



## **NEW APPLICATIONS**

### **DP For Heavy Lift Applications**

**John Flint, Richard Stephens, Allan Meahan**  
*Converteam*

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## New Applications

### Dynamic Positioning for Heavy Lift Applications

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

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## Summary of Presentation

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



# New Applications – Heavy Lift

## Background

- Location
  - Area - Far East

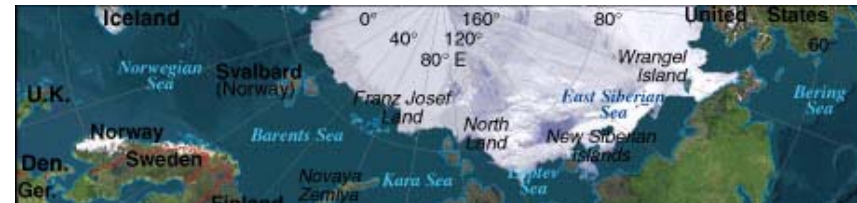


# New Applications – Heavy Lift

## Background

### ■ Location

- Area - Far East
- Country – China

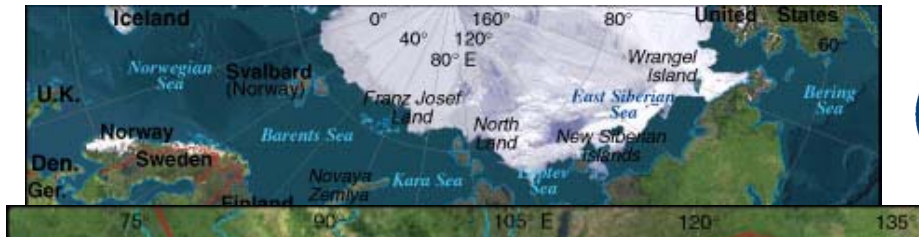


# New Applications – Heavy Lift

## Background

### Location

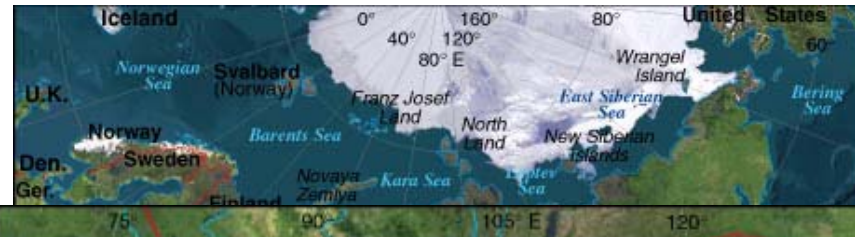
- Area - Far East
- Country – China
- City – Hong Kong



## Background

### Location

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



## Background



### ■ Stonecutter Bridge

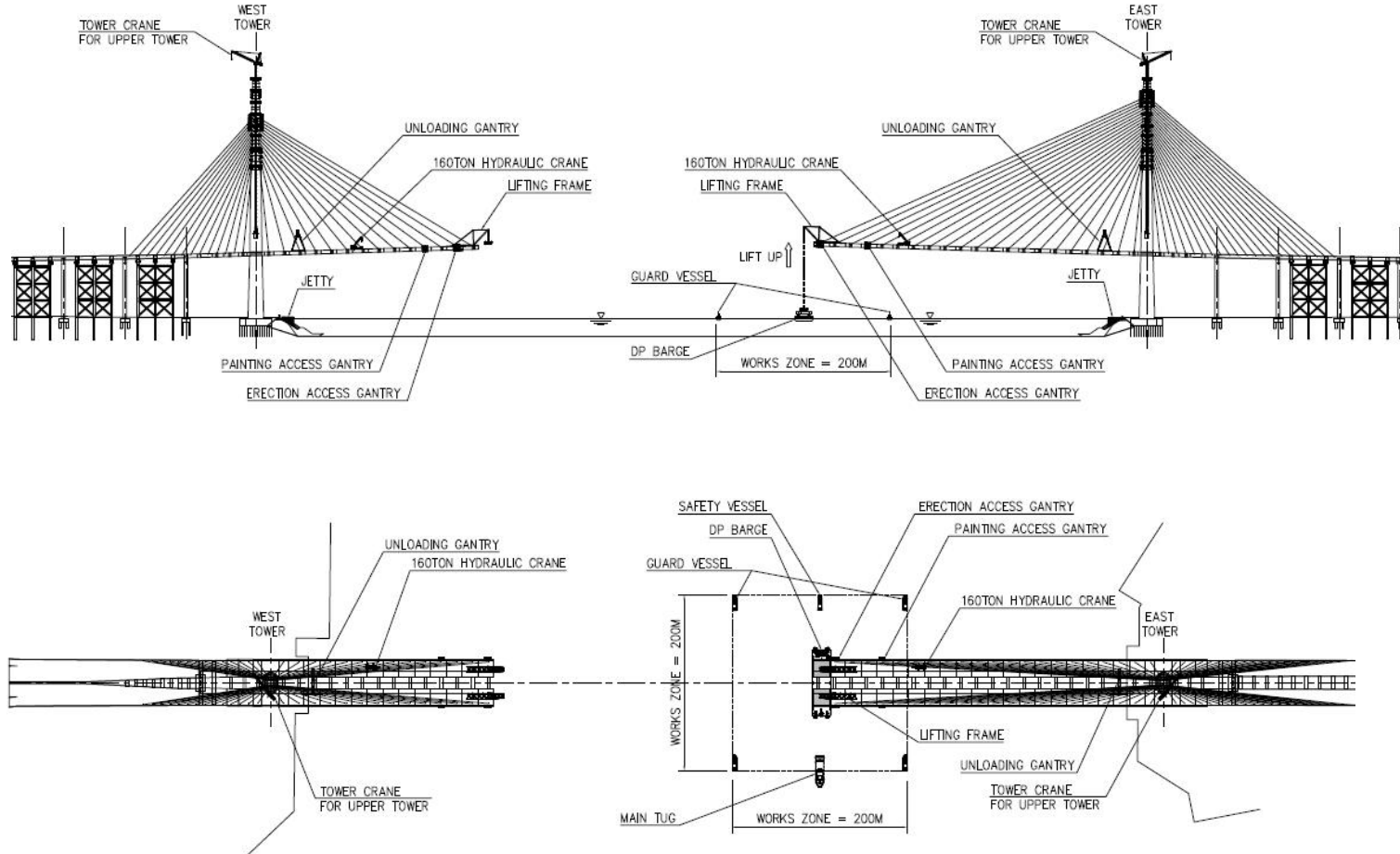
- Stonecutter Bridge will be one of the longest span cable-stayed bridges in the world.
- The partially constructed bridge's deck is about 75 m above water level
- The span will comprise 65 segments, each with a mass in excess of 500 tonnes



# New Applications – Heavy Lift



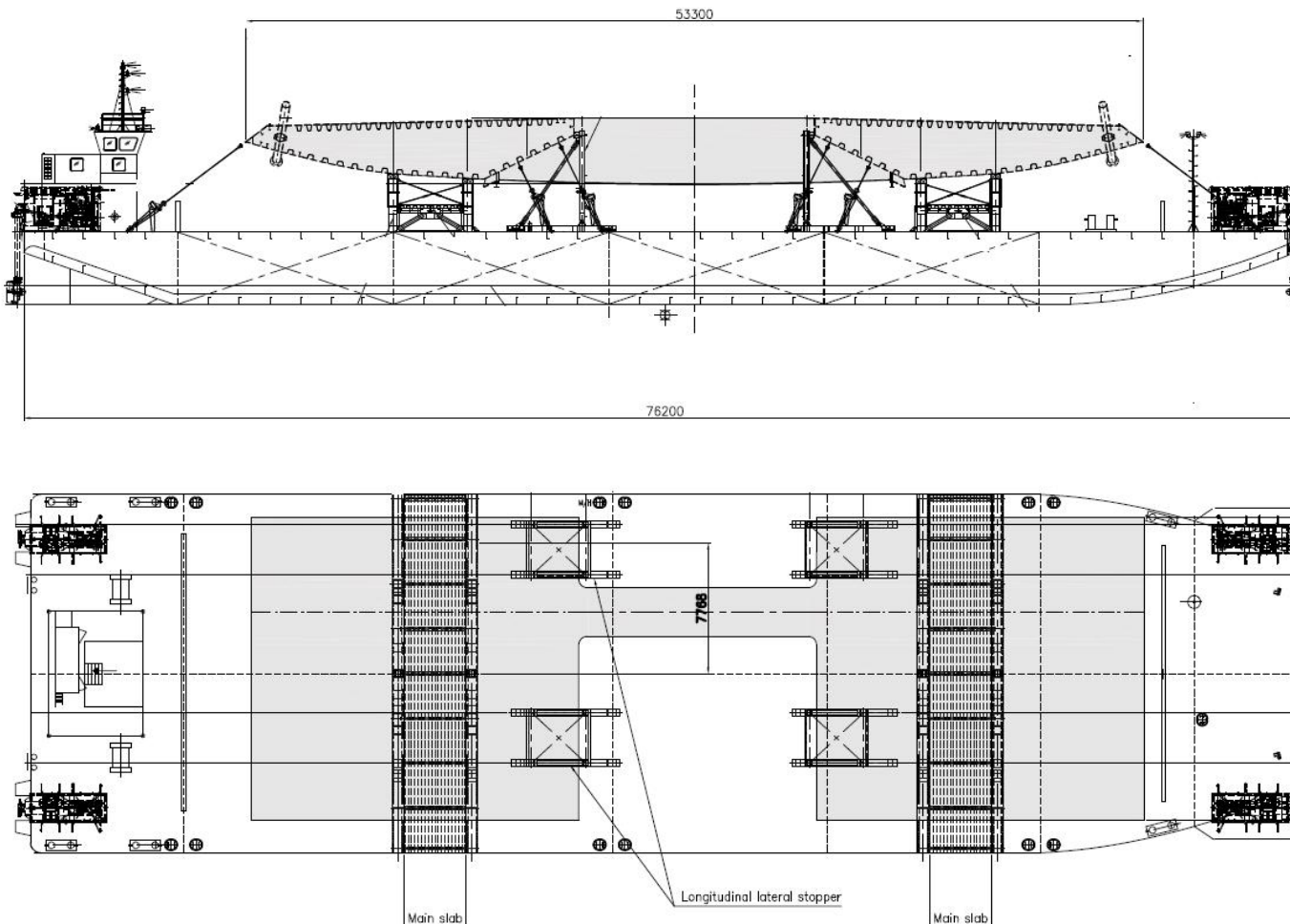
## Background



SIDE

PLAN

## 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

## Application

### ■ Heavy Lift

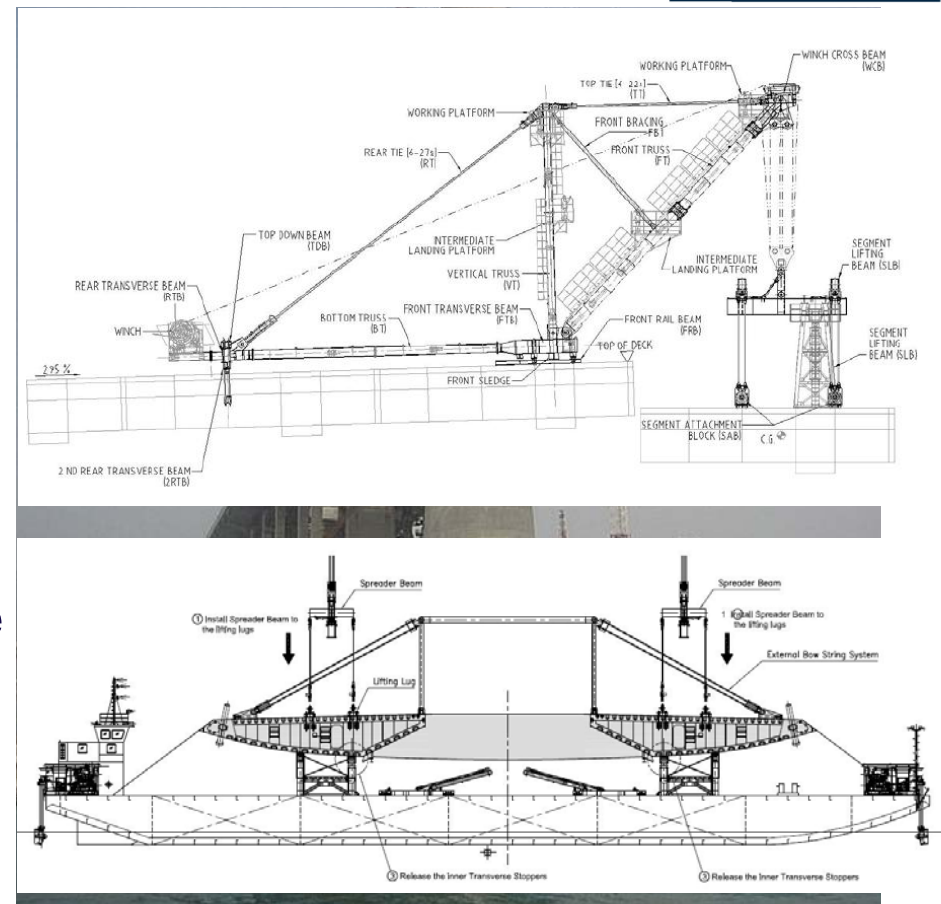
- Barge Chang Sheng 302 fitted with a Converteam A-series duplex dynamic positioning system.
- Using DP, the segment is positioned vertically below its final position in the span.
- Hoist cables attached, tension is gradually applied, and the segment is lifted from the barge
- At 25%, 50% and 75% tension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



## Application

### ■ Heavy Lift

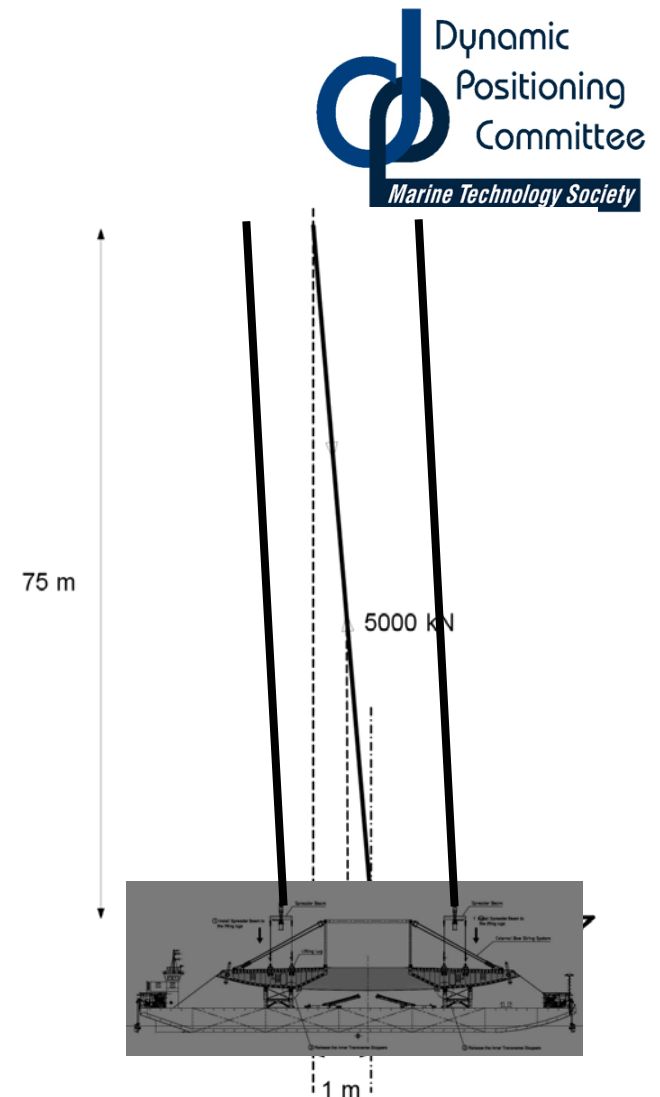
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## Application

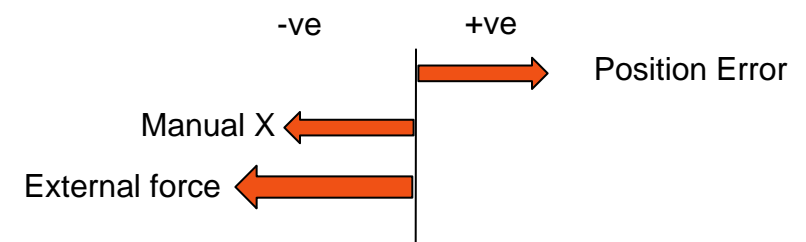
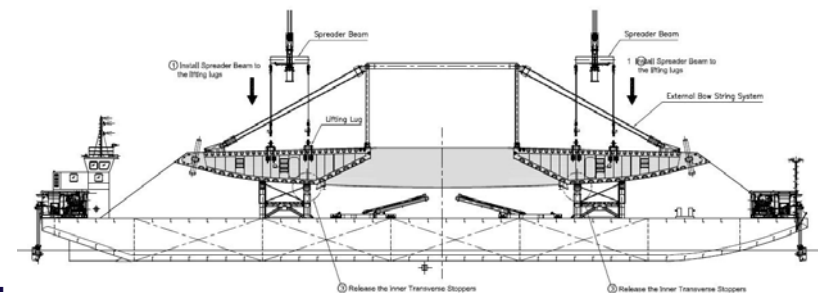
### ■ Forces

- 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



## 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.



## Issue



### ■ In automatic

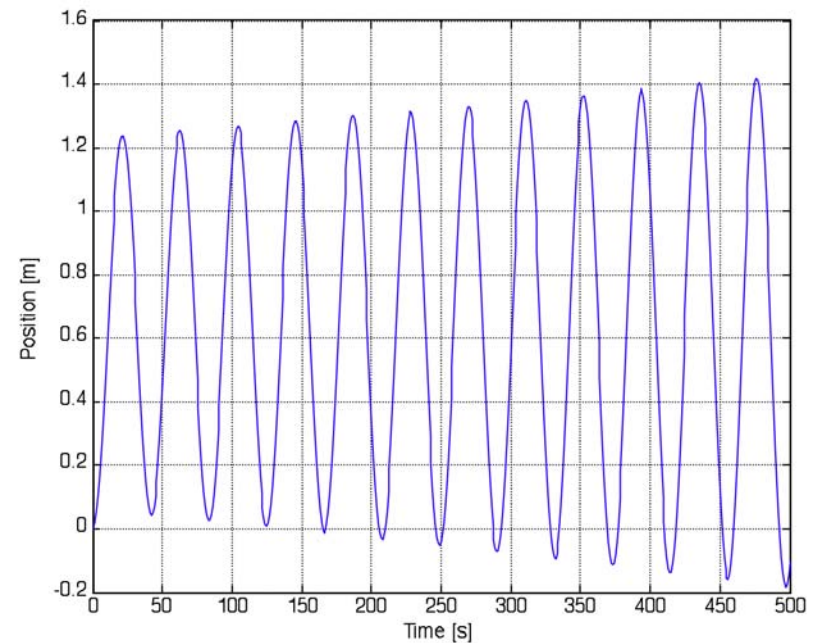
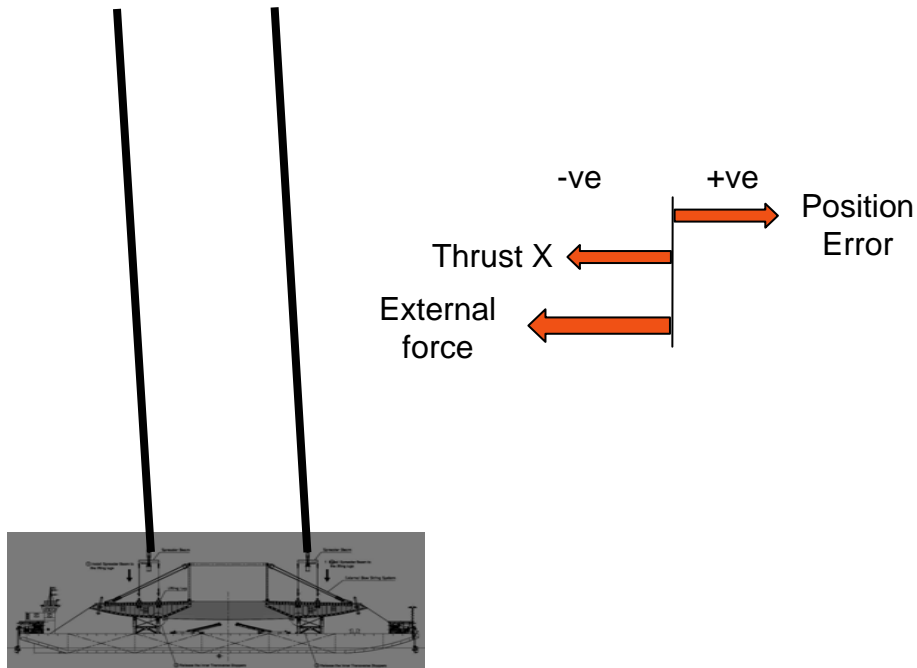
- Normal reaction from the DP control system:-
  - Forces from crane are completely unknown to the DP system. They degrade the position and velocity estimates used to calculate thrust references to control the vessel.
  - Controller will apply thrust towards the aim position.
  - These two factors lead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



## Issue

### ■ Simulation

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

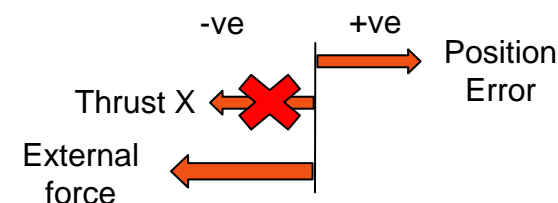


## Solution



### ■ Manual control

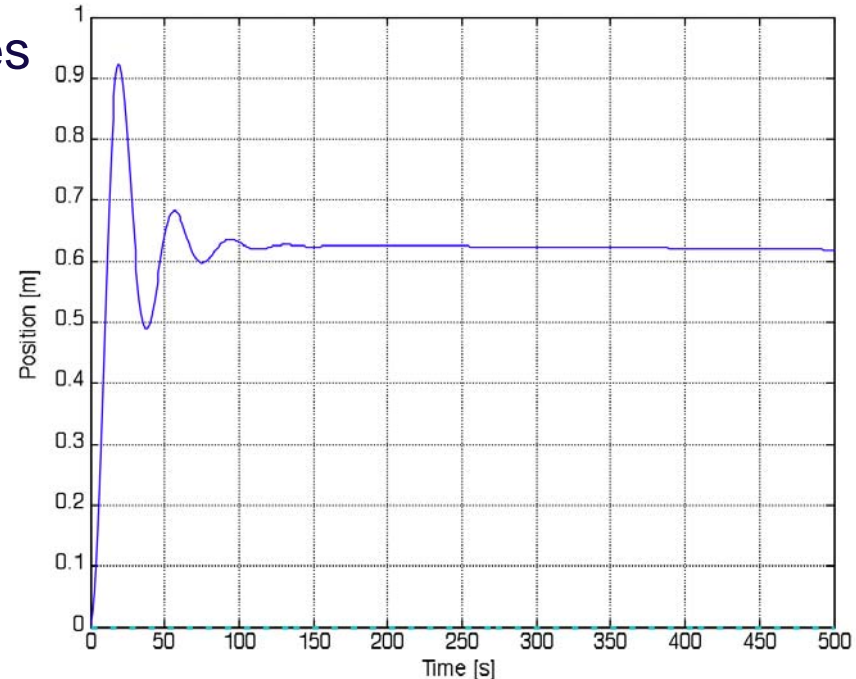
- Matrix modes - Allow the operator to select which axes are controlled manually.
- Operator should not be overwhelmed, the advice for operators inexperienced with heavy lift operations:-
  - Do not attempt to dampen oscillations unless it is necessary to do so. Hydrodynamic drag forces will gradually 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.



## 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.



## 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

## 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.

## 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.

## 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.

**Thank you for your attention**

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