

Expansion of Operability Assessment Criteria in Bulk Carrier Transhipment Operations

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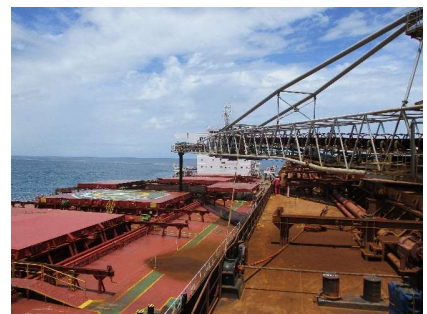


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Project Overview

Investigate the viability of bulk carrier transhipment operations in the Mid-West region of Western Australia.

1. Derive a set of expanded **criteria** against which to assess transhipment **availability**.
2. Determine the **frequency** and **magnitude** of tug intervention at the proposed site.
3. Inform the **required upgrades** to standard self-unloading bulk carriers to allow efficient long-term operation.
4. Execute **9000+** dynamic mooring analysis scenarios to estimated **annual** operational availability.



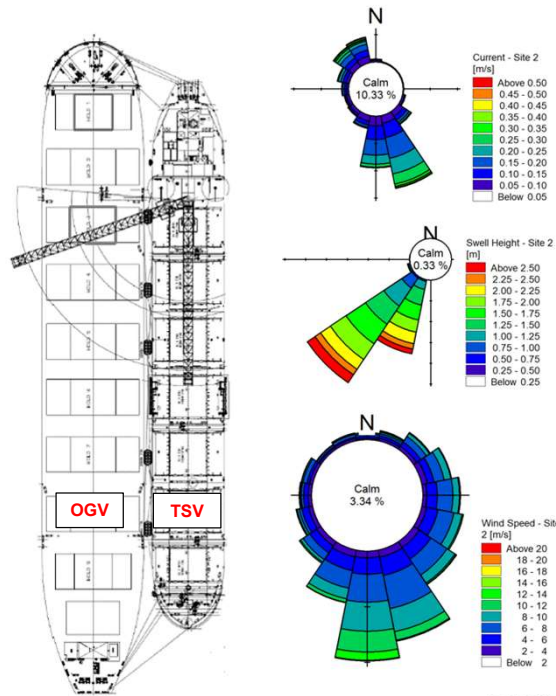
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1. Define the Problem

- 2 vessel system
 - 12 mooring lines (2,2,2)
 - 5 pneumatic fenders
 - OGV anchor chain
- 1-hourly hindcast metocean conditions
 - Calibrated 3DHD/SW models
 - 2015 nominally selected
 - Wind, sea, swell, currents considered



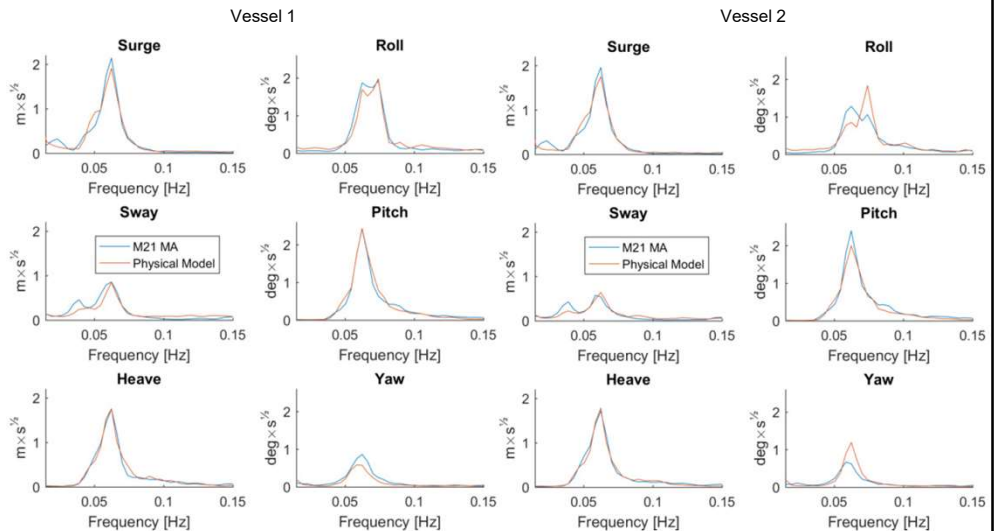
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2. Develop a Model – MIKE21 Mooring Analysis

M21MA has been extensively validated in single and multi body applications.



A. Harkin et al. 2017 Coasts and Ports Conference (DHI)

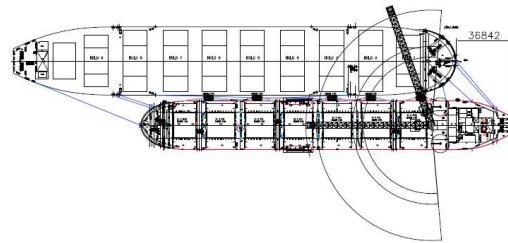
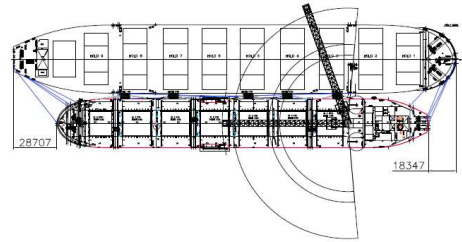
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3. Screening Assessment

- What vessel arrangement should be considered?
- What vessel loading states should be assessed?
- 575 simulations executed to understand the system
- Full year availability arrangement:
 - OGV Laden / TSV Ballast
 - Midships aligned (top)



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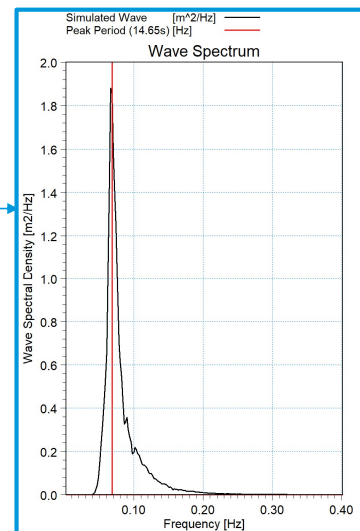
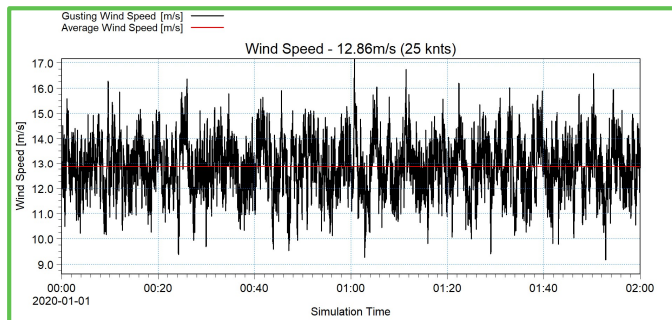


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4. Full Year Simulations

8760 hourly representative simulations completed

Sim No.	Time	Wind Speed [m/s]	Wind Direction [deg]	Swell Hs [m]	Swell Tp [s]	Swell Direction [deg]	Current Speed [m/s]	Current Direction [deg]
285	12/01/2015 21:00	10.11	186.73	0.82	14.80	253.68	0.19	122.73
286	12/01/2015 22:00	12.86	189.80	0.82	14.65	253.69	0.16	122.01
287	12/01/2015 23:00	11.65	191.51	0.81	14.55	253.82	0.14	120.68



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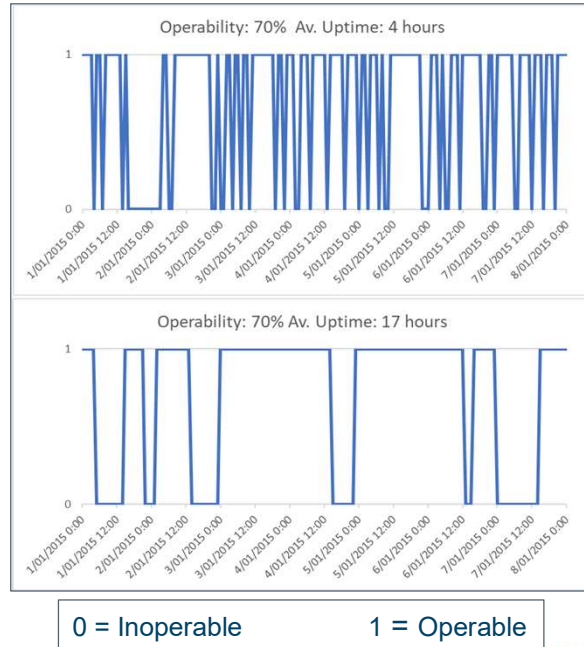


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4. Full Year Simulations

Advantages:

- Allows for a **clear connection** between simulation success and availability. (Availability = number of successful scenarios / 8760)
- Assesses **seasonal shifts** in availability.
- Produces **uptime profile** of potential sites and berths.



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5. Operational Criteria

- Traditional:

Criteria	Assessment Mechanism	Limit*
Line Forces	Line force timeseries	< 50% MBL
Fender Loads	Fender force timeseries	< 100% MRF
Vessel Motions	Peak-to-peak TSV motions	Roll and pitch < 1.5°

*Limits as applied in early pre-feasibility study phases

- Nouvelle
 - Vessel-vessel motions assessed via loading boom tracking
 - Tug requirements considered

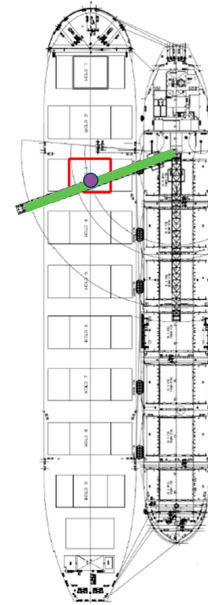
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5. Operational Criteria – Vessel-Vessel Motions

- Typically assessed via relative peak-to-peak motions around the vessel centre of gravity.
- Impacts of coupled motions (i.e. roll and yaw induced sway) at vessel extremes can be understated.
- Vessel-vessel motions have operational implications based on equipment limitations and standard operating procedures.

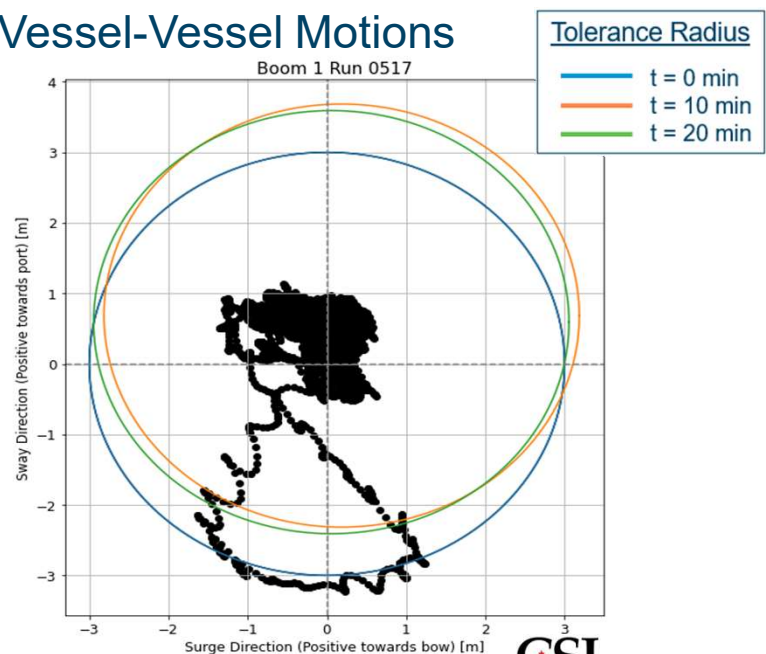


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5. Operational Criteria – Vessel-Vessel Motions

- “Boom plots” track TSV loading arm relative to target OGV hatch.
- Project tolerance: <3m movement over 10 minutes.
- Can be applied to any location on the vessel. E.g. manifold tracking for gas or liquid transfers.



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6. Tug Requirements Assessment

- Strong **beam seas** can cause excessive vessel **roll** during transshipment operations.
- Desire to operate with the system oriented within **30 degrees of swell**.
- Tugs deemed necessary if **equilibrium orientation** of the transshipment system lay outside the desired envelope.

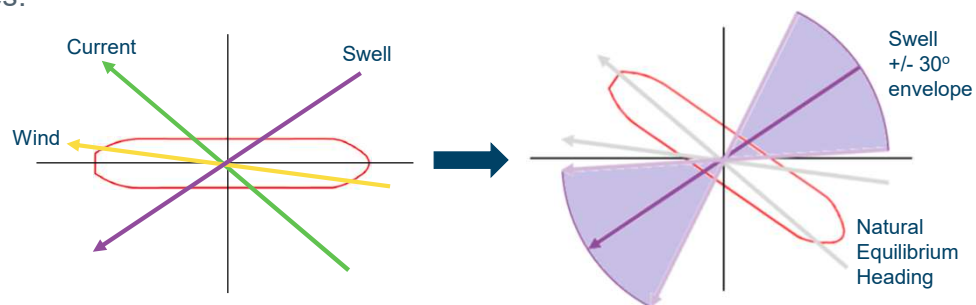
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6. Tug Requirements Assessment

- System equilibrium heading determined based on metocean conditions.
- System **within** envelope = Execute simulation as normal.
- System **beyond** envelope = Orient system to envelope edge and track required tug forces.



- System found to generally align with the **current conditions**.

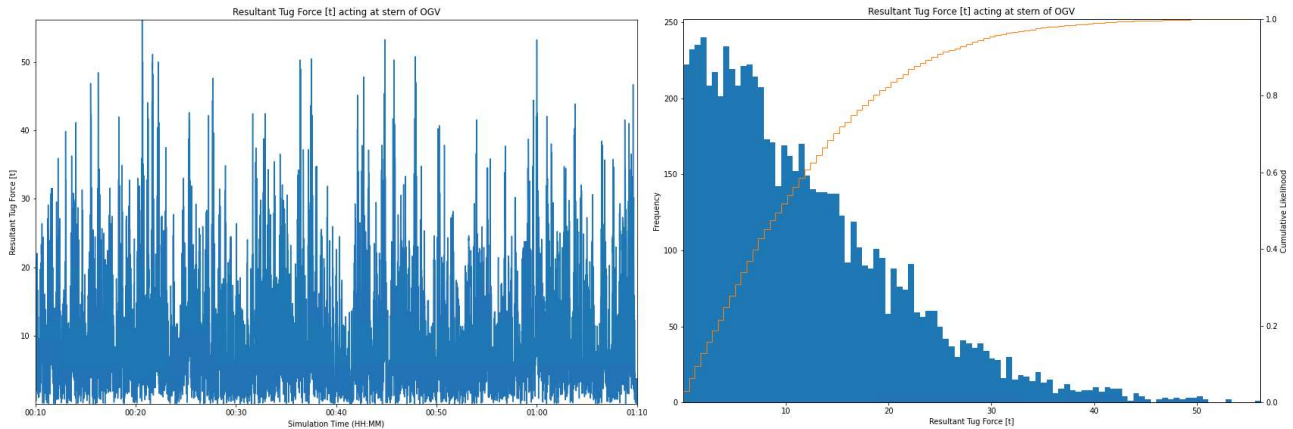
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6. Tug Requirements Assessment

- Tug assumed to act perpendicular to vessels at OGV stern



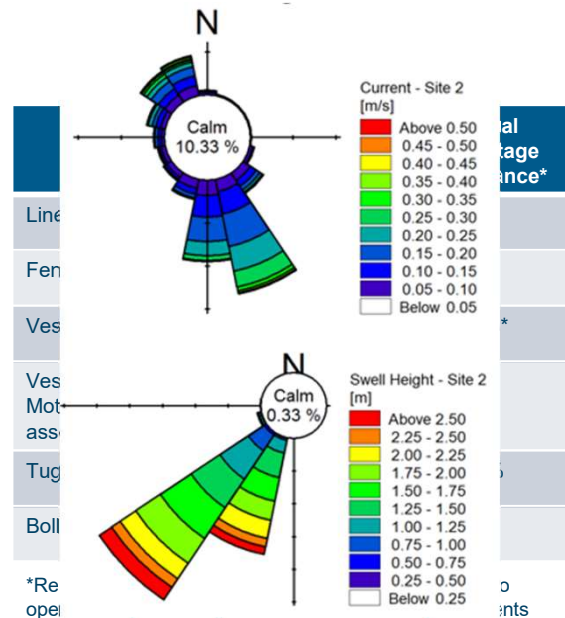
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Results

- Vessel motion identified as limiting criteria. Used to inform priority process and vessel adjustments.
- Nouvelle boom plot method shown to have an impact on availability equal to that of traditional line and fender force considerations.
- Tugs required for the majority of the years (due to swell typically acting perpendicular to the current at the site).



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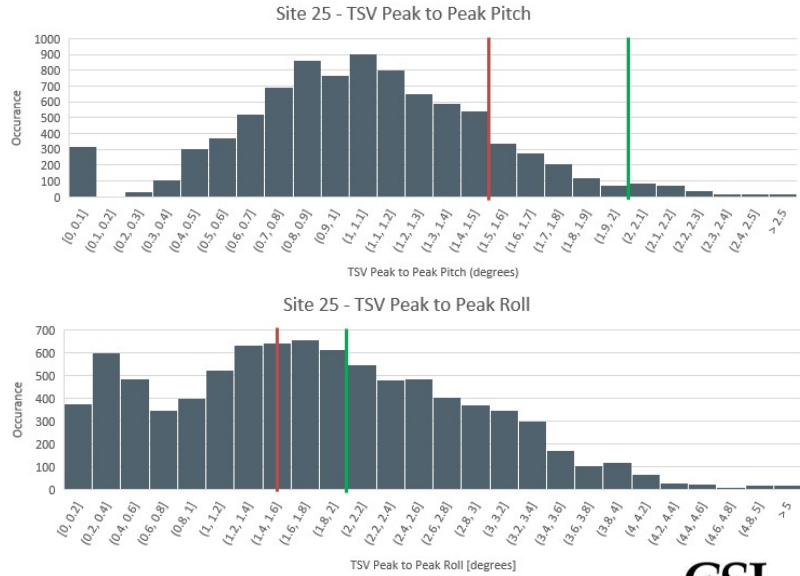


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Upgrade Opportunities

Limits

- Limit applied in study
- PIANC WG24-limit



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Conclusions

- The ability to represent a full year of simulations allow for a more direct coupling of observed operability and metocean conditions.
- The ability to assess the impacts of operability criteria on a more granular level facilitates informed adjustment to operation procedures.
- The addition of nouvelle operability criteria beyond traditional mechanisms such as fender and line forces have the potential to impact reported operability estimates.

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Thank you



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