TRELLEBORG MARINE AND INFRASTRUCTURE

Application of Dynamic Mooring System (DynaMoor)

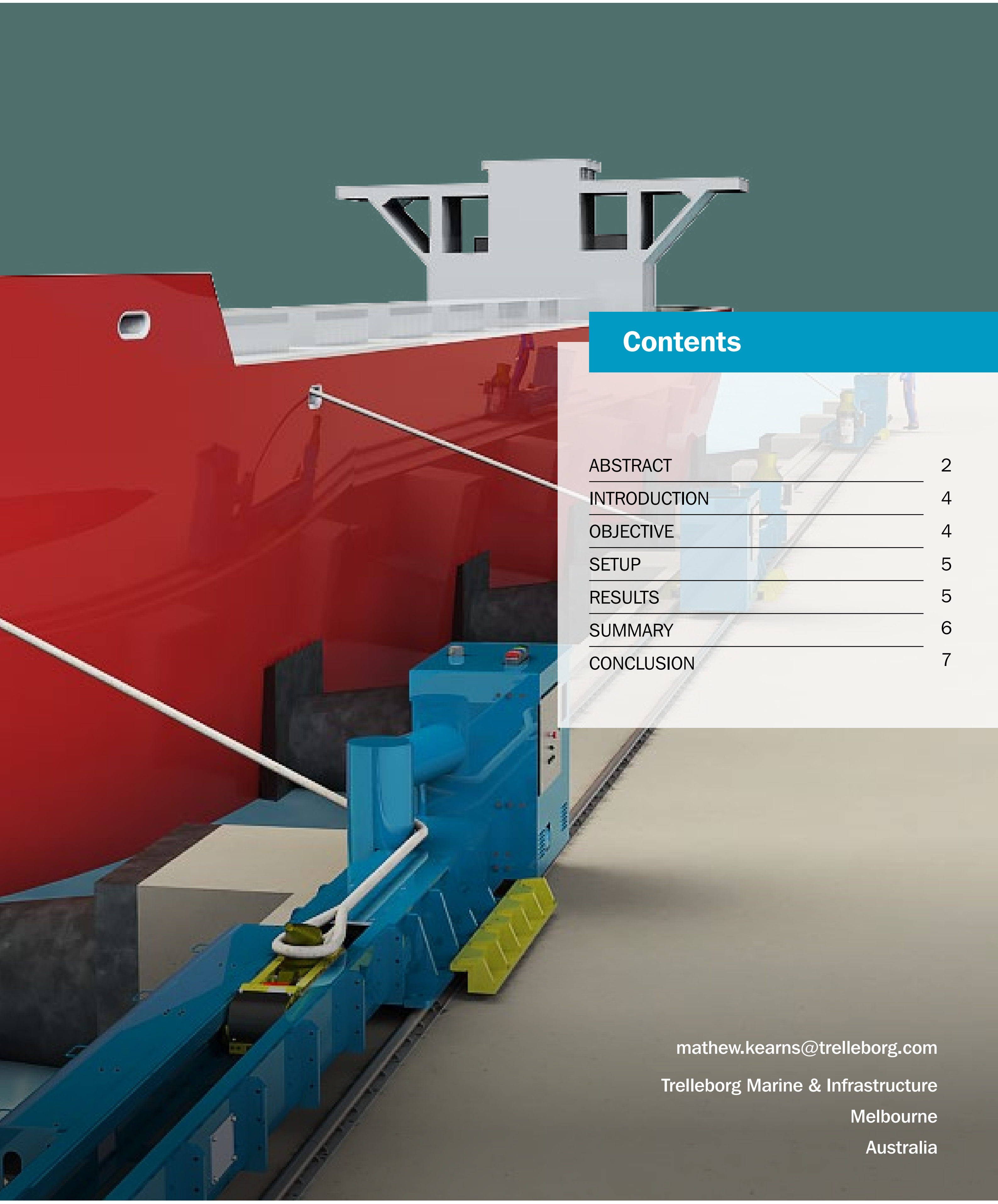
TO ELIMINATE PASSING SHIP EFFECT FACILITY - UPSTREAM FUEL OFFLOADING

WHITEPAPER

Abstract

Increasing operational efficiencies is a key goal of most ports and the shipping industry as a whole. External forces such as inclement weather, long period waves and the effects from passing ships can reduce berth efficiencies by increasing the motions of the ship at berth. This paper aims to demonstrate how DynaMoor can reduce the effects of passing ships to allow a greater product transfer window.

Keywords: *Passing Vessel, Vessel Motion, Dynamoor, Dynamic Mooring.*



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Introduction

The port industry continually faces the challenge of maintaining and increasing berth utilization to allow product or passenger transfers to occur as seamlessly as possible with minimal downtime. In general, this challenge arises from the need to:

- Prepare port infrastructure to cater for ever-increasing vessel sizes.
- Discover innovative ways to reduce capital investment.
- Increase vessel traffic due to higher demand on ports and terminals.
- Find ways to compete, requiring new and innovative ways to lower operational costs and make a port more attractive.
- Reduce incidents that jeopardize safety and cause downtime.
- Minimize the effects of adverse environmental and metocean conditions.
- Minimize the effects of passing vessels.

The use of automation in port operations is becoming more commonplace, with applications ranging from offshore autonomous ships to onshore fully automated container yards in an effort to address any of the above challenges.

Focusing on factors that affect moored vessels at berth; in the simplest of terms, for a mooring system to be effective, it must overcome external forces acting on the vessel to restrain the motion suitably to allow efficient product transfer. External forces can be grouped into two main categories:

i. Static – forces that for the purpose of analysis can be considered not to change significantly within a short period of time including current, constant wind and short period waves.

ii. Dynamic – forces that change significantly within a short period of time including long period waves, gusting winds or the effects of passing ships.

The efficiency of a mooring system is dependent on a number of factors:

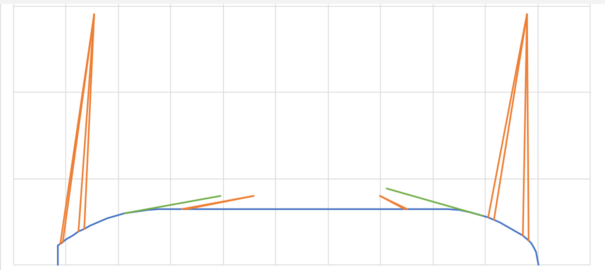
- The 'human element' – lack of data to make informed decisions; inaction or bad practice.
- Ineffective facility designs or mooring pattern selection.
- The environment – metocean conditions or passing vessel.

Objective

The objective of this paper is to demonstrate the effectiveness of DynaMoor to expand the window of operation for product transfer by reducing vessel motions. This is achieved by applying the forces of a passing vessel to a moored vessel and benchmarking the DynaMoor solution against a conventional static mooring line arrangement.

Setup

An in-house passing vessel analysis[1] was performed for an upstream facility. The passing vessel was at a distance of 160m traveling at 10 knots at complete low tide. The berthed vessel was moored with 4 lines on the bow with 3 on the stern, two spring lines – 1 AFT facing and 1 FWD. These lines were modeled as Steel wire Nylon with soft tails, Steel wire MBL 85T, Soft tail MBL 110T. A DynaMoor unit (Green) was placed at both bow and stern in line with spring lines (see plot 1.1 below). The hook was started at the halfway point of the 3m travel Dynamoor unit.



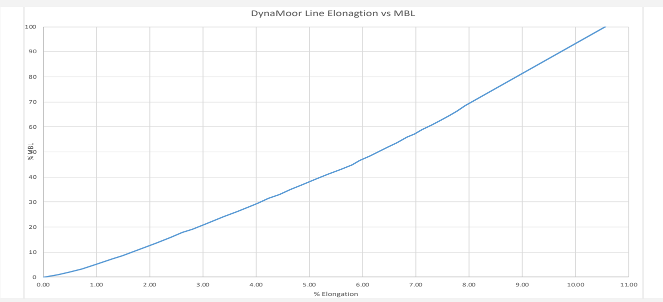
1.1

The passing vessel is in the following positions relative to the berthed vessel at the times listed below in 1.2.

Vessel Position	Time (sec)
End to End	60
In-line	105
End to End	150

1.2

Mooring line used in conjunction with DynaMoor as per table 1.3.



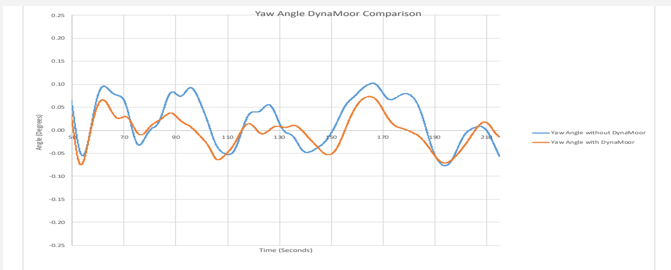
1.3

Results

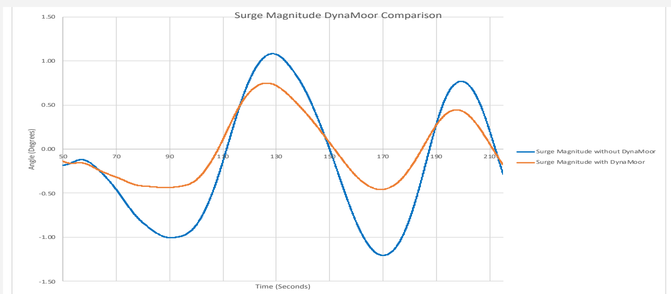
The results in table 1.4 below compare the scenario without DynaMoor in place with a scenario where the only change is the addition of DynaMoor. The pay-in load is set at 10T and pay-out is set to 25T. The main motions of concern in a passing vessel analysis is the surge and yaw of the moored vessel and the peak loads on the spring lines and short breast lines. In this mooring situation due to the geometry of the mooring area Yaw is minimal in both cases, tables 1.4 and 1.5 demonstrate this. The Surge translation of the vessel is +1.08m and -1.21m, which exceeds the PIANC guidelines for acceptable motion criteria for safe mooring[2] (2 meters), this is reduced to +0.75m and -0.46m with DynaMoor with the successive peaks in the static lines reducing in magnitude due to the dampening effect of holding till the pay-out threshold, see Surge plot 1.6 below.

		Without DynaMoor		With DynaMoor	
Motion		Positive	Negative	Positive	Negative
Surge Movement	[M]	1.08	-1.21	0.75	-0.46
Yaw Movement	[deg]	0.20	-0.20	0.18	-0.22

1.4



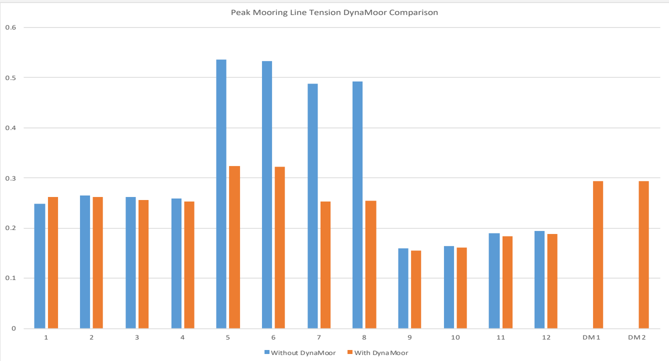
1.5



1.6

Summary

The peak loading on the mooring lines is focused on the spring lines due to the main motion being in Surge. The maximum line load is 54% of MBL without DynaMoor. The line loads are reduced to a maximum line load of 32% when DynaMoor is used. Given that the lines are also becoming slack between peak loads when DynaMoor is not in use, the reduction in the maximum load will reduce the possibility of parting due to snap loads while the DynaMoor lines pay-in at 10T, maintaining line tension through this oscillation cycle.



1.7

The following table 1.8 is a summary of all the peak loads and motions of the berthed vessel with and without DynaMoor.

Naturally the addition of mooring lines will reduce load on others, where DynaMoor stands out is its ability to apply a known controlled tension, removing the reliance on deck crew tending to lines. This means the results presented in this paper can be replicated in a real mooring as the human factor is removed.

MOORING ANALYSIS RESULTS	Without DynaMoor - 160m Separation at 10 knots - Slack Water (3BD- 2MD)	With DynaMoor - 160m Separation at 10 knots - Slack Water (3BD- 2MD)
Max Mooring Line Load	45.5T	27.5T
Max Mooring Line Load of MBL	54%	32%
Max Rotation Roll (RX)	2.30 Deg	1.54 Deg
Max Rotation Pitch (RY)	0.49 Deg	0.28 Deg
Max Rotation Yaw (RZ)	0.20 Deg	0.22 Deg
Max Vessel Movement Surge (X)	1.21 m	0.75 m
Max Vessel Movement Sway (Y)	0.47 m	0.23 m
Max Vessel Movement Heave (Z)	0.0 m (Locked)	0.0 m (Locked)
Max Fluid Force Surge (FX)	75.08 T	75.11 T
Max Fluid Force Sway (FY)	221.75 T	220.27 T

1.8

Conclusion

Thanks to DynaMoor, the effect of passing vessels has been minimized, as well as parting lines caused by spike loading, thus addressing significant safety and efficacy factors. Shipping lines will now have confidence during the berthing process, knowing there is active control of lines, providing the maritime industry with solutions to age-old problems.

In addition, DynaMoor allows operations to continue regardless of a vessel's size, distance or speed.
The addition of two more DynaMoor units (4 in total) would further improve vessel stability and almost eliminate the human factor from the equation,
thus allowing vessels to be moored with confidence.

[1] STAR CCM+

[2] Permanent International Association of Navigation Congresses (PIANC) (1995). Criteria for Movements of Moored Ships in Harbours, A Practical Guide, pp. 7.

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