



Operational Forecasting of Container Stacking Risk



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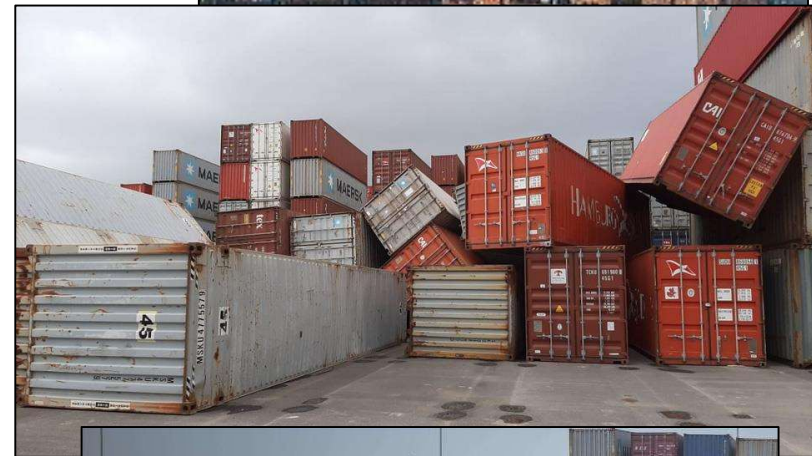
DHI Seaport – DHI' Digital operation services for ports

Operationally forecasting of container stacking risk.
To help reduce risk and reduce unnecessary moves.



Container Stacking Risks

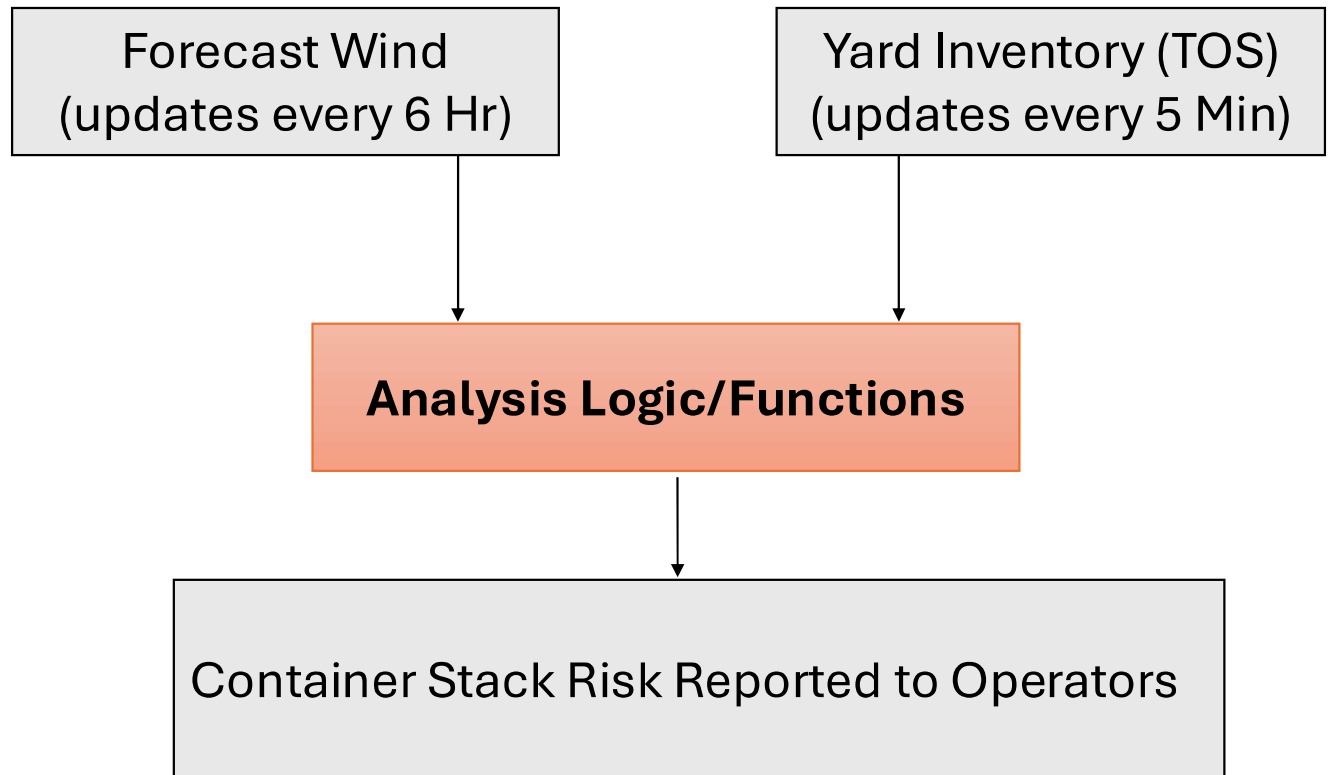
- Largest risk is wind induced movement
- Either sliding or toppling
- Empty Containers
- Extreme Weather



”Yard Safe” Operational Decision Support

Yard Inventory is constantly changing

Forecast on current inventory extends up to 48h.

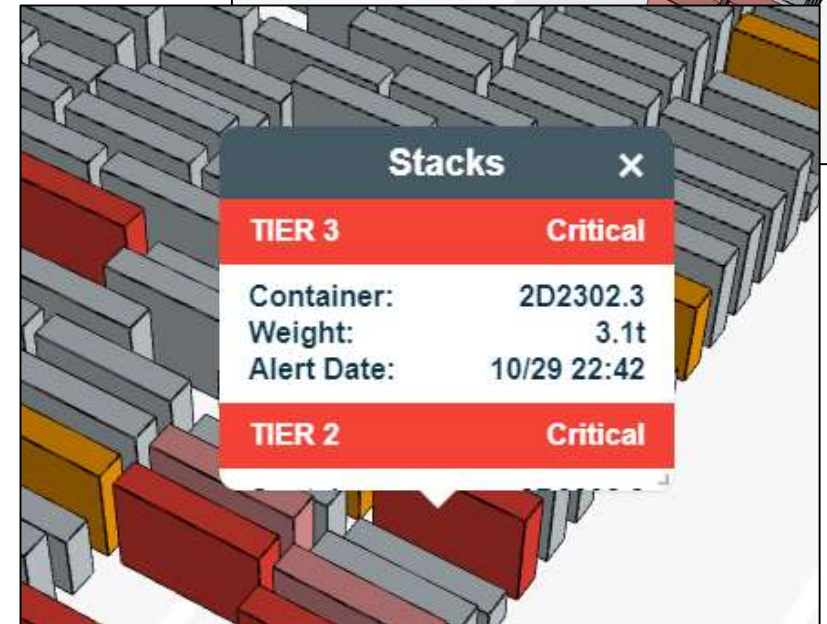
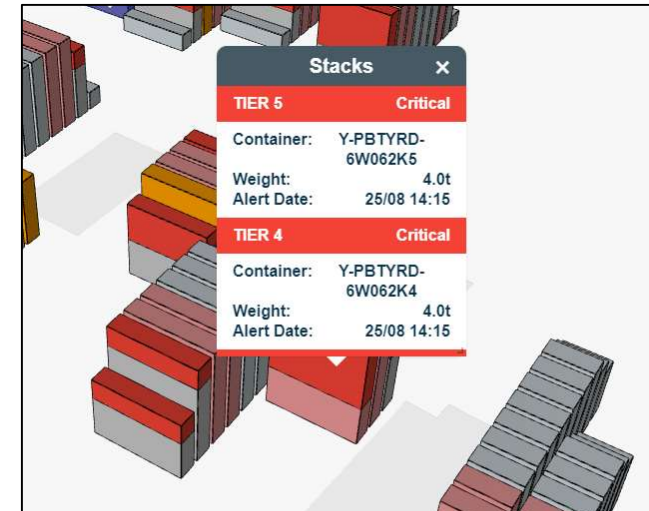


Yard Safe

- Decision Support system
- Identifies at risk containers in yard
- Reduces unnecessary moves based on static rules
- MedPort Tanger¹“...now only needs to move about 20 containers for each wind warning, down from 800.”



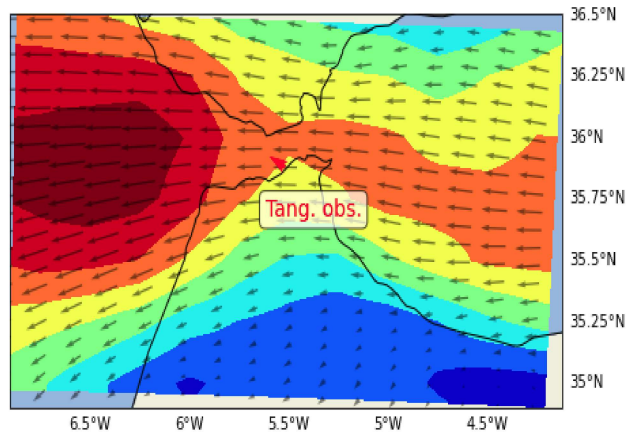
¹<https://www.apmterminals.com/en/news/news-releases/2022/220902-advanced-software-reduces-wind-gust-damage-to-zero>



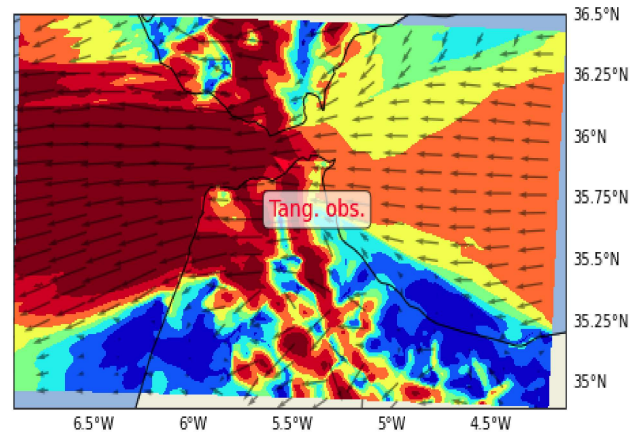
Wind Forcing

- Wind Forecast from downscaled WRF models
- Corrections using ML

ERA5 wind forecast

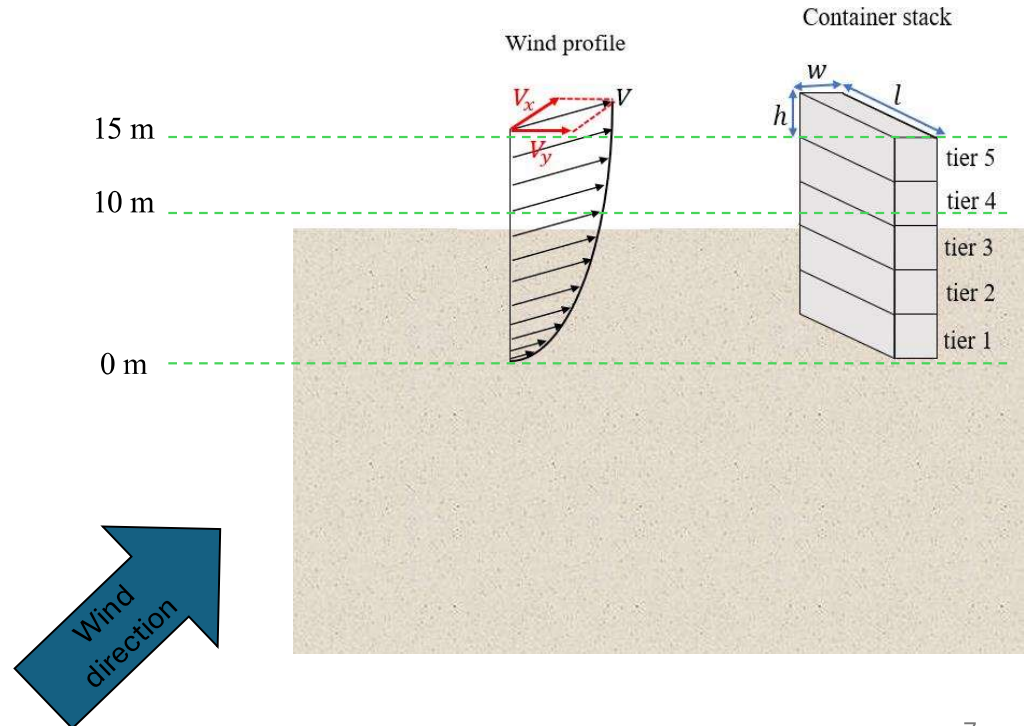


WRF wind forecast



Wind Forces

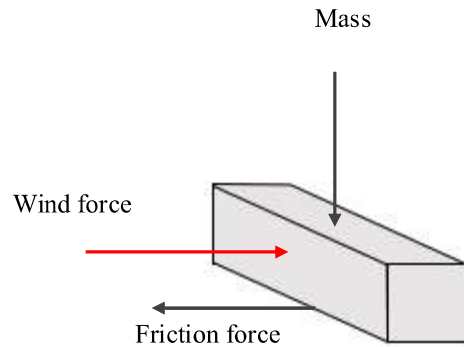
- Logarithmic Wind Profile
- Wind Gusts
- 3D sheltering/amplification effects (determined by CFD)
- Force on container
 - Longitudinal
 - Transverse



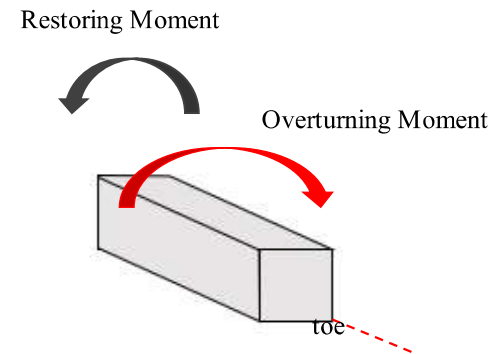
Container Forces

- Force Equilibrium
- Container characteristics from actual Yard Inventory

Friction Force



Overturning Moment



Safe Stack Height Extension

Why?

- Longer forecast periods are unreliable
- Uncertainty in future yard inventory
- Constantly Changing Yard Inventory and Container Positions
- Especially in fully automated yards

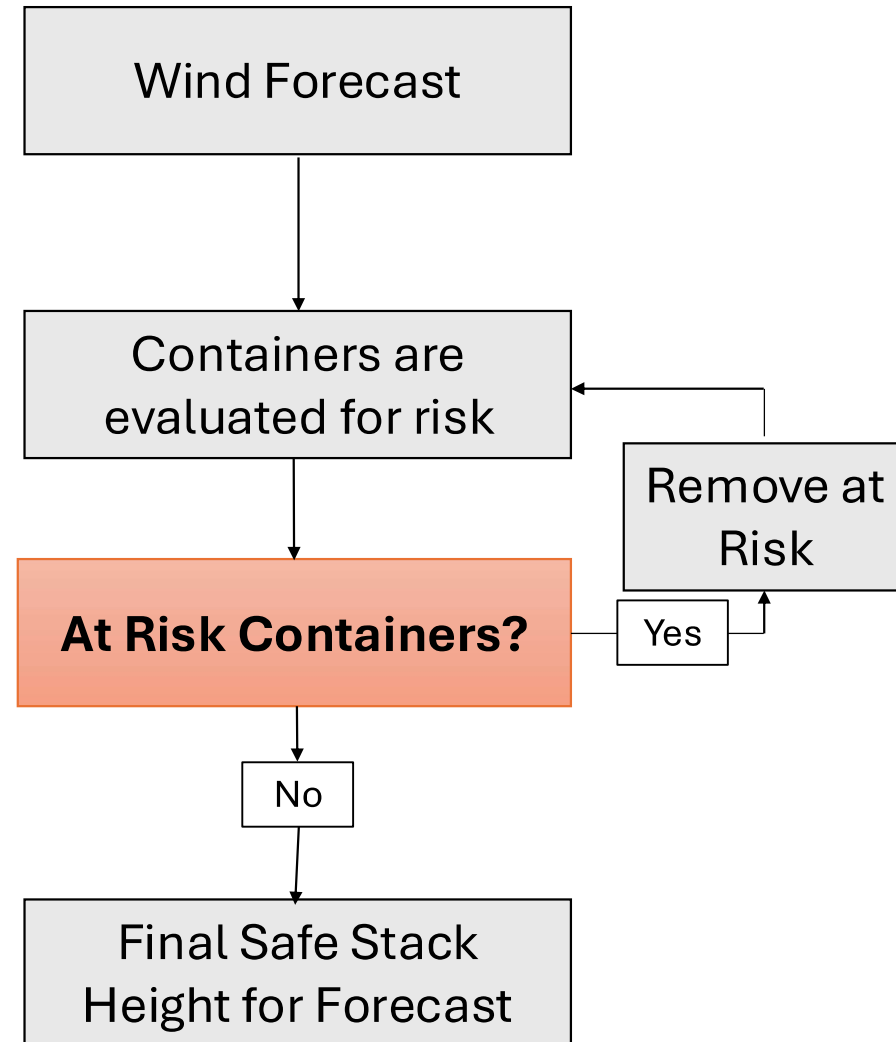
Safe Stack Height Extension

- Assumption based on conservative yard inventory
- Enables down stacking in areas most affected
- Movement can done as part of housekeeping

- Extension of Yard Safe
- Help reduces moves required prior to arrival of storms
- Physics based rules to help reduce total required moves compared to static rules

Methodology

- Based on assumed layout
- Iterative Process
- Container Risk is evaluated for 5 day wind forecast
- At risk containers are removed
- Changes 3D sheltering effects



Results

- Graphical representation of results **1**
- Down stacking required in some areas. **2**
- Areas to downstack can be input into Yard Software
- Allows early down stacking in high risk areas

A

3	3	3	3	3	3
3	3	3	3	3	3
3	3	3	3	3	3
3	3	3	3	3	3
2	2	2	2	2	3
3	3	3	3	3	3
3	3	3	3	3	3
2	3	3	3	3	3
2	3	3	3	3	3
2	2	2	2	3	3

B

2	2	2	2	2	2
2	3	3	3	3	2
2	3	3	3	3	2
2	3	3	3	3	2
2	2	2	2	2	2
2	2	2	2	2	2
2	3	3	3	3	2
2	3	3	3	3	2
2	3	3	3	3	2
2	2	2	2	2	2

Results

- Movement can be done as part of housekeeping days ahead of major events
- Reduces overall moves compared to fixed rules
- Reduces risk when combined with "Yard Safe" to monitor at risk containers in near-future
- No sudden increase of containers to move 24h or 48h before event

Limitations

- Dependant on one or several assumed potential layouts
- Based on conservative estimates
- Results are very dependant on accuracy of wind forecast

Conclusion

- Physics based decision support system for Container Yards
- Help reduce risk and required moves

Relevant UN SDG



Thank You for your Attention

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