Dynamic Positioning Committee

Marine Technology Society

NEW APPLICATIONS

DP For Heavy Lift Applications

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Converteam

New Applications

Dynamic Positioning for Heavy Lift Applications

John Flint/Richard Stephens/Allan Meahan 7th/8th October 08

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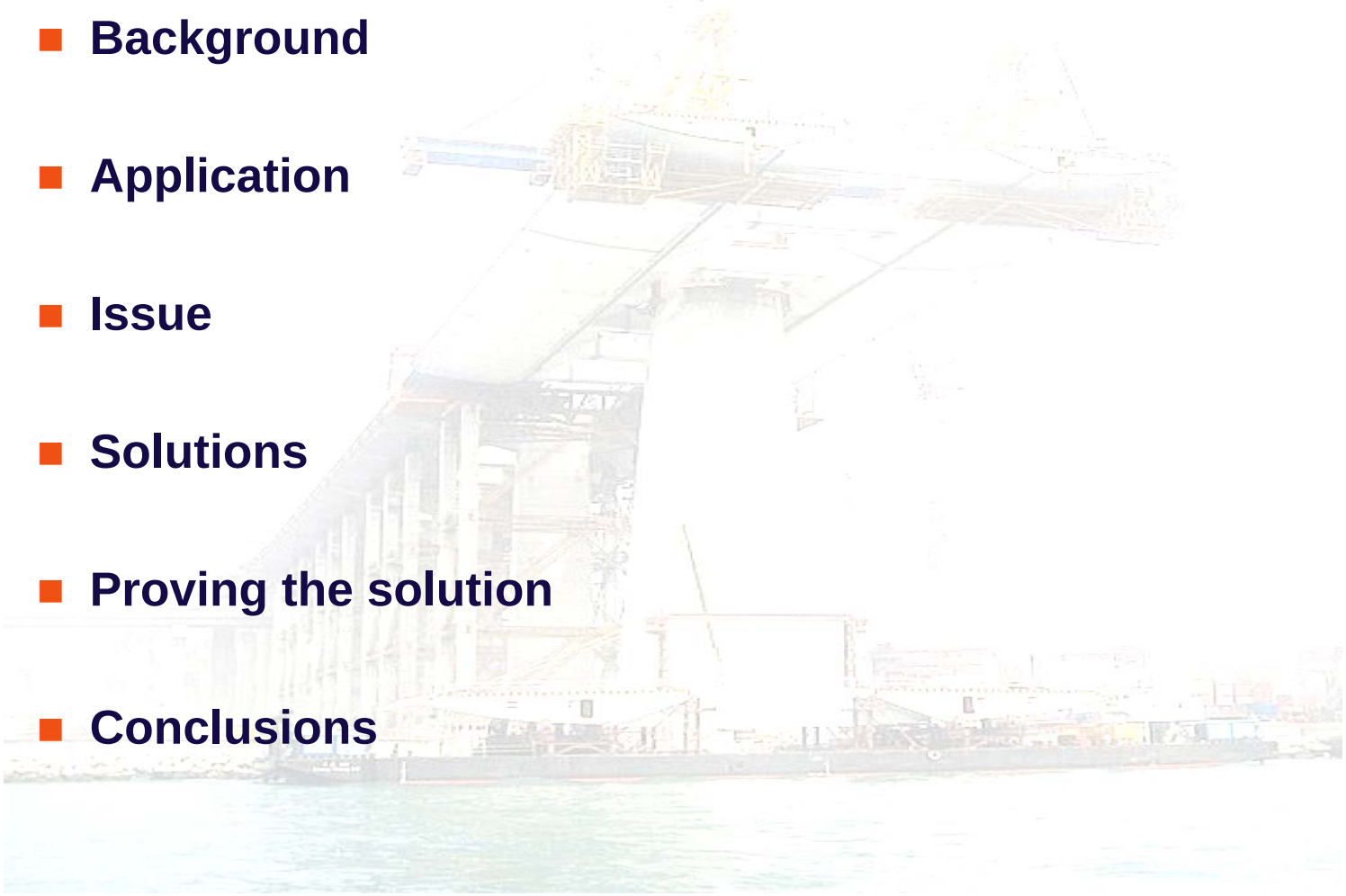
New Applications – Heavy Lift

Summary of Presentation

- Background
- Application
- Issue
- Solutions
- Proving the solution
- Conclusions



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New Applications – Heavy Lift

Background

- **Location**
  - Area - Far East

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New Applications – Heavy Lift

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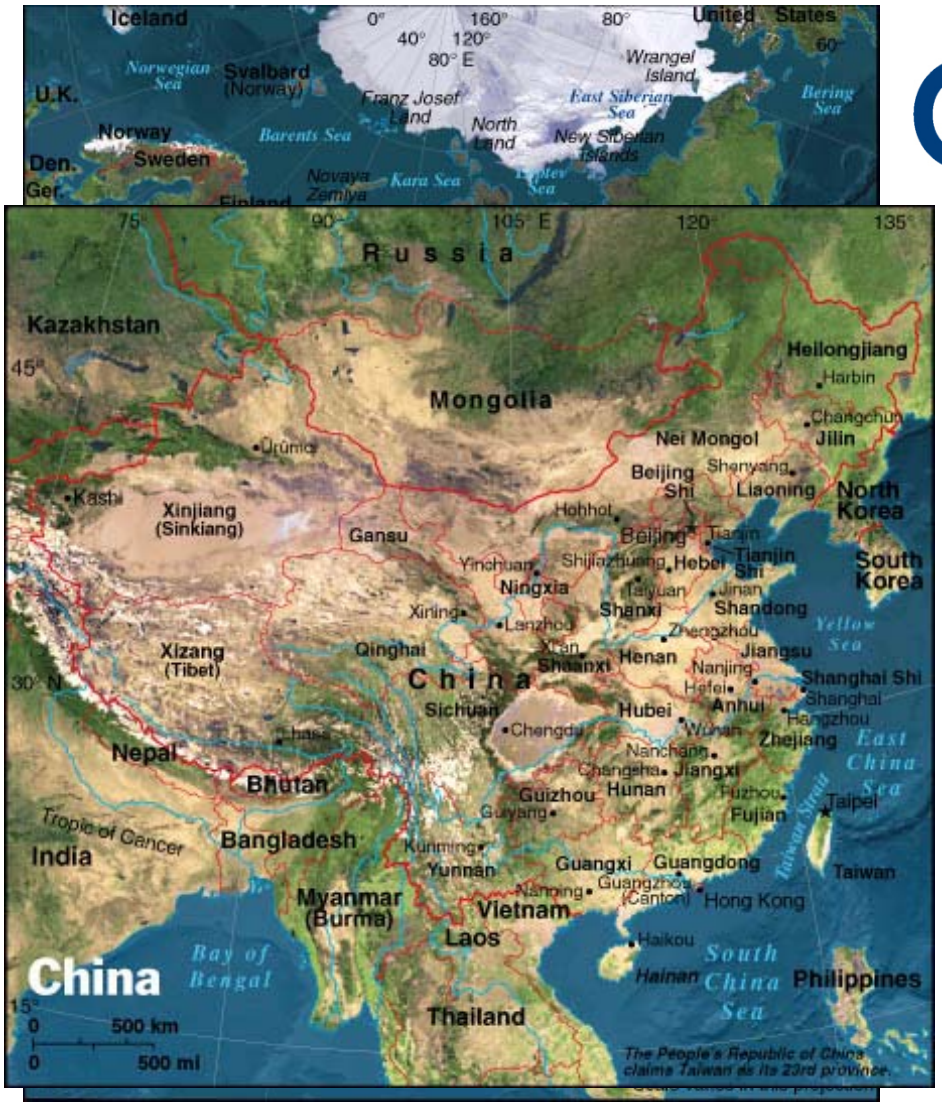
- **Location**
  - Area - Far East
  - Country – China



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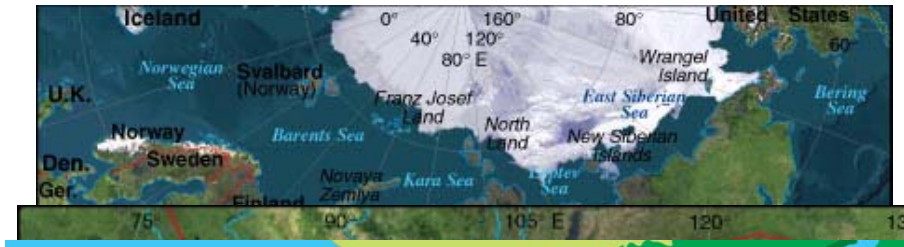
New Applications – Heavy Lift

Background

- **Location**
  - Area - Far East
  - Country – China
  - City – Hong Kong



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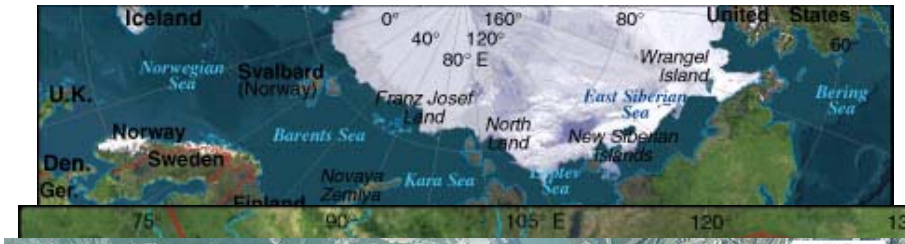
New Applications – Heavy Lift

Background

- **Location**
  - Area - Far East
  - Country – China
  - City – Hong Kong
  - Bridge – Stonecutters



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Background

- **Stonecutter Bridge**
  - Stonecutter Bridge will be one of the longest span cable-stayed bridges in the world.
  - The partially constructed bridge's deck is about 75 m above water level
  - The span will comprise 65 segments, each with a mass in excess of 500 tonnes

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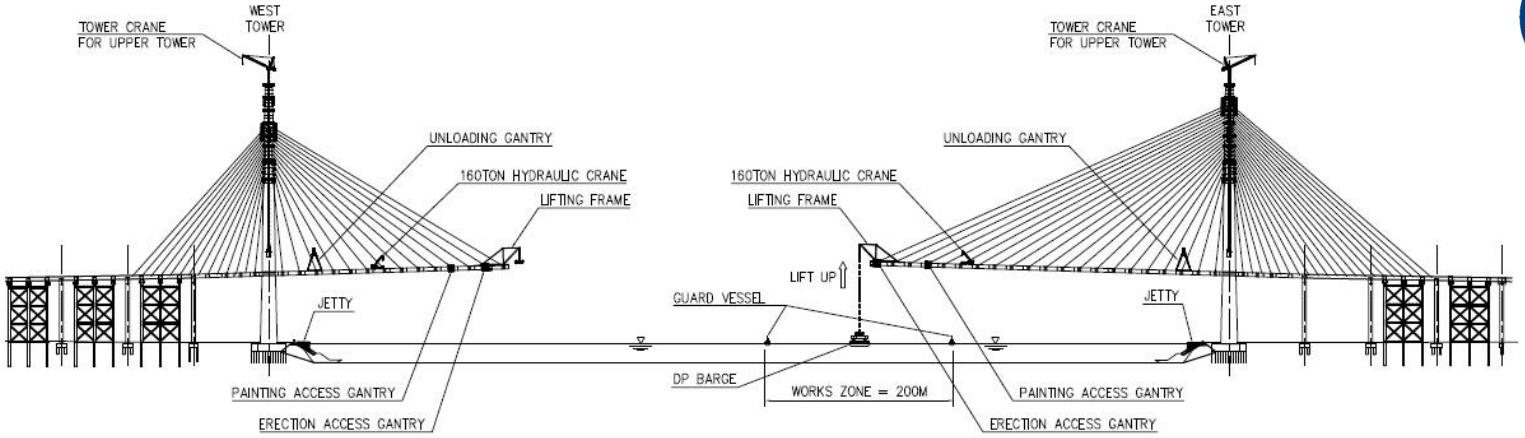
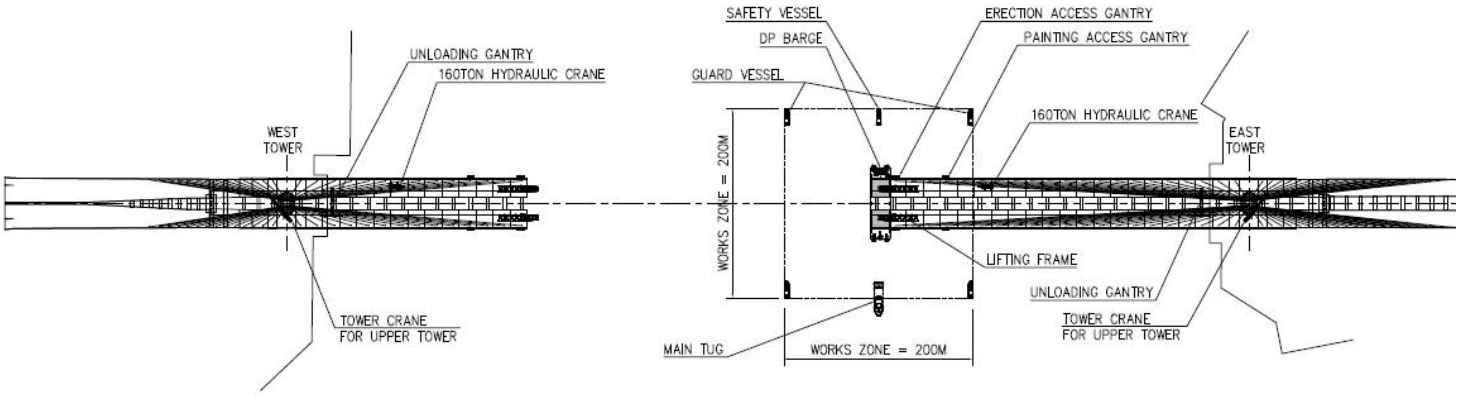
Background



SIDE



PLAN

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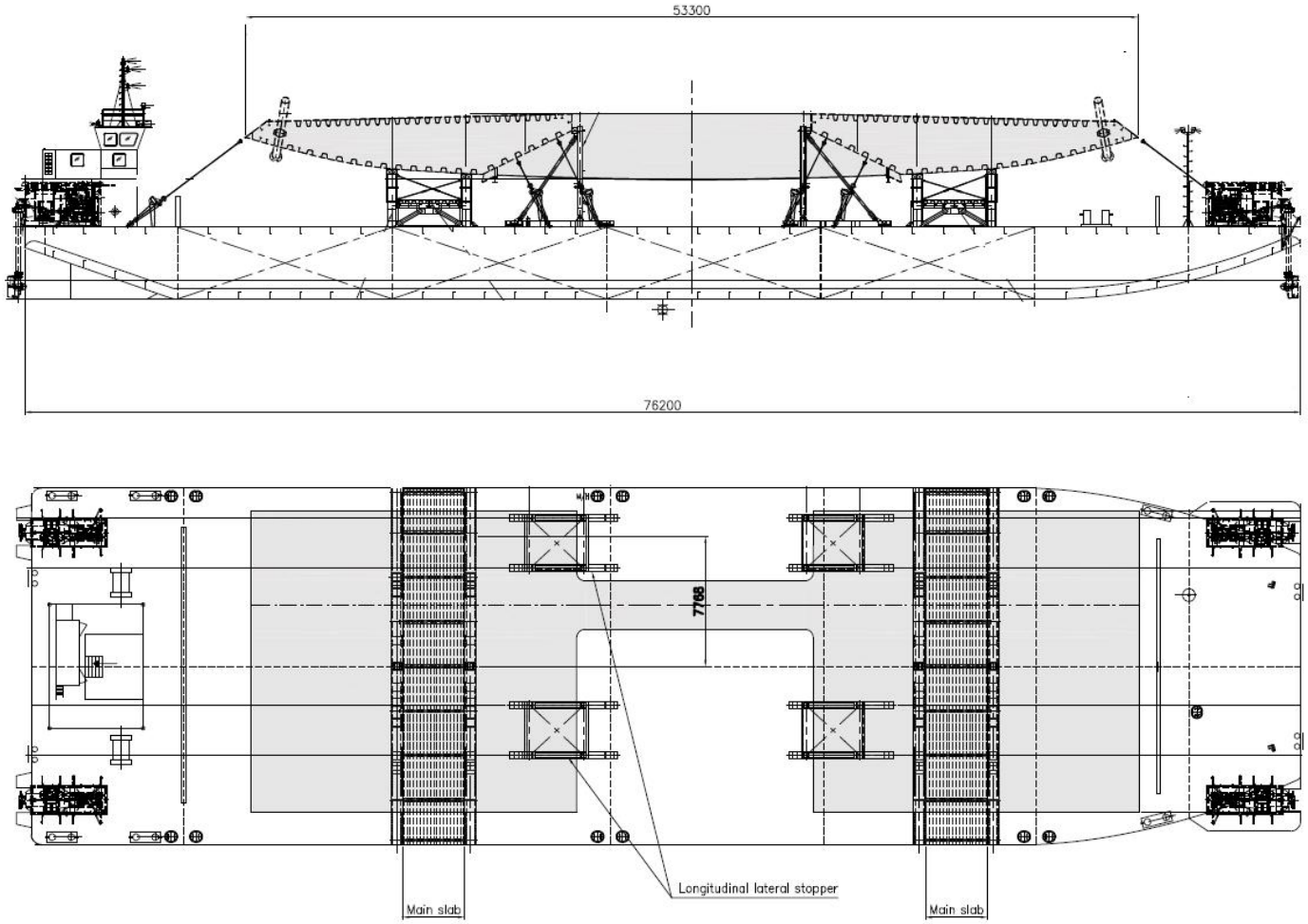
New Applications – Heavy Lift

Background



- **Barge**
  - OAL = 76.2m,
  - B = 21.3m
  - 4 off azimuth thrusters, 6.5T Thrust each
  - Class 2 DP system
  - 2 off DGPS + 1 off Laser System
- **Segment**
  - L = 53m
  - W = 18m
  - M = 500T

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New Applications – Heavy Lift

Application

- **Heavy Lift**
  - Barge Chang Sheng 302 fitted with a Converteam A-series duplex dynamic positioning system.
  - Using DP, the segment is positioned vertically below its final position in the span.
  - Hoist cables attached, tension is gradually applied, and the segment is lifted from the barge
  - At 25%, 50% and 75% tension levels the operation is halted with all systems being evaluated

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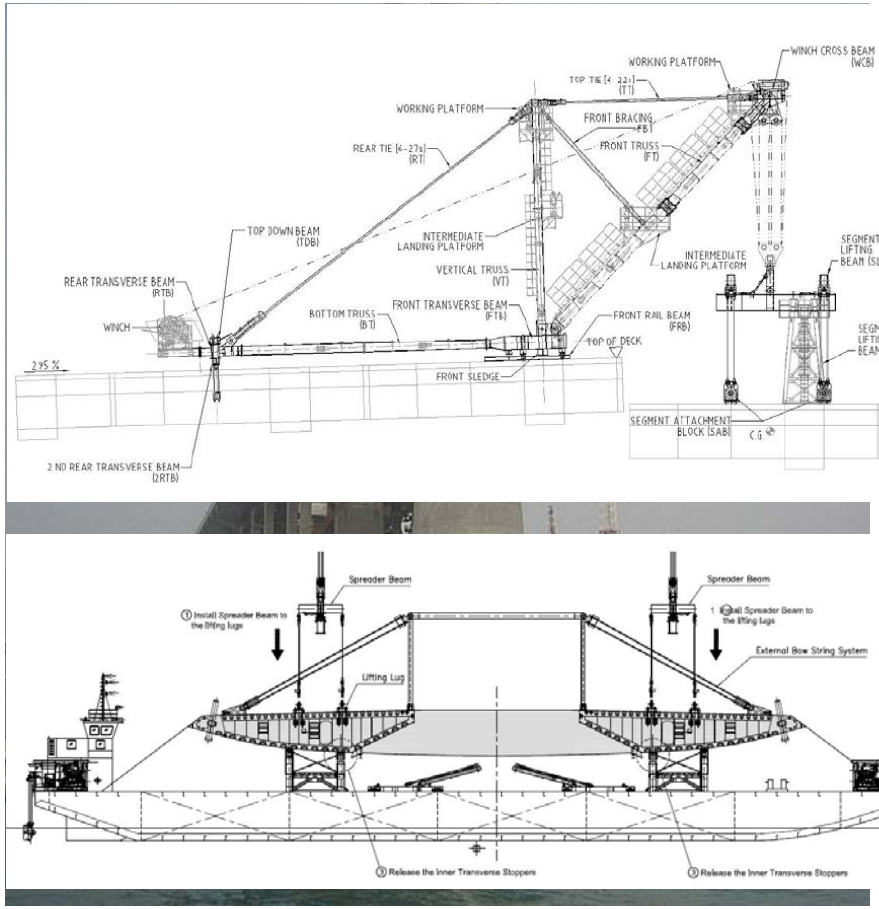

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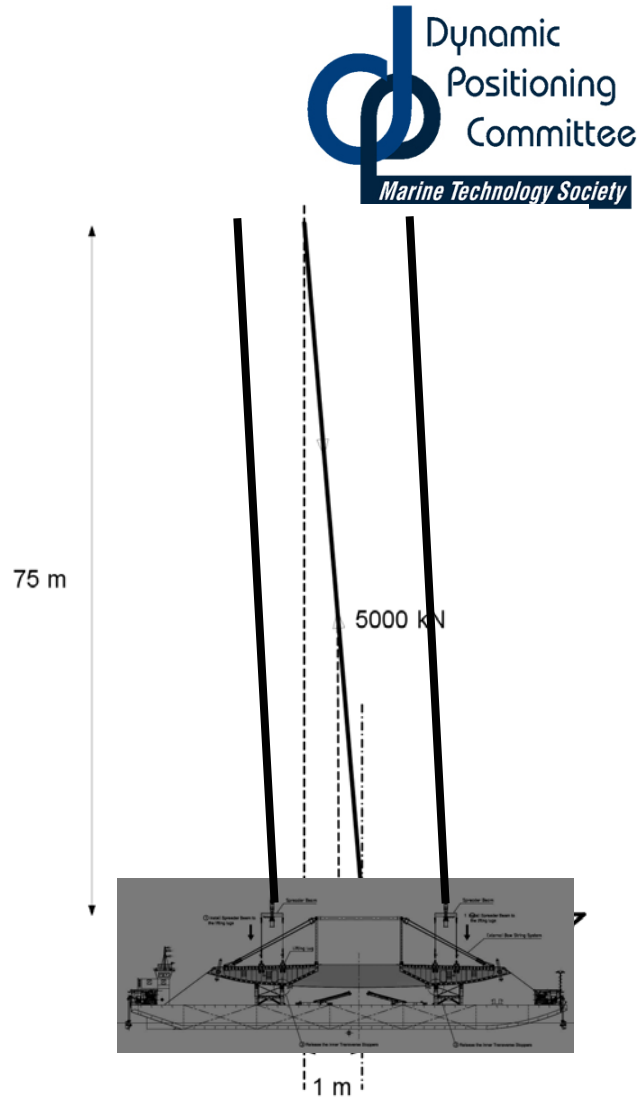
Application

- **Forces**
  - Crane imparts an oscillatory force.
  - Force is unknown to DP controller
  - The force is up to 10 times the thruster force normally requested by the DP controller.
  - In order to damp oscillations it is necessary to apply thruster force in anti-phase to the velocity, not the position.
  - Affects both Manual and Automatic control



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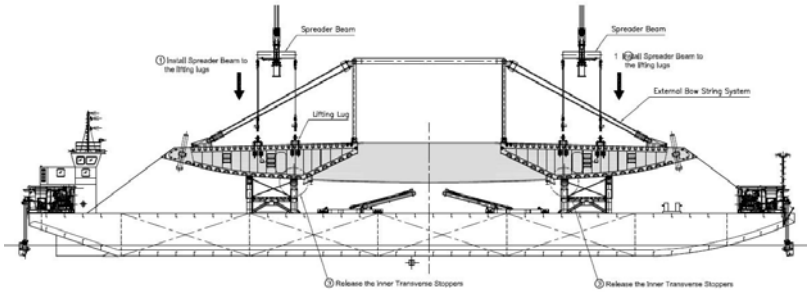
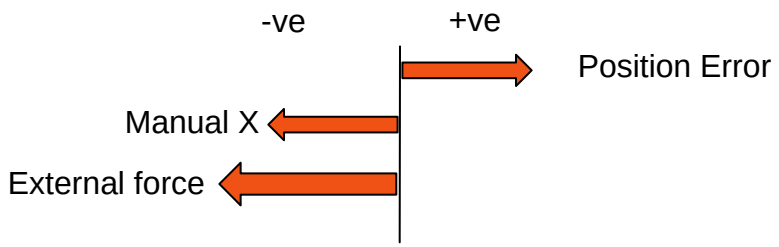
New Applications – Heavy Lift

Issue

- **In manual control**
  - The normal reaction of a DPO is to
    - apply thrust in the direction to reduce any position error
    - back off the thrust
    - apply a decelerating thrust as the vessel approaches the target position.
    - Unsuitable during heavy lift operations
    - Likely to increase amplitude of the oscillations.





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New Applications – Heavy Lift

Issue

- **In automatic**
  - Normal reaction from the DP control system:-
    - Forces from crane are completely unknown to the DP system. They degrade the position and velocity estimates used to calculate thrust references to control the vessel.
    - Controller will apply thrust towards the aim position.
    - These two factors lead to poor damping of the oscillations, or even instability.

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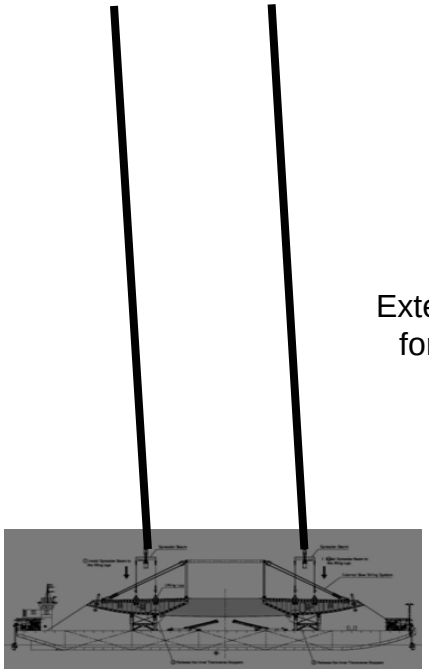
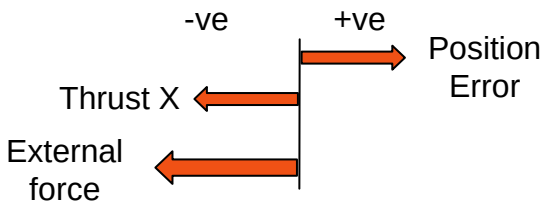
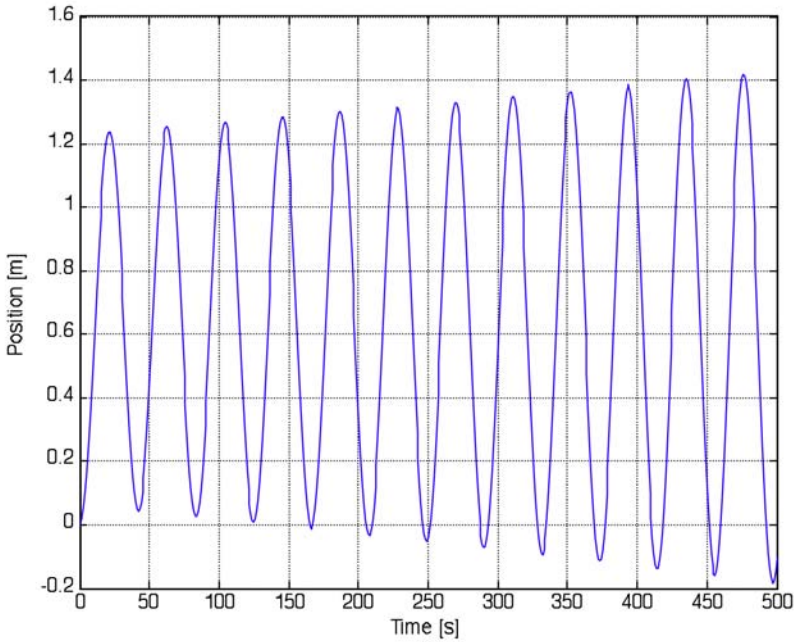
New Applications – Heavy Lift

Issue

- **Simulation**
  - Chang Sheng 302 Barge during a lifting operation using the control system with no changes







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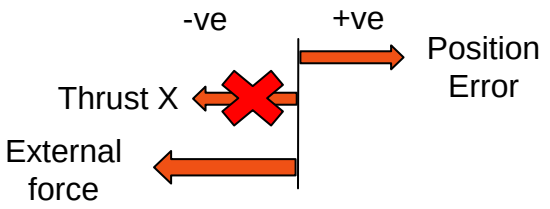
Solution

- **Manual control**
  - Matrix modes - Allow the operator to select which axes are controlled controlled manually.
  - Operator should not be overwhelmed, the advice for operators inexperienced with heavy lift operations:-
    - Do not attempt to dampen oscillations unless it is necessary to do so. Hydrodynamic drag forces will gradually reduce any oscillations.
    - If it necessary to change the average position of the barge, adjust the joystick position to apply a different thrust and leave it constant.
    - To damp out oscillations: at the peak of an oscillation, apply thrust *away from* the aim position.



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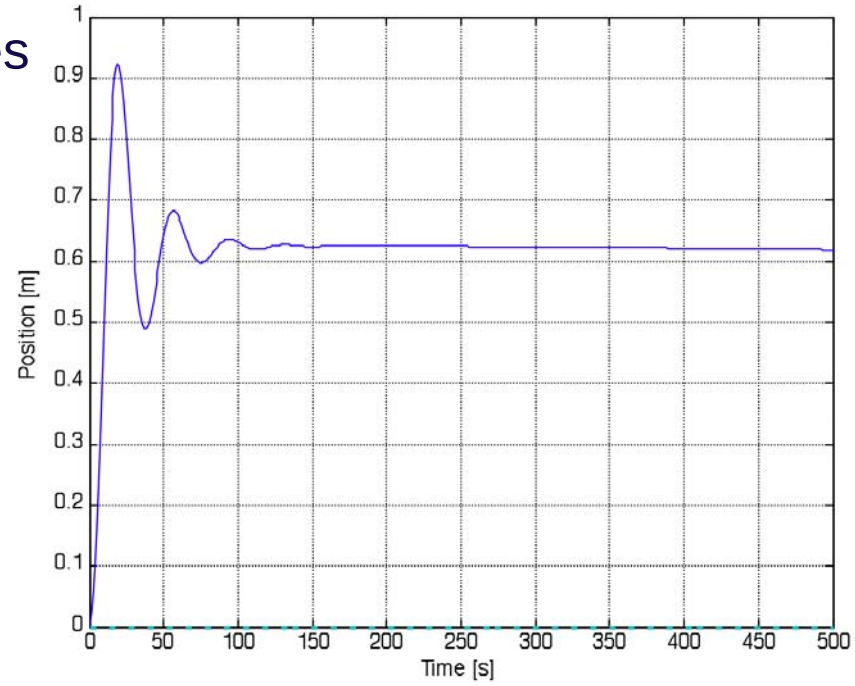
Solution

- **Automatic control**
  - Provide option to increase the velocity gain and decrease the proportional gain, which increases damping.
    - Done via slider.
  - During Lifting operations in DP control:-
    - Keep gains at ‘normal’.
    - Oscillations will only increase gradually.
    - Increase damping if oscillations become noticeable.



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New Applications – Heavy Lift

Proving the solution and understanding the issue

- **Manual control**
  - Untrained operator.
    - An initial response of no interventions. The barge oscillated slightly in the surge axis, and a lift could have been safely conducted.
    - Operator attempted to dampen the oscillations, and as expected, The interventions were inappropriate.
    - The amplitude of oscillations increased, and position control was rapidly lost

- **Manual control**
  - Trained operator.
    - Understanding the external forces exerted on the vessel during lifting.
    - Understanding the effect of using manual thrust for offsetting the vessel.
    - Understanding how to manage the situation
      - thruster selection – free or bias
      - Sensor & position reference selections

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New Applications – Heavy Lift

Proving the solution and understanding the issue

- **Automatic control**
  - Extensively tested in a lifting environment.
    - Tensions equivalent to 10%, 25% and 50% of the segment weight were applied and held for long periods.
    - To induce position errors, a tug was used to drive the barge off position.
    - At all times the controller response was as expected and the barge was under control.

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Conclusions

- **Lessons**
  - A DP vessel under-taking heavy lift operations can become unstable.
    - This instability is due to the stiffness of the ship-crane system, the unknown forces acting on the vessel and the unavoidable lags associated with feedback control.
    - This instability can occur under both manual and automatic control.
  - For manual control
    - Extra operator training needs to be included to understand the risk and its mitigation
    - Improve the modes of operation to make the task easier.
  - For automatic control
    - Understanding the complex control but offering a simple operator interface for sound judgment calls.

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Conclusions

- **Dynamic Position System**
  - DP systems are designed from building blocks, high standards are maintained and lessons are continuously being learnt by all suppliers.
  - Sometime even users believe these systems could even make cups of tea – perhaps that will be in next years development.
  - BUT make no mistake – DP designers do want to understand what effects performance, whether it is weird thruster arrangements, strange power systems, new position reference systems, external forces etc. We need to know.
  - TRAINING, TRAINING, TRAINING especially how to cope with external unknown forces.

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