Berth 408 Marine Oil Terminal Passing Vessel Dynamic Mooring Analysis

Prevention First 2008

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Long Beach, CA

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Why Conduct Passing Vessel Analysis for MOT?

- Larger Vessels with deeper Drafts and Confined Channels are Inducing Greater Forces on Moored Vessels
- Passing Vessel Analysis Required by MOTEMS
- MOTEMS Suggests PASSMOOR Analytical Approach
- Analytical Approach Based on Lab Tests of Previous Generation Vessels

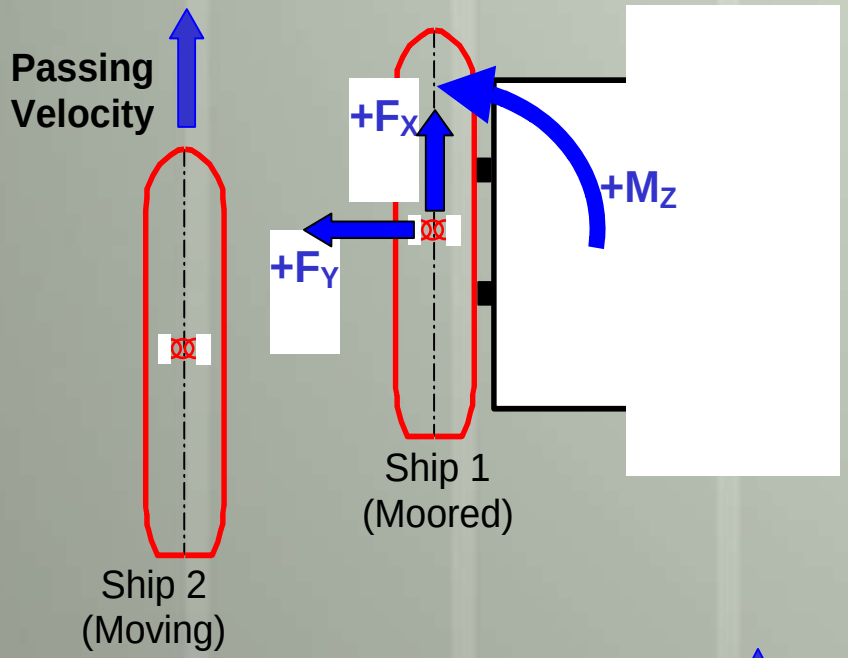
Limitations of MOTEMS Recommended Approach

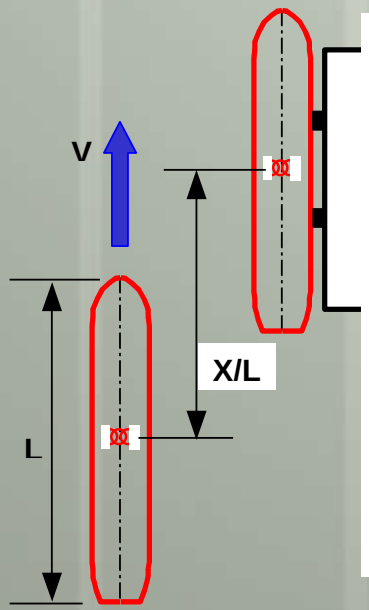
- Force factors based on limited number of tests of specific ship hulls, passing speeds/distances – cannot account for all variations in ship type
- Open water only – no harbor effects (seiches, quay walls, etc)
- Only parallel passing ships

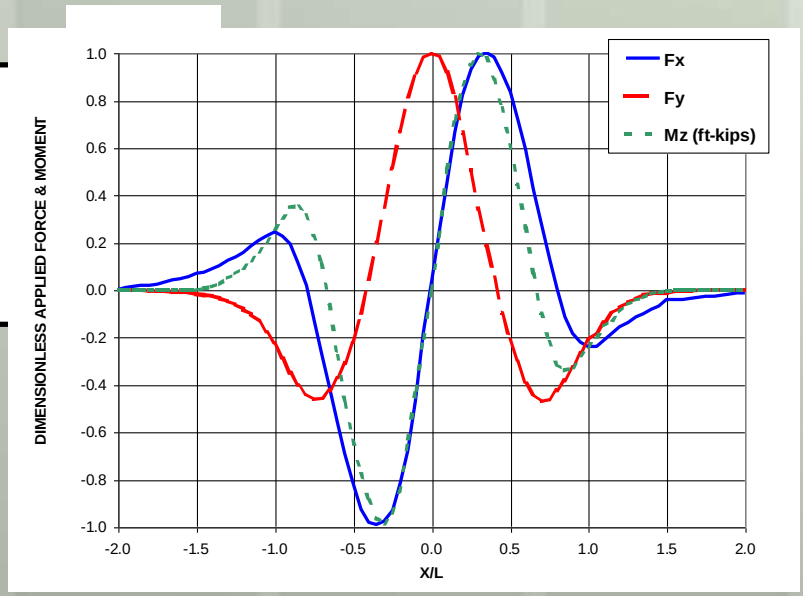
Dynamic Mooring Analysis

- Dynamic analysis is critical for assessing effects of passing vessels
- Mooring system acts as a spring, storing energy
- Due to the oscillating surge force during passing events, stored energy and passing forces act together to amplify mooring response
- These effects cannot be evaluated with static mooring models

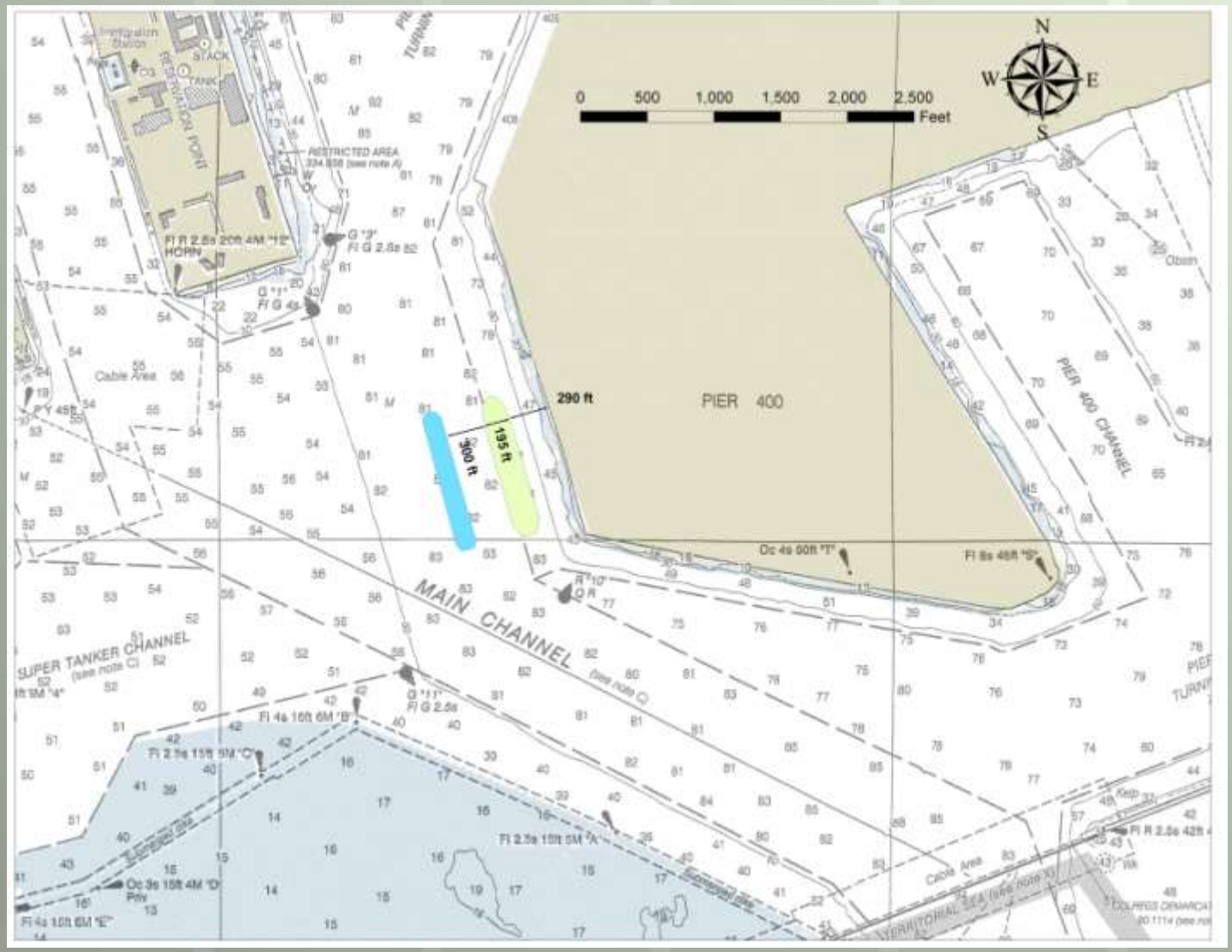
Passing Vessel Dynamic Mooring Analysis







Berth 408 Passing Vessel Dynamic Mooring Analysis



Moored Vessel Characteristics

Item	Unit	Vessel	
Vessel class	-	**VLCC**	**SUEZMAX**
Vessel name	-	"Generic" Design Vessel	*Asian Spirit*
DWT	Metric ton	325,000	152,000
Displacement	Metric ton	370,000	174,000
LOA	ft	1,135	883
LBP	ft	1,070	846
Beam	ft	197	150
Loaded draft	ft	74	57
Ballast draft	ft	33	27
Type of mooring lines	-	Wire	Wire
Diameter of mooring lines	in	1 5/8	1 1/2
Minimum breaking load	Metric ton	114	94
Tail length	ft	36	36
Diameter synthetic tail	mm	100	76
Breaking strength of tail	Metric ton	167	134
Pre-tension mooring lines	ton	17	9
Winch brake holding capacity	ton	68	75

Post-Panamax Emma Maersk Characteristics

Deadweight	157,000 mt
Design TEU	11,000
Length Overall	398 m
Length Between Perpendiculars	376 m
Beam	56.4 m
Hull Depth	30.2 m
Loaded (Design) Draft	15.5 m
Displacement	221,605 mt

DYNAMIC ANALYSIS METHODOLOGY

Calculated
Forces on Moored Vessel
Time History

Moored Vessel
Hydrodynamic
Coefficients and
Mooring Configuration

Dynamic
Mooring Model Time
Domain Simulation

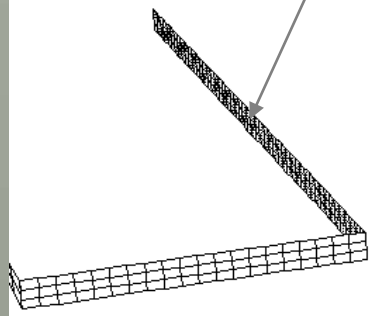
Dynamic
Mooring Loads and
Motions

DELPASS Model

- Developed by Prof. J.A. Pinkster of Delft University in conjunction with Maritime Research Institute of the Netherlands (MARIN)
- Panel Model based 3D Potential Theory
- Panel models represent precise representation of ship hulls, channels, and walls
- Allow computation of pressures and velocities at any point on the hulls or channels

DELPASS Features

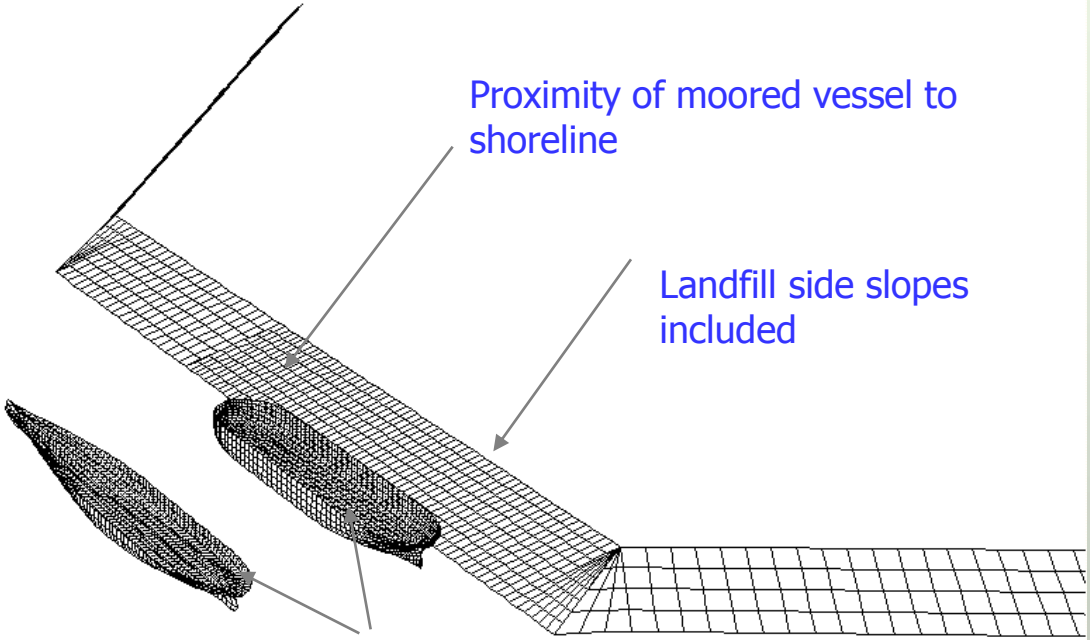
Basin geometry accounted for



Bathymetry explicitly modeled

Proximity of moored vessel to shoreline

Landfill side slopes included

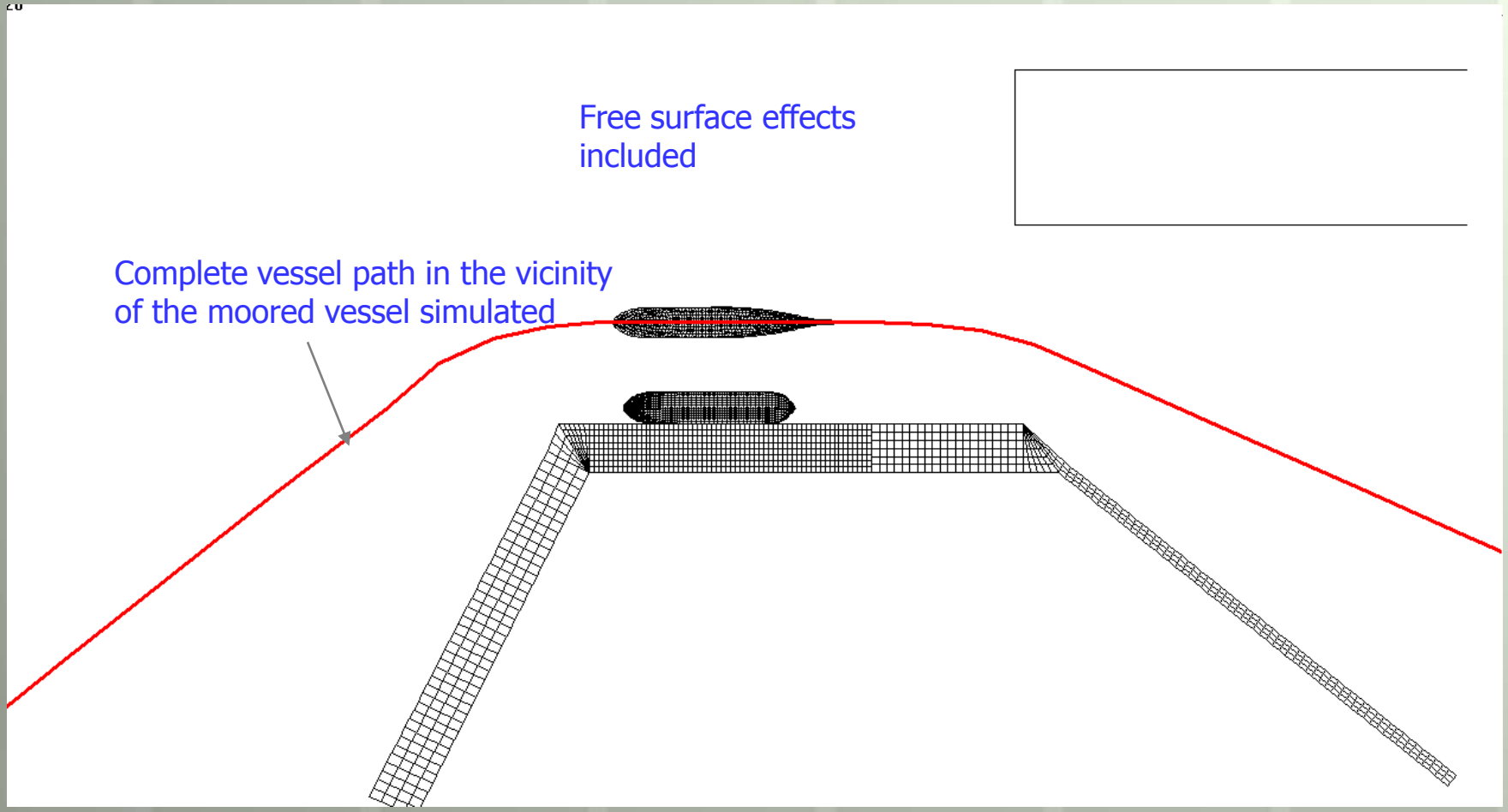


Actual vessel shapes incorporated

DELPASS Features

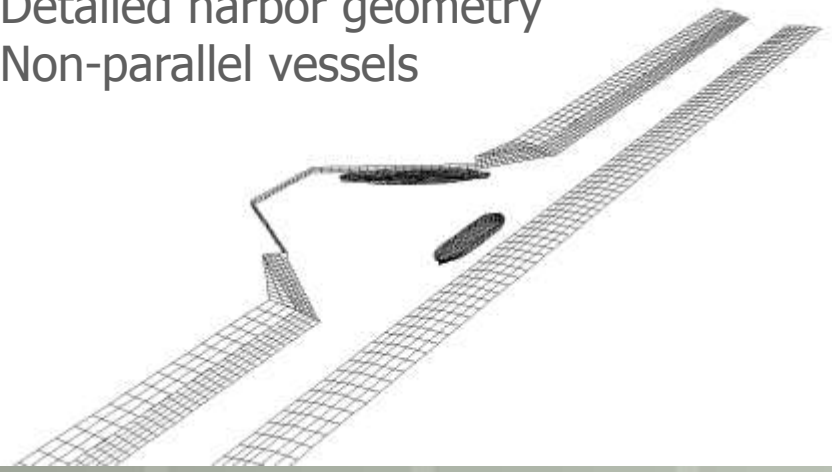
Free surface effects
included

Complete vessel path in the vicinity
of the moored vessel simulated



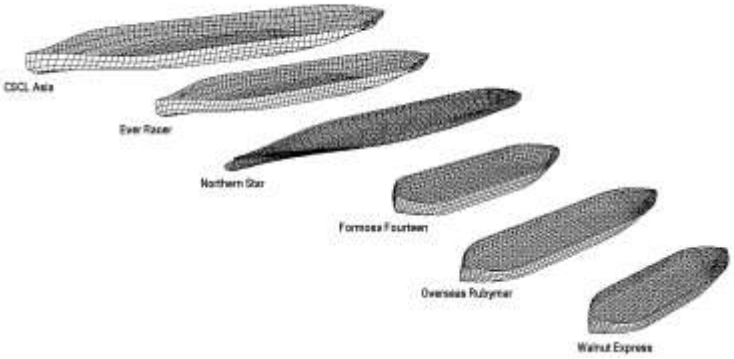
DELPASS features

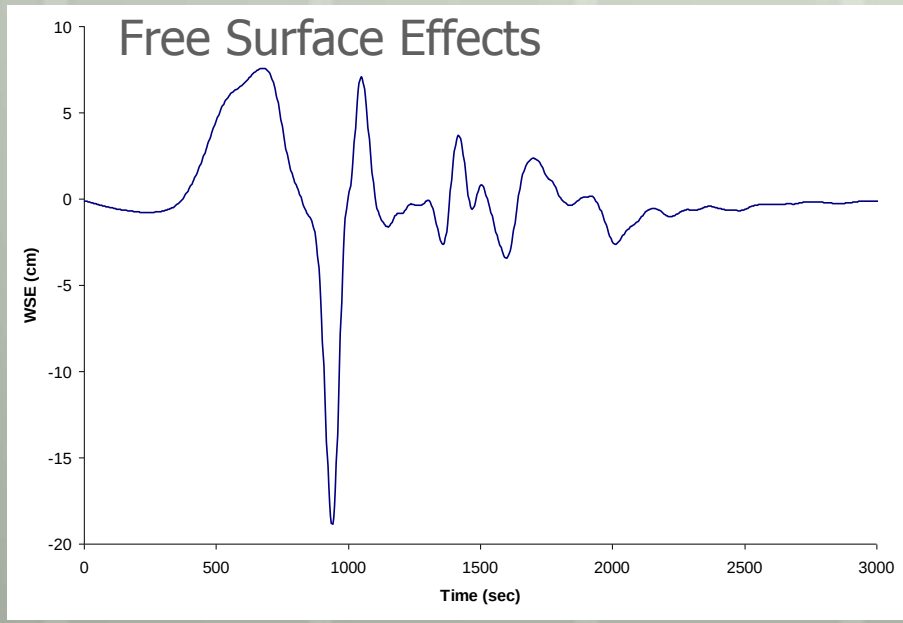
Detailed harbor geometry
Non-parallel vessels



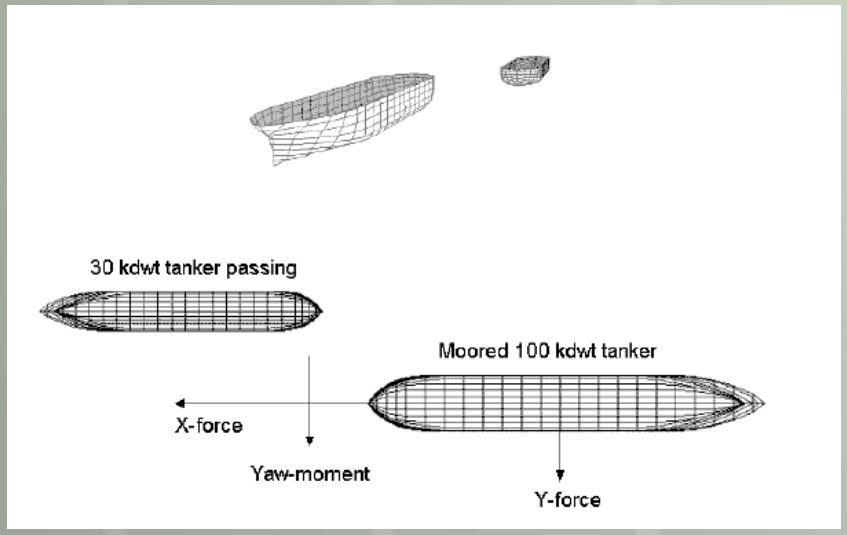
Computes Confined Channel Effects

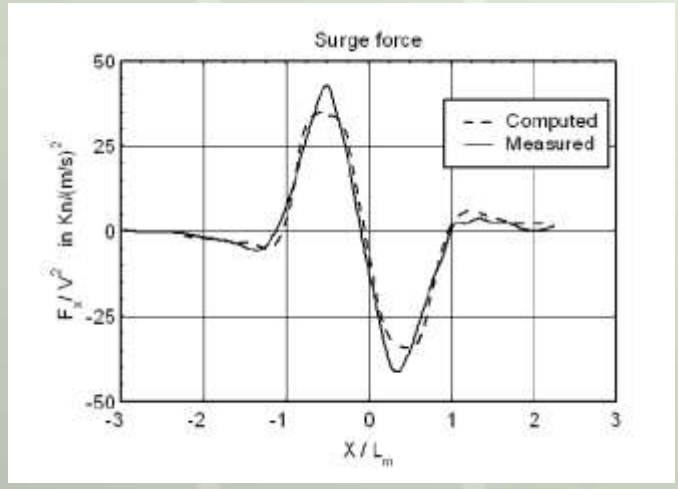
Explicit panel models of hull forms



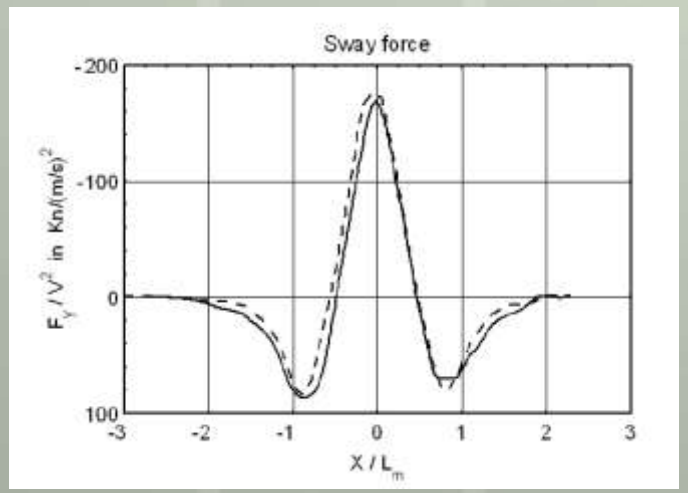


DELPASS Validation Laboratory Data Remery, 1974

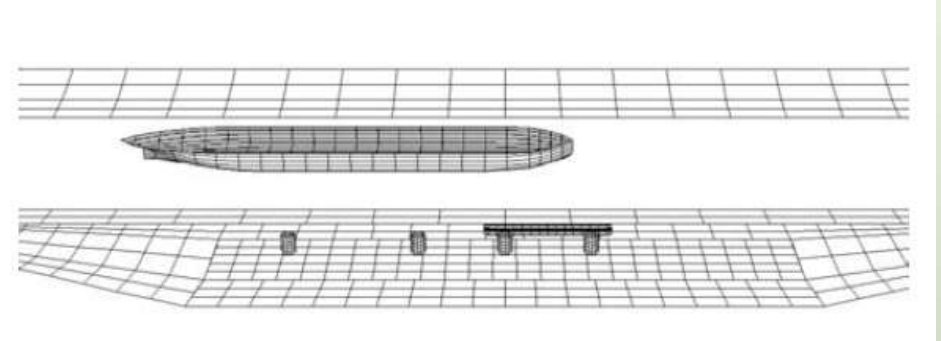




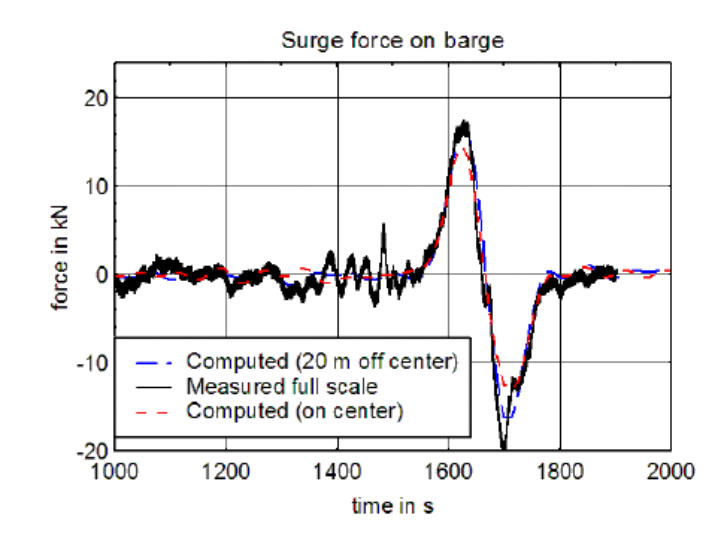
Same data set original PASSMOOR used

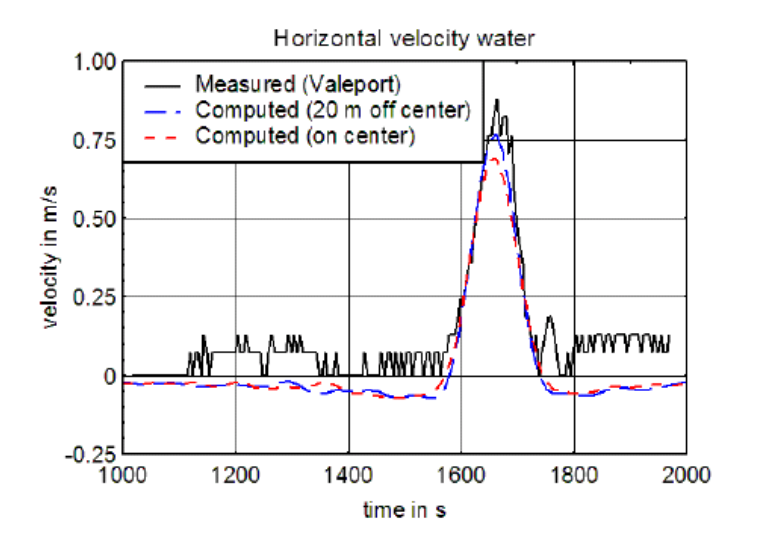


DELPASS Validation (Pinkster, 2004) Full-Measurements, Amsterdam 2003

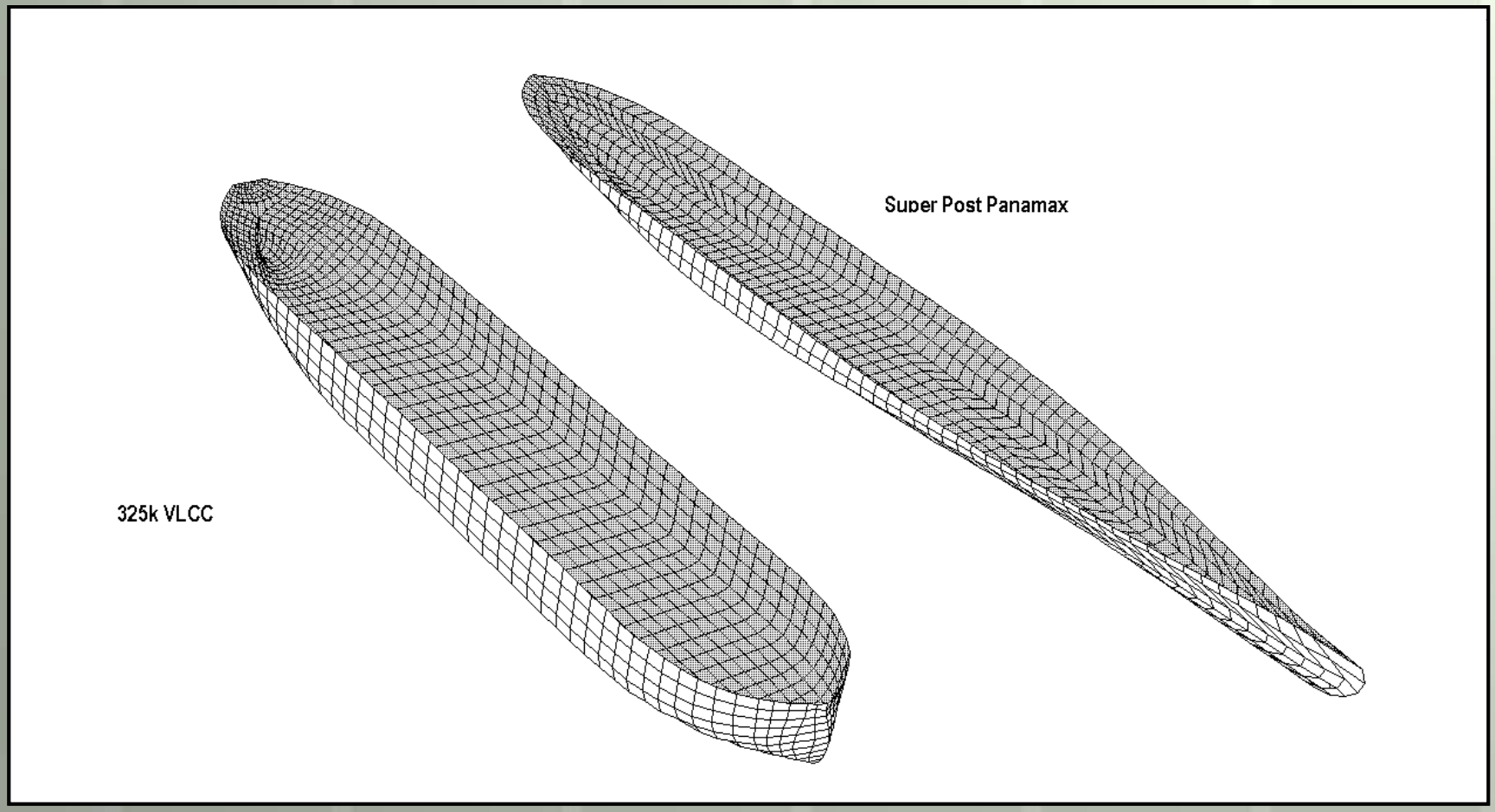


Bulk Carrier passing barge berth

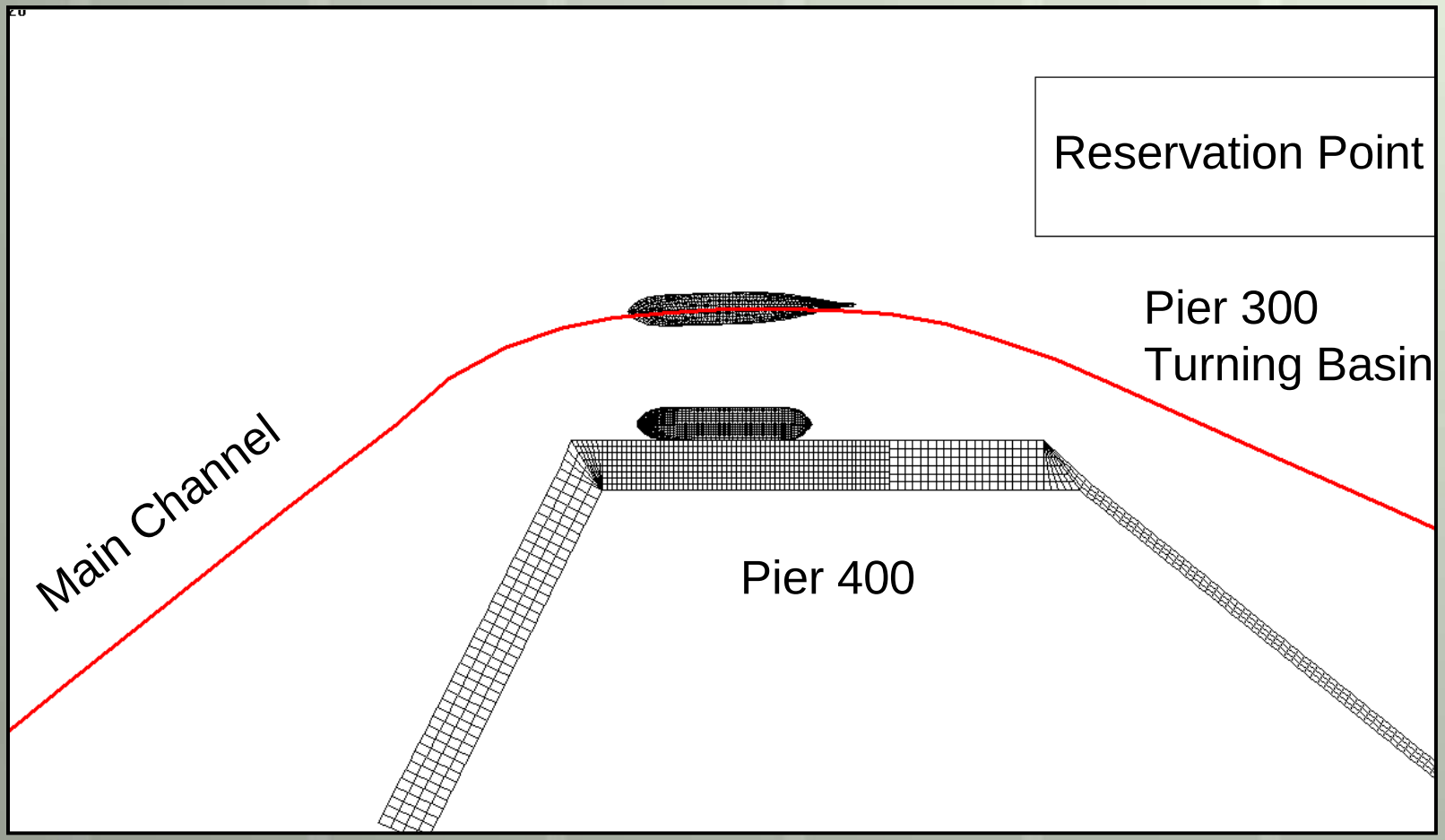




Panel Models for Moored VLCC and Passing Vessel

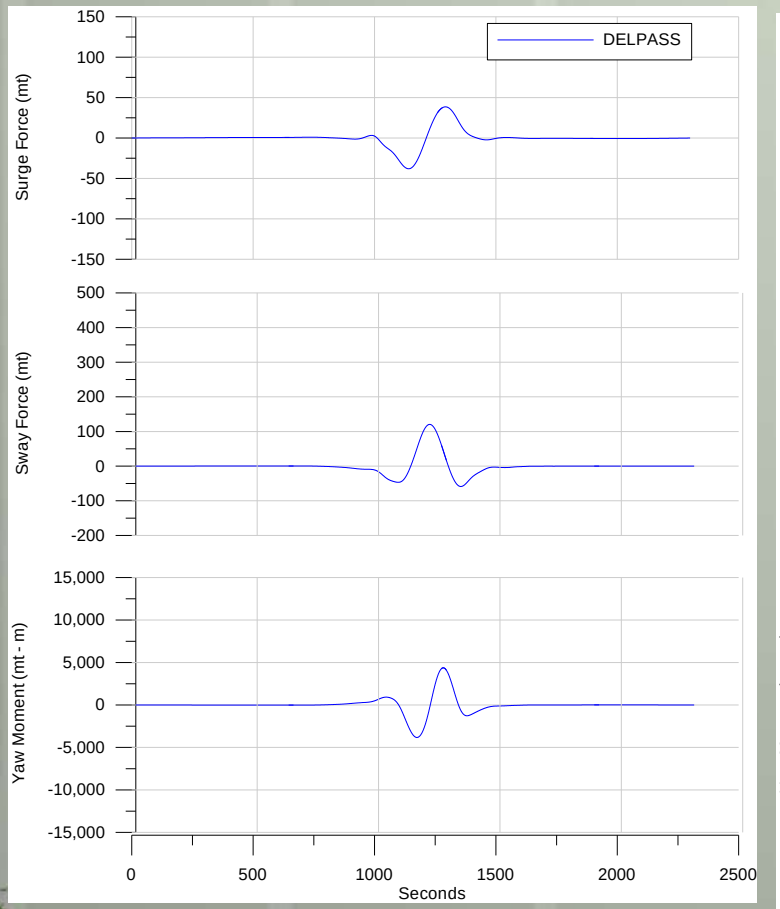


Moored Vessel and Passing Vessel Course

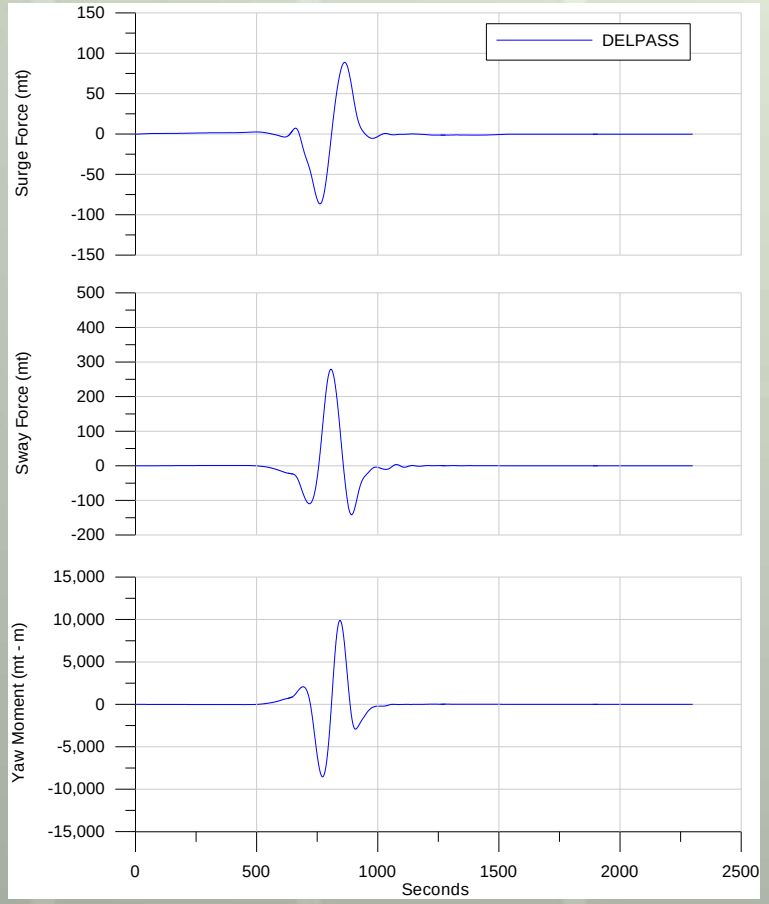


Forces on VLCC with 100 m Gap

4 Knots



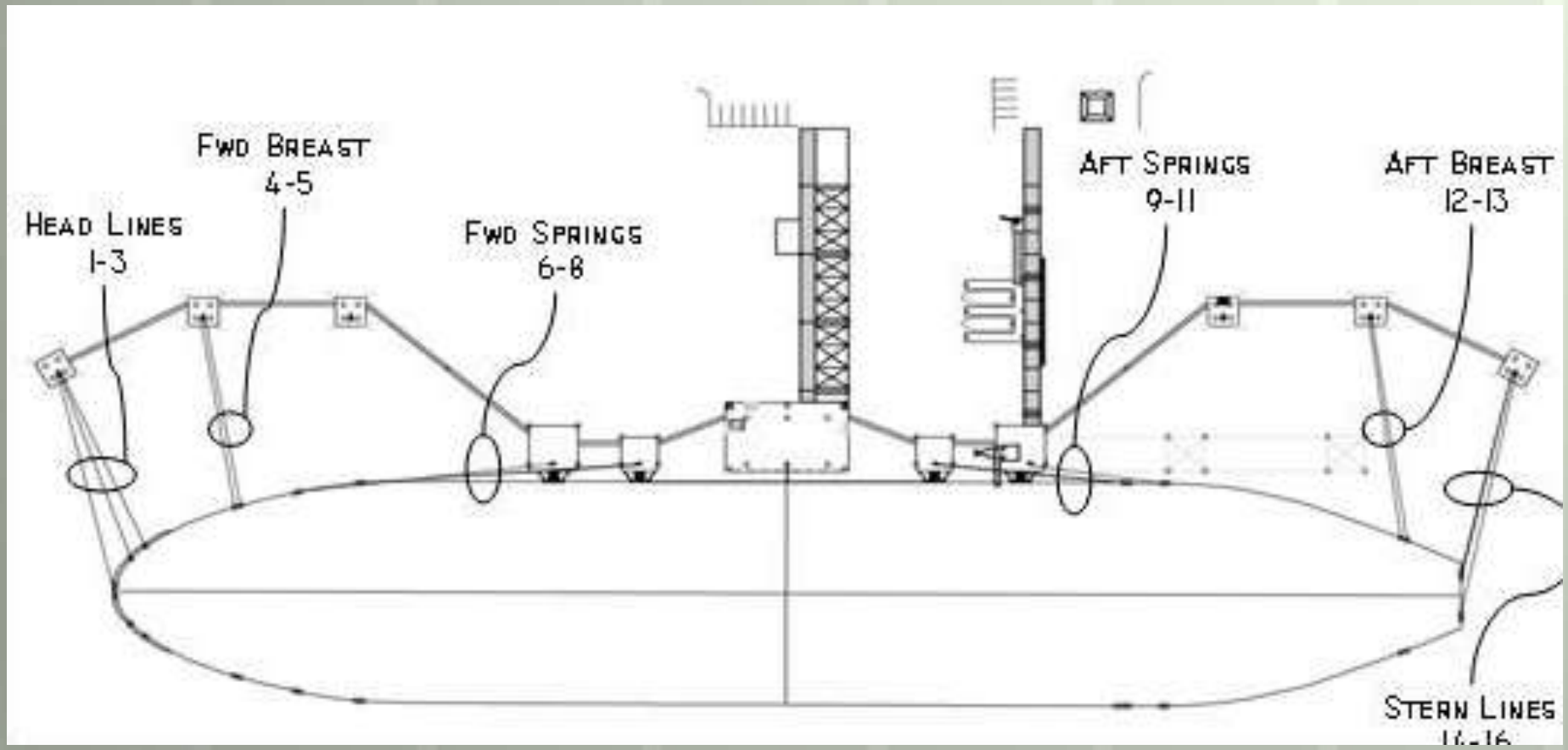
6 Knots



Dynamic Mooring Model

- Time Domain- 6 Degrees of Freedom
- Hydrodynamic Coefficients
  - Added mass/Damping Coefficients
  - Impulse-Response Functions, Constant Inertial Coefficient
  - Viscous damping terms
- Models Wind, Wave, and Current
- Nonlinear Mooring Restraints
  - Mooring lines, fenders, chains, etc.

Mooring Line Arrangement



Line Loads and Manifold Motions without Wind and Waves

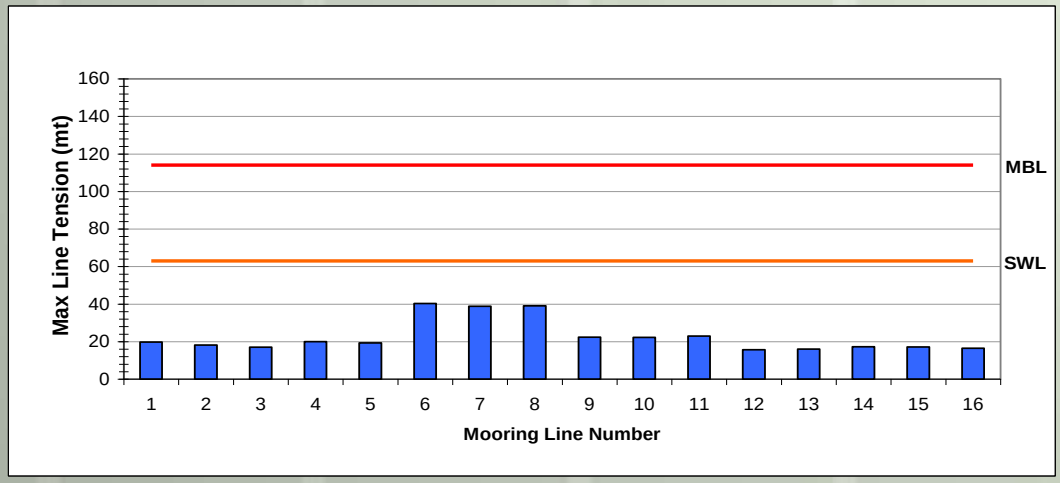
Case	Passing Speed (kts)	Gap (m)	Maximum Line Load (mt)	Percent SWL Criteria?	Surge		Sway		Meets Motion Criteria?
					Max (m)	Min (m)	Max (m)	Min (m)	
1	4	100	22.7	36%	0.36	-0.27	0.03	-0.04	Yes
2	5	150	22.5	36%	0.36	-0.28	0.02	-0.04	Yes
3	6	200	21.7	35%	0.34	-0.22	0.00	-0.03	Yes
4	6	150	40.3	64%	0.85	-0.48	0.15	-0.06	Yes
5	6	100	87.6	140%	1.50	-0.82	0.78	-0.19	Yes
Suezmax	6	150	15.0	29%	0.17	-0.19	-0.01	-0.03	Yes

Line Loads and Manifold Motions with Wind and Waves

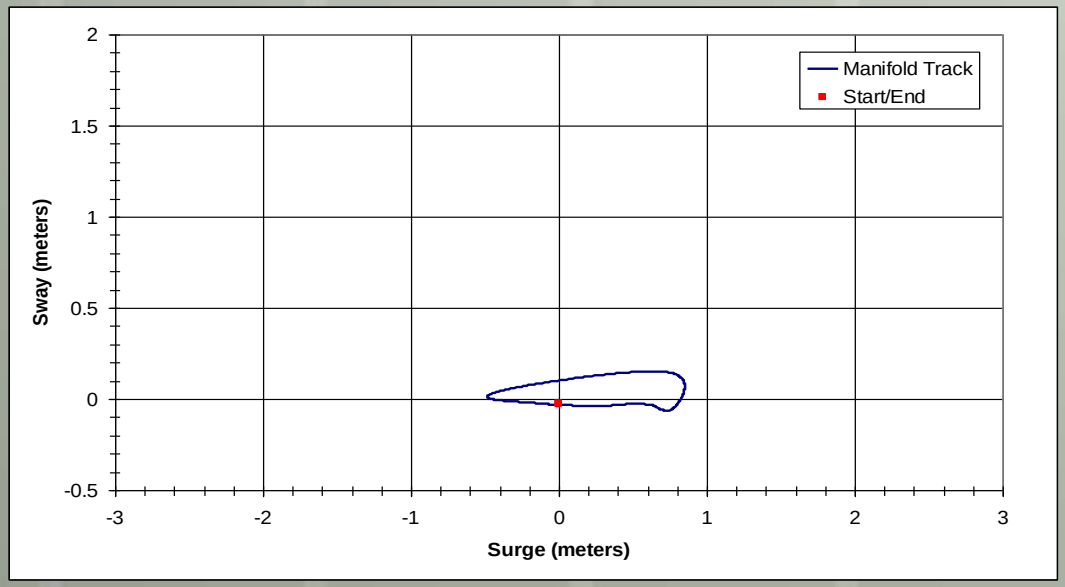
Case	Passing Speed (kts)	Gap (m)	Maximum Line Load (mt)	Percent SWL Criteria?	Surge		Sway		Meets Motion Criteria?
					Max (m)	Min (m)	Max (m)	Min (m)	
1	4	100	26.9	43%	0.48	-0.33	0.23	-0.07	Yes
2	5	150	25.1	40%	0.45	-0.32	0.16	-0.07	Yes
3	6	200	24.5	39%	0.45	-0.32	0.11	-0.06	Yes
5	6	150	47.1	75%	0.97	-0.53	0.39	-0.11	Yes
5	6	100	94.7	151%	1.57	-0.87	0.98	-0.20	Yes
Suezmax	6	150	31.5	61%	0.38	-0.34	0.39	-0.10	Yes

Results for Case 6 kt and 150 m Separation without Wind or Waves

Maximum Mooring Line Loads, No Wind, No Waves

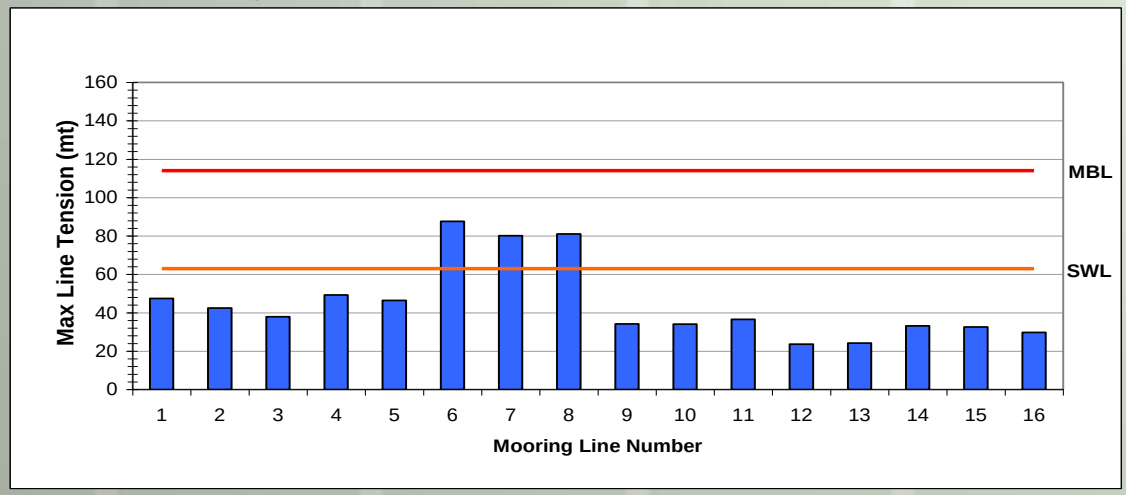


Manifold Motion

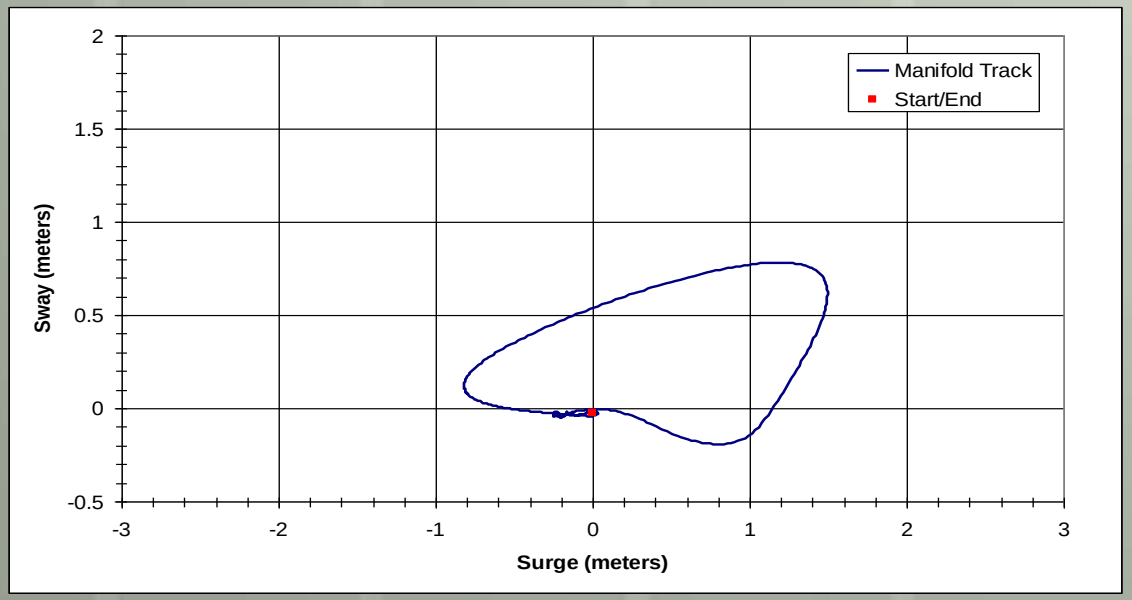


Results for Case 6 kt and 100 m Separation without Wind or Waves

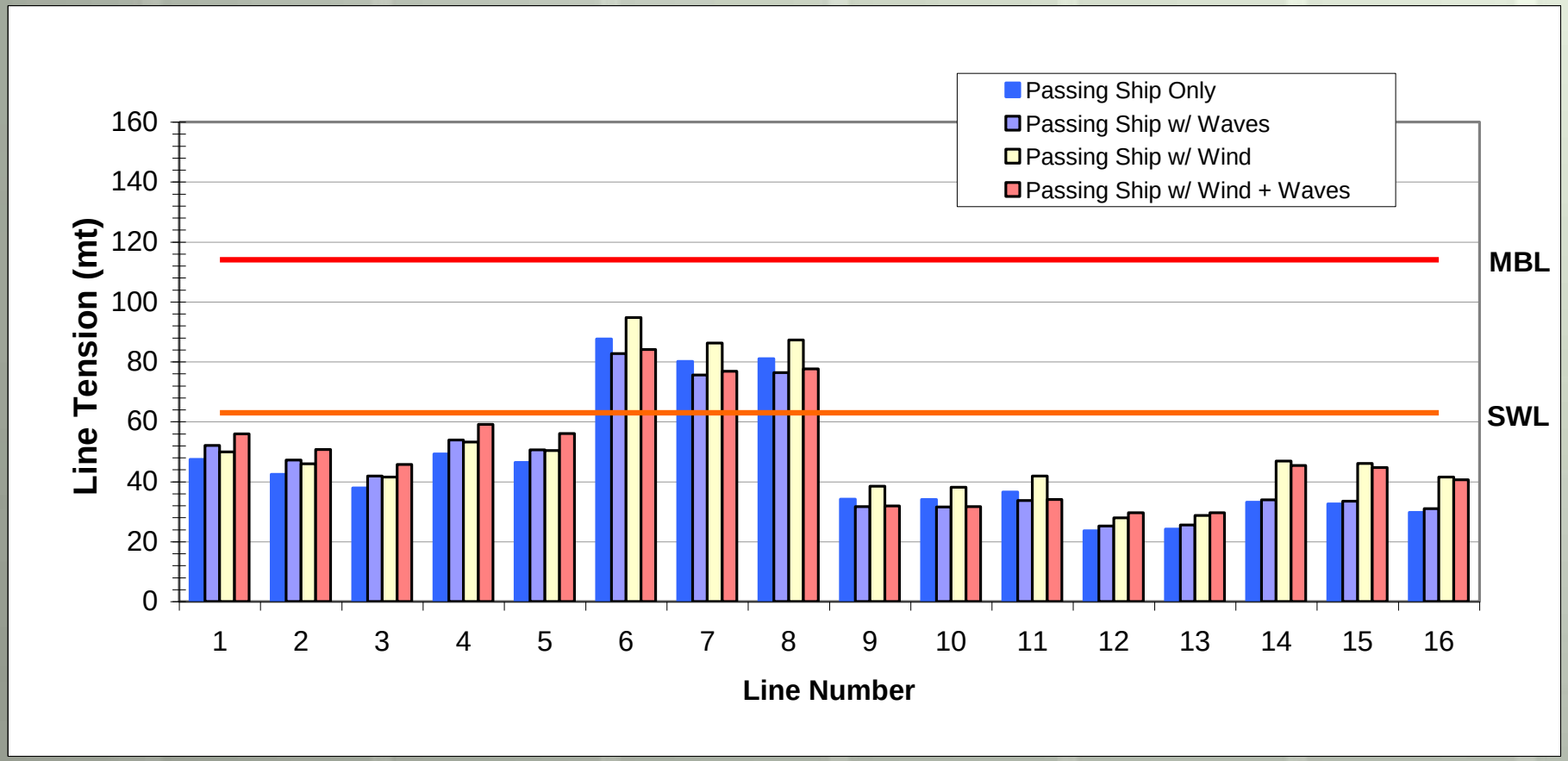
Maximum Mooring Line Loads, No Wind, No Waves



Manifold Motion



Effects of Wind and Waves



Summary and Conclusions

- Dynamic analysis of moorings is an essential tool for port designers
- Threatening loads – in excess of computed stationary loads – may be experienced for high passing speeds and narrow separations.
- Simplified MOTEMS approach may not produce accurate forces.
- Vessel speeds may need to be reduced or separation distances increased where potential problems exist

Berth 408 Marine Oil Terminal
Passing Vessel Analysis

Thank You!

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