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# Surge Movement Criteria Related to Container (Un)Loading Efficiency

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# Presentation Outline

- Overview of WG 212 in general
- Results related to acceptable movements for container ships at berth
- Background on Container Handling
- Overview of Historical Criteria
- Data Sources
- Numerical Simulations and results
- Criteria and conclusions

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# WG 212 Overview

- Established in 2019
- Report published June 2023
- Chairman: Majid Yavary
- Co-chairman: Martijn de Jong
- Previous PIANC criteria:
  - WG 24 (1995) covering all ships
  - WG 115 (2012) for container ships
- Mandate: "*Review and update criteria from WG 24 (and WG 115) through collection of new publicly available information*"
- Vessel/terminal types:
  - Liquid bulk
  - Dry bulk
  - General cargo
  - Container
  - Ro-Ro
  - Cruise
  - Marine support
  - Fishing

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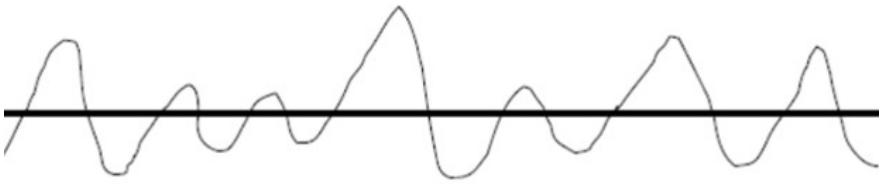
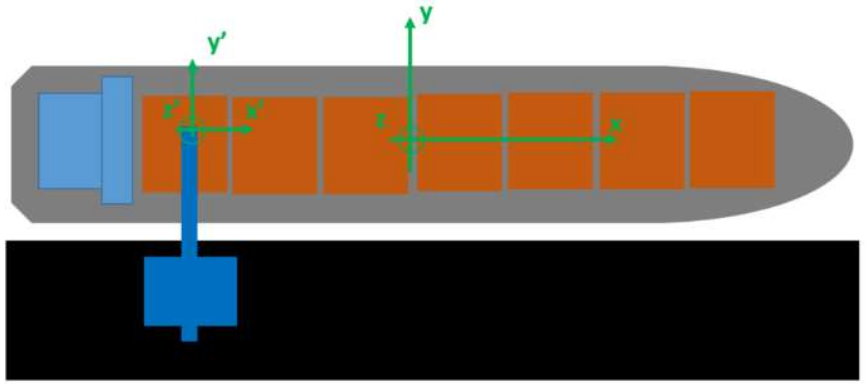
# Definition of Criteria

- Amplitude for all degrees of freedom
- Maximum motions for all vessels, except significant for efficiency criteria for container ships
- Surge, sway and heave criteria defined at the location on the vessel where the (un)loading takes place
- Roll criteria maintained
- Pitch and yaw criteria not needed





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# Container Handling

- Ship-to-Shore Gantry Cranes with typical Loading rates of 25-40 moves per hour
- Terminal competition led to a focus on efficiency
- Efficiency negatively impacted by excessive motions
- (Un)loading longitudinally per bay – above and below deck
- Crane operators adjust and follow motions in sway but not surge
- Containers are placed below deck in cell guides (tolerances +/- 19mm and 12.5mm) through entry guides (tolerances +/- 120mm and 110mm)
- Above deck with the help of spreader flaps and connecting twist locks

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# Historical Criteria

- The first report on Criteria was from WG 24 (1995) and expressed as 100% and 50% loading efficiency criteria
- WG 115 (2012) reviewed the criteria and expressed them in terms of Significant Motion Amplitudes
- WG 212 (2024) further reviewed the criteria by analysing data from various sources.

| Source | Surge (m) | Sway (m) | Heave (m) | Roll (°) | Pitch (°) | Yaw (°) |
|---|---|---|---|---|---|---|
| Jensen et al. (1990) | ± 0.50 | + 0.40 | ± 0.45 | ± 1.50 | ± 0.75 | ± 0.25 |
| Smitz (1992) [1] | ± 0.50 | + 0.30 | ± 0.30 | ± 1.00 | NA | NA |
| PIANC WG 24 (1995) | ± 0.50 | + 0.60 | ± 0.40 | ± 1.50 | 0.50 | ± 0.50 |
| D'Hondt (1999) | ± 0.24 | + 0.22 | ± 0.20 | ± 0.24 | ± 0.40 | ± 0.10 |
| Moes (2000)[1] | ± 0.30 | + 0.30 | ± 0.30 | ± 0.50 | ± 0.50 | ± 0.50 |

*Note: 1. Unpublished communications.*

| Surge (m) | Sway (m) | Heave (m) | Roll (°) | Pitch (°) | Yaw (°) |
|---|---|---|---|---|---|
| 0.2 to 0.4[1] | ± 0.4 | + 0.3 | ± 1.0 | ± 0.3 | ± 0.3 |

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# Data Sources

- Additional feedback from terminal operators.
- Actual field recorded surge and sway measurements with associated container handling rates
- Experimental container handling rates from idealised surge oscillations
- Computer simulations of container loading under prescribed oscillatory movements

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# Terminal Operator Feedback

- Limited to modern and efficient Northern European terminal operators
- Loading efficiency decreases with a significant surge amplitude of 0.2 m for loading and unloading below deck
- Loading efficiency decreases with a significant surge amplitude of 0.4 m for loading above the deck with the use of spreader flaps
- Operators deem 0.3 m an appropriate limit for the onset of operational efficiency reduction as an average of below and above deck handling

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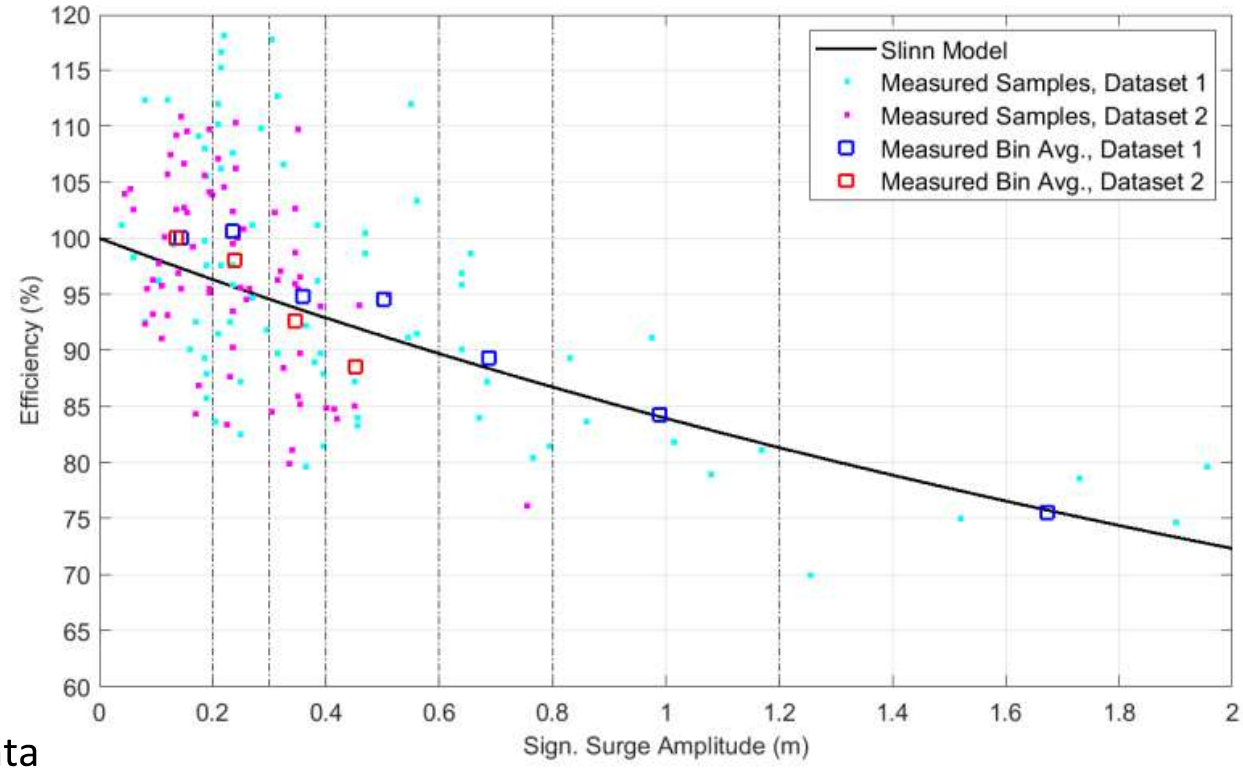
# Field Data

- 150 vessel calls from two measurement campaigns (2000; 2008)

- Scatter due to
  - Container position
  - Bay adjustment
  - Operator skill level
  - Quayside influences




- Main observations from data
  - Efficiency remains constant for small movements
  - Subsequent downtrend in efficiency with increased surge movement
  - Efficiency stabilises for large surge movements

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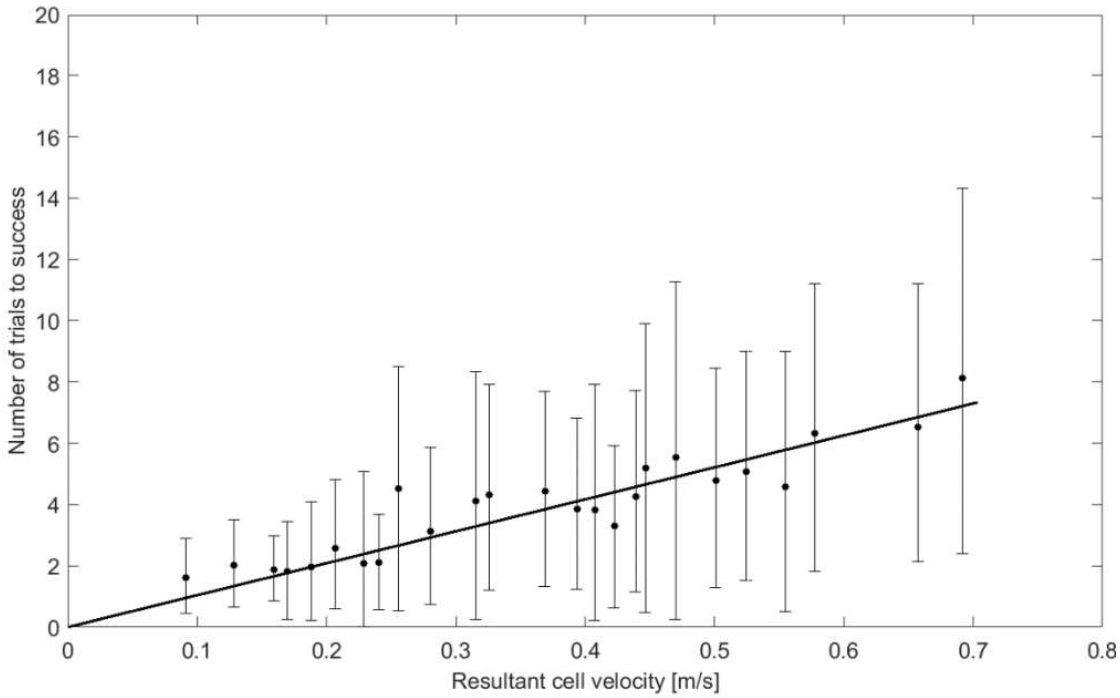
# Experimental Data

- Slinn (1979) Experimental setup container crane and oscillating target
- Number of attempts (N) is proportional to target velocity (V)
- Measured ratio:
  - $m = N/V = 10$ s/m
- Delay time:
  - $t_d = mV_{rms}T_s/2$
- Moves per hour:
  - $M = \frac{3600}{t_c + t_d}$
  - $t_c$ is undisrupted cycle time



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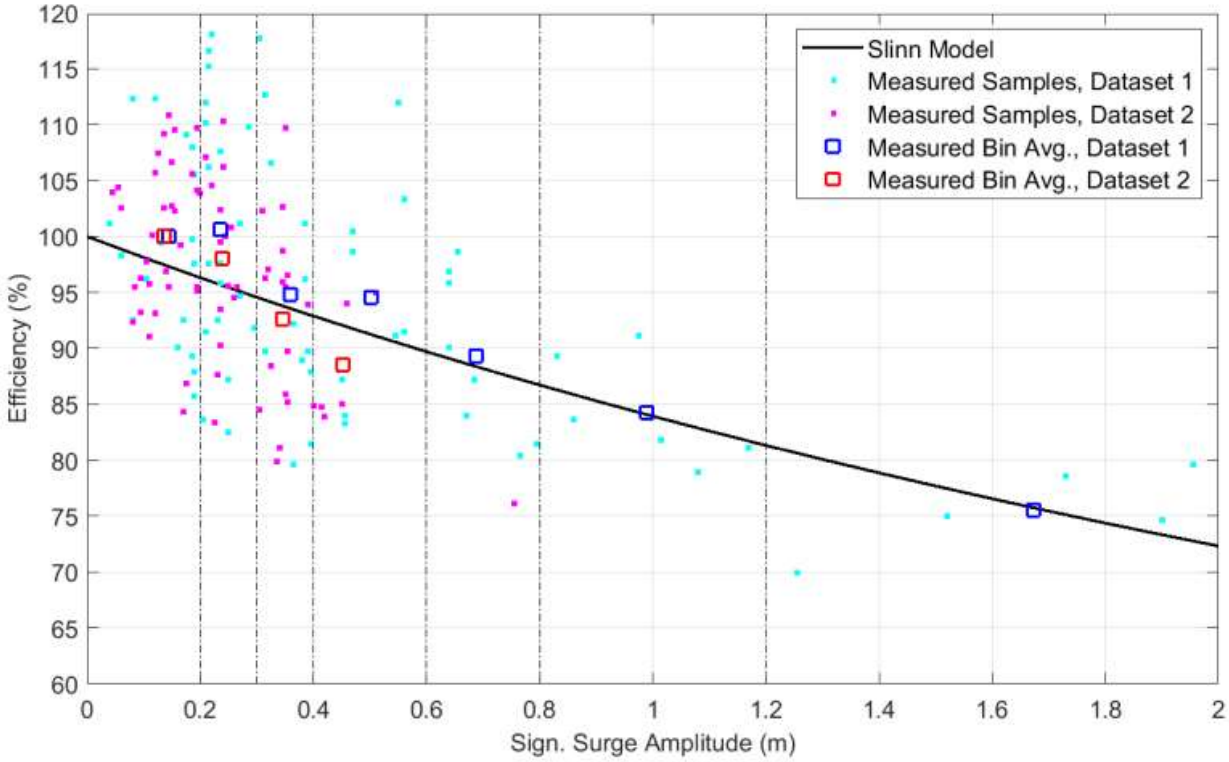
# Experimental Model

- Independent of period $T_s$
- Immediate loss of Efficiency
- Less pronounced decrease of efficiency for large motions
- (un)loading can still continue for large movements



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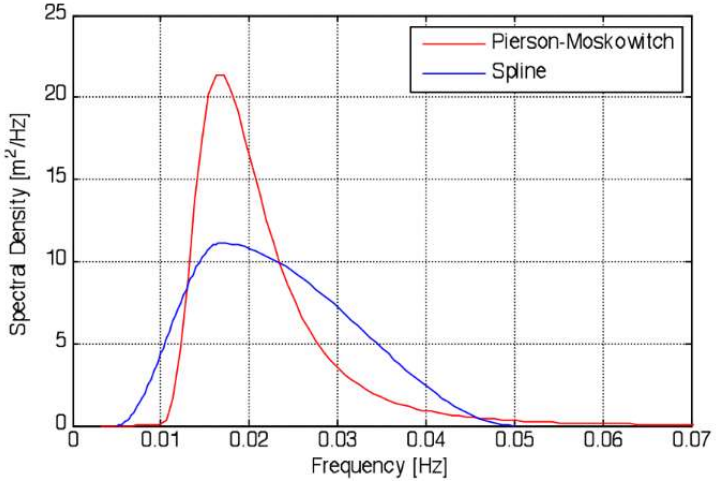
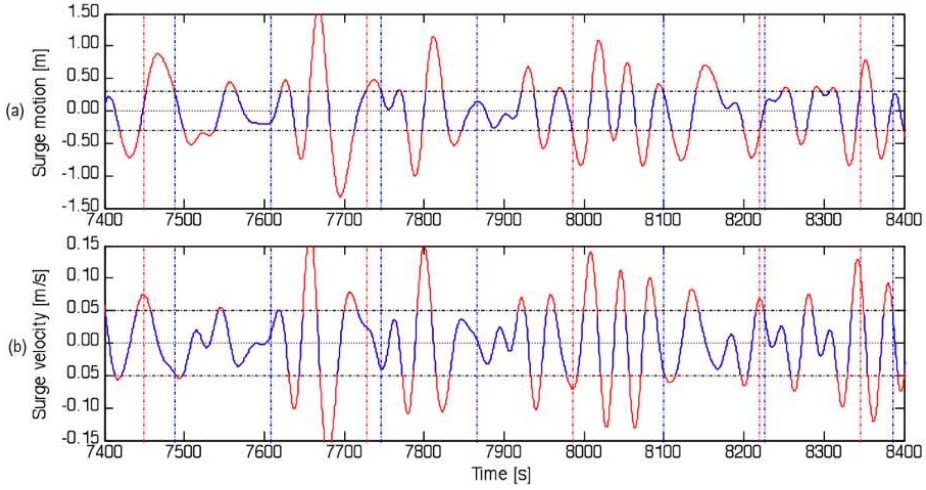
# Computer Simulation

- Simulates container loading onto a moving target according to a defined surge motion spectrum
- Additional parameters implemented in the model:
  - Surge displacement tolerances for placing containers
  - Surge velocity tolerance for placing the container
  - Time to place container
  - Time allowance to accommodate spreader movement



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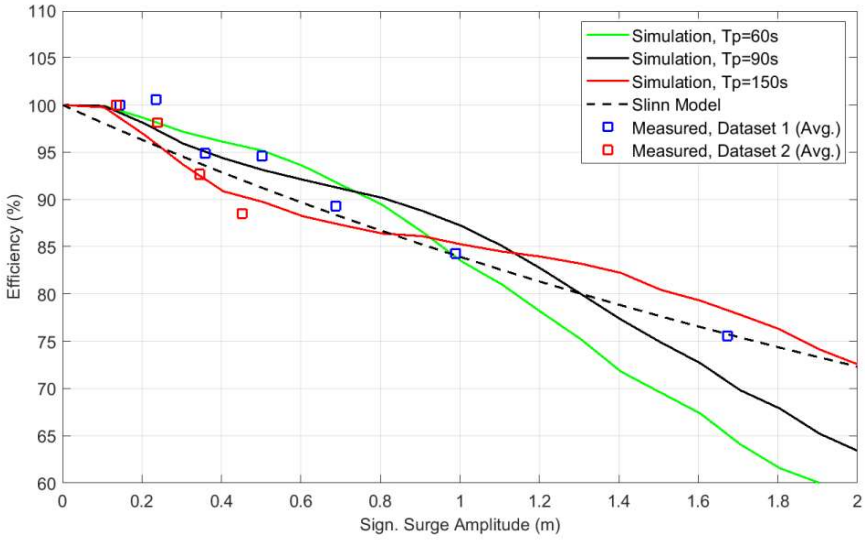
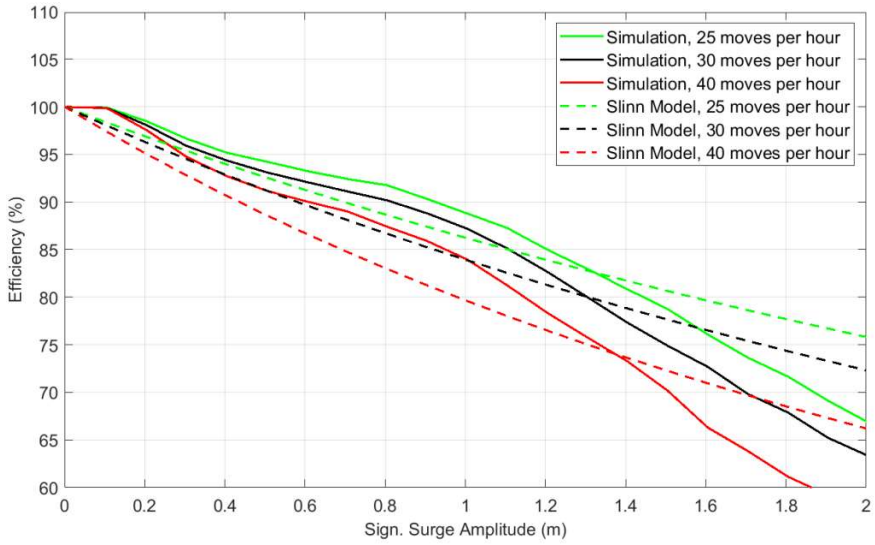
# Computer Simulation

- Parameters calibrated using measured and experimental results
  - Average baseline undisrupted loading rate 30 moves per hour (120 s per placement)
  - Surge displacement tolerance 0.12m – corresponding to entry guide tolerance
  - Surge velocity tolerance 0.10 m/s – corresponding to the experimental results from Slinn
- Efficiency impacted more for higher loading rates
- 95 – 100 % Efficiency rates are not strongly dependent on nominal crane productivity rate



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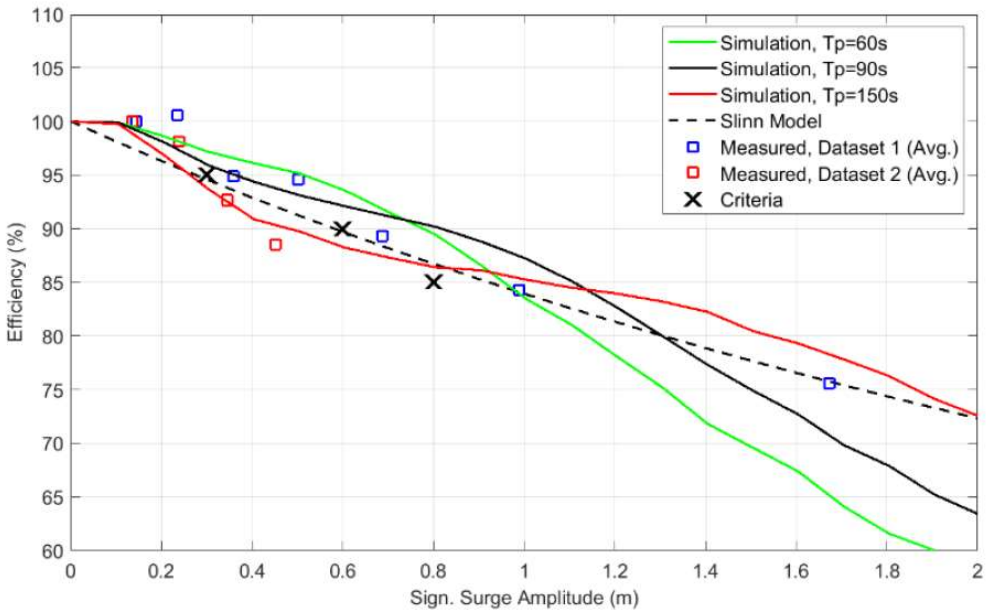
# Analysis for Criteria

- Surge movement criteria for container loading efficiency were reviewed based on:
  - Operator surveys
  - Field measurement
  - Experimental data
  - Calibrated numerical simulations
- First noticeable reduction in efficiency (95%) occur at 0.3 m
- 90% and 85% Efficiency levels are based on data and simulation results



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# Efficiency Criteria for (Un)loading of Container Ships

- Surge is usually governing
- Significant amplitudes
- Sway defined at the bay that is loaded

**Criteria**

- 95% efficiency:
  - Surge: ±0.3 m
  - Sway: ±0.5 m
  - Roll: ±1° to 2°
- 90% efficiency:
  - Surge: ±0.6 m
- 85% efficiency:
  - Surge: ±0.8 m