Simulating Complex Passing Ship Hydrodynamics

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Presentation Outline

• Passing Ship Effects and Model Validations
• Broken Bore Formation and Propagation
• Harbor Sloshing/Bathtub Effects
• Ultra Large Container Vessels
• Conclusions
Passing Ship Effects
Passing Ship Effects
Validation - Laboratory Passing Vessel Forces

REMERY (1974)

Longitudinal Load (metric tons)

-300 0 150 300 450 600

0 100 200 300 400 500 600

Time (seconds)

Lateral Load (metric tons)

-40,000 -20,000 0 20,000 40,000

0 100 200 300 400 500 600

Time (seconds)

Moment (metric ton-meters)

-40,000 0 20,000 40,000

0 100 200 300 400 500 600

Time (seconds)
Validation - Laboratory Passing Vessel Forces
MARIN (2008)

Passing Ship Speed: 5.5 knots
Passing Ship Distance: 75 m, 150 m

Data from van Wijhe et al. 2008
Harbor Sloshing/Bathtub Effects

Water Surface Elevation [ft, MLLW]
Harbor Sloshing/Bathtub Effects
Harbor Sloshing/Bathtub Effects

Summer 2014 Field Campaign

Norweigan Gem

WSE [ft]


West Gage
Harbor Sloshing/Bathtub Effects

Summer 2014 Field Campaign

WSE [ft]

Norweigan Gem


West Gage

East Gage
Harbor Sloshing/Bathtub Effects

Summer 2015 Field Campaign

**East Gauge**

- Modeled
- Measured

**West Gauge**

- Modeled
- Measured

WSE [ft]


Harbor Sloshing/Bathtub Effects

Summer 2015 Field Campaign

Norwegian Gem

Disney Fantasy

Modeled vs. Measured WSE [ft]

Time


MOTT MACDONALD
Broken Bore Formation and Propagation
Broken Bore Formation and Propagation
Broken Bore Formation and Propagation
Ultra Large Container Vessels

<table>
<thead>
<tr>
<th>Particular</th>
<th>CMA CGM Ben Franklin</th>
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<tbody>
<tr>
<td>Length Overall</td>
<td>1309.0 ft</td>
</tr>
<tr>
<td>Length Between Perpendiculars</td>
<td>1251.4 ft</td>
</tr>
<tr>
<td>Breadth</td>
<td>177.2 ft</td>
</tr>
<tr>
<td>Moulded Depth</td>
<td>99.1 ft</td>
</tr>
<tr>
<td>Draft</td>
<td>52.5 ft</td>
</tr>
</tbody>
</table>
Ultra Large Container Vessels
Ultra Large Container Vessels
Ultra Large Container Vessels

Speed Over Ground (SOG) = 8.10 knots
Course Over Ground (COG) = 127.32 degrees
Heading = 123.99 degrees
Time Elapsed = 00:01:45
Ultra Large Container Vessels

Full Bridge Simulations

Ship Hydrodynamic Modeling

Dynamic Mooring Analysis

- Berthed vessel size or location
- Berthed vessel draft
- Berth depth
- Mooring arrangement modifications
- Berth infrastructure improvements

Loads and Motions within Limits?

NO

YES
Ultra Large Container Vessels

Water Surface Elevation [ft]

Surge Forces

Sway Forces
Ultra Large Container Vessels
Ultra Large Container Vessels

Chart showing the relationship between clear distance between hulls and passing speed in knots for different vessels.
Ultra Large Container Vessels

- Thorough analysis performed to determine feasibility of accommodating 18k TEU vessels
- Real-time full bridge simulations determined to be essential for pilot comfort and testing maneuvering-based risk mitigation measures
- Efficient system developed:
  - Simulator data taken directly into ship hydrodynamic model to produce loads and moments on berthed vessel(s)
  - Hydrodynamic model data taken directly into dynamic mooring analysis to determine potential mooring impacts
  - Mooring analysis results used to develop guidance for pilots, risk assessment for berth infrastructure, recommended improvements
Ultra Large Container Vessels

- Results indicate that ULCVs are so large that:
  - Maneuvering safety sensitive to environmental forces
  - Difficult to control speeds given large swept path with drift angle
  - Loads on berthed vessels are highly sensitive to speed and passing distance
- Maneuvering improvements crucial to reduce passing speeds
- In some instances, ULCVs *passing* a particular berth pose the largest new risk to existing berth infrastructure (vs. ULCVs mooring at a berth).
Conclusions

• ULCVs require particular attention be paid to passing ship effects.

• Berth infrastructure risk during accommodation of ULCVs should also consider smaller ships passed at berth.

• Validations successfully expanded to include complex (realistic) maneuvering and hydrodynamic processes such as bow solitary waves, broken bore effects, and sloshing/bathtub effects.

• Real maneuvering is often complex, accurate loads on berthed vessels require simulations and/or AIS information.

• Numerical modeling proven critical in the development and testing of measures to mitigate the harmful impacts of these hydrodynamic phenomena.
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