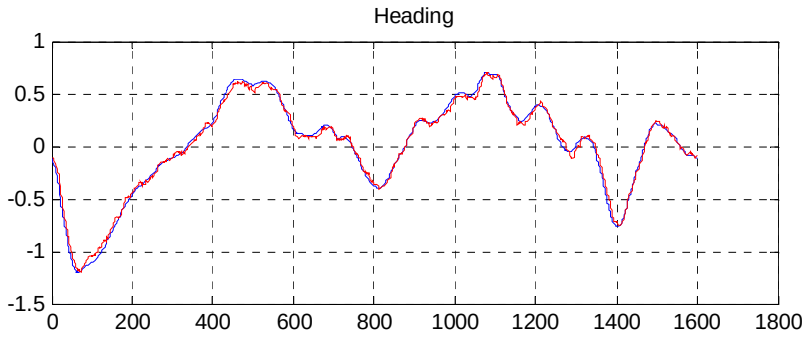
Design of DP Control System

- Apply recorded ice loads in DP simulator
- Normal open water DP

- The excursions are so large that the validity of the simulation is zero
- Kalman filter does not keep up with the peaks and lags behind dramatically







Measured value Estimated value

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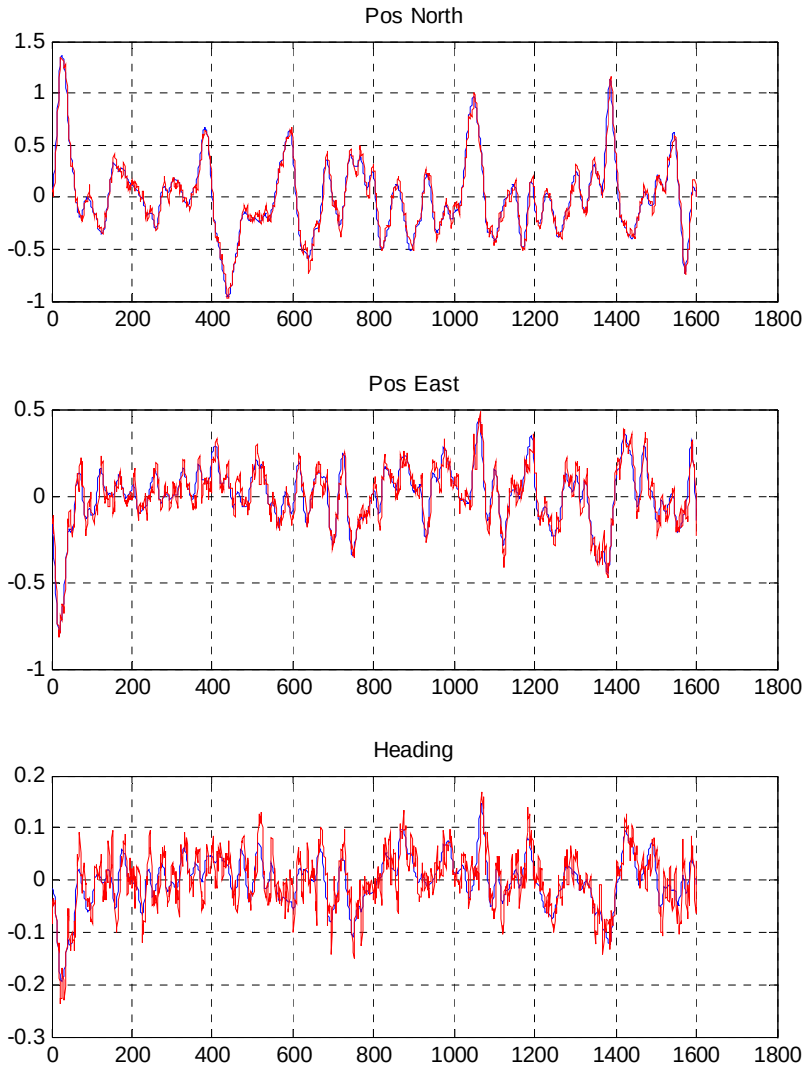
Design of DP Control System

- Apply recorded ice loads in DP simulator
- DP in "ice mode"
- Improved Kalman filter tracking capability
- No significant improvement by just increasing controller (restoring and damping) gains
- Position reference systems must be of very good quality



Measured value Estimated value

THE FULL PICTURE

Design of DP Control System

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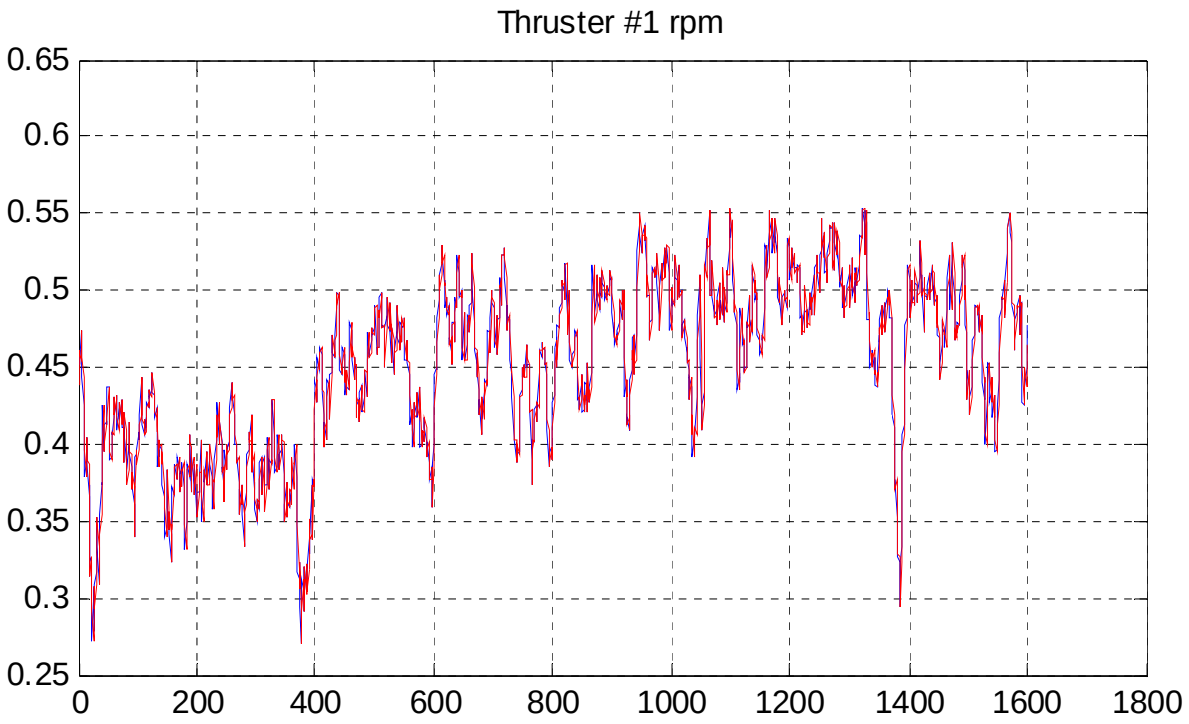
- The tracking capability comes at the cost of increased thruster utilization



THE FULL PICTURE

Conclusions

- There is no experience in Arctic DP operations in heavy ice conditions
- Lack of qualified analytic tools for readily designing a DP system. Need to rely on ice model basin tests
- Safe and efficient DP operation in the Arctic rely on robust ice management
- Provided effective ice management, DP operations should be feasible with a DP control system capable of compensating for the quickly changing ice forces
  - This will however be at the expense of increased thruster utilization and additional wear and maintenance
  - Given that drilling activity in ice conditions is a limited seasonal activity (≤ 3 months) this could be manageable

Thank you for your attention