PIANC NEW TECHNOLOGIES SEMINAR AND AGM 2019 – SYDNEY 9 & 10 MAY

MID WEST PORTS

Peter Duplex, General Manager – Strategy & Asset Development :

‘ Experience in Geraldton of trials undertaken with new technology’

Geraldton Port

Geraldton Port

HOW WE DO IT

MWPA is responsible for the whole of life management of a wide range of facilities and infrastructure used to support the delivery of Port services including:

88.3 hectares of land including 55 leases

6.5 km of MSIC and regular fencing

6.6 km of breakwaters and rockwalls

18 conveyors

2 shiploaders

6 berths with a total length of 1140m

7 km of rail

6.4 km of road

5 km long main shipping channel

156 Fishing boat pens

37 buildings

KEY DRIVERS

Mid West Ports Authority

Our Markets and Our Other Key Drivers

	Key Drivers			
	Global demand including from China, India, South East Asia, the Middle East, Africa, USA and Europe. 	Reducing Emissions, Water Efficiency, and Improving Environment 	Automation and Innovation 	Social Standards and Expectations 
Sustainability Theme	Prosperity	Planet	Prosperity Partnerships	People Partnerships
	Bigger market place for resources and food Global population, urbanisation and middle class growth High demand for high grade premium product - e.g. high content Fe Unlocking regional mineral, energy and aquaculture resources Helping to enable the regional tourism economy	Land use efficiency Recycling (e.g. dredge material) Increase % of renewable energy use Increased demand for higher grade premium product Ensure adaptive infrastructure Sustainably working with all port users, e.g. a. Cargo emission abatement, and b. Noise and light spill containment Cooperative stewardship of Champion Bay	Maximise operation condition window - modern ship mooring technologies Remove barriers to port entry Digitally connected Maritime Industry Increased fleet efficiency and cleaner fuels Use of drones and sensory devices for operations and maintenance Provide a productive and comfortable work environment	Ensure Port Safety and Security Port as an integral and active community member Identify and protect critical supply chains and adjacent land use amenity Promote stakeholder engagement, inclusiveness and transparency Partner to manage the Port-City interface Help to grow the local Tourism Economy * Cruise Ship Facilities * Eco Tourism * FBH Tourist Hub * Industrial Tourism
Alignment with UN SDGs				

Modern Mooring Techniques – The Harbour Paradox

A Coupled Ship and Harbour Model for Dynamic Mooring Analysis in Geraldton Harbour

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Abstract
In this article, we develop a coupled ship-and-harbour model for moored ship motions and loads in Geraldton Harbour. WAMIT software is used to model the ship and harbour as a two-body system. The resulting first-order and second-order wave loads, as well as Impulse Response Functions, are fed into the nonlinear time-domain solver MoorMotions. Timeseries of 6-DoF ship motions, mooring line loads and fender loads are then output. The method is tested, without a ship present, against long wave measurements in Geraldton harbour, showing good agreement. The method is then tested against GNSS measurements of 6-DoF moored ship motions for a Panamax bulk carrier at Geraldton Berth 5, also showing good agreement.

Keywords: ship, mooring, long waves, harbour.

Nomenclature

CoG	Centre of gravity
DoF	Degrees of freedom
FD	Frequency-domain
GM$_t$	Roll metacentric height above ship CoG
GNSS	Global navigation satellite system
IRF	Impulse response function
LBP	Length between perpendiculars
LOA	Length overall
MBL	Minimum breaking load
MWPA	Mid West Ports Authority
PE	Polyethylene
PP	Polypropylene
RAO	Response amplitude operator
TD	Time-domain
UHDPE	Ultra-high-density polyethylene

1. Introduction

Geraldton is situated on the mid-west coast of Australia and is exposed to large, long-period Indian Ocean swells from the SW to WSW. The harbour is protected by a headland and reefs, however some swell and long wave energy propagate in through the harbour entrance. A satellite view of the harbour is shown in Figure 1.

Figure 1 Satellite view of Geraldton Harbour. Shipping channel comes north out of the harbour, then curves to the west.

Geraldton provides an illustration of the "harbour paradox" which was found by Miles and Munk [6] when studying the harbour shape shown in Figure 2.

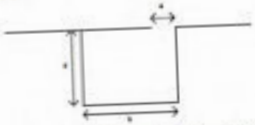
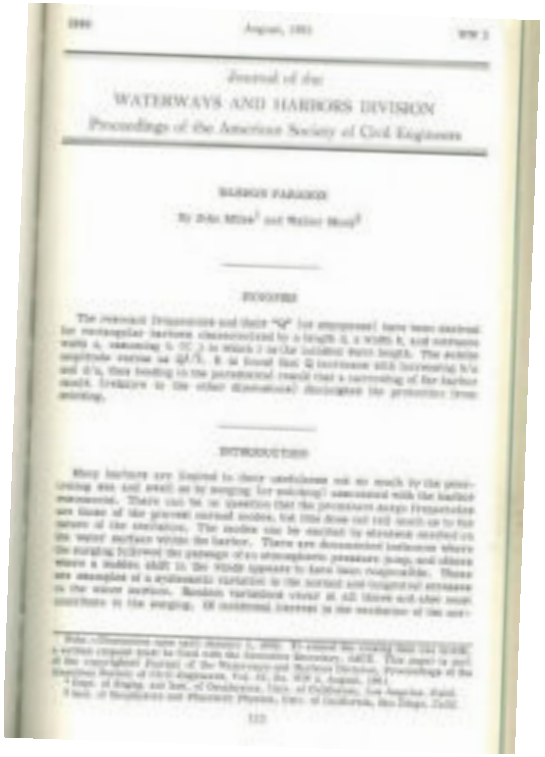


Figure 2 Idealized harbour used by Miles and Munk [6] to study the "harbour paradox". As the ratio a/b decreases, long wave energy in the harbour increases.

The harbour paradox states that as the harbour entrance is made smaller, less wave energy can enter the harbour, but less wave energy can also escape from the harbour. The result is that there is less swell energy within the harbour, but more long wave energy.

Principal long wave resonant periods of Geraldton harbour are 128 s and 64 s for E-W waves, and 92 s and 46 s for N-S waves [18]. Moored ship natural surge, sway and yaw periods also fall within this range, leading to the possibility of "double-resonance" when the ship natural motion period is the same as a harbour resonant period.

Much work has been done to understand and predict long waves in Geraldton Harbour and their effect on ship motions, see e.g. [7]. In this paper, we build on these studies and focus on developing a coupled ship-and-harbour model.



Journal of the
WATERWAYS AND HARBORS DIVISION
Proceedings of the American Society of Civil Engineers

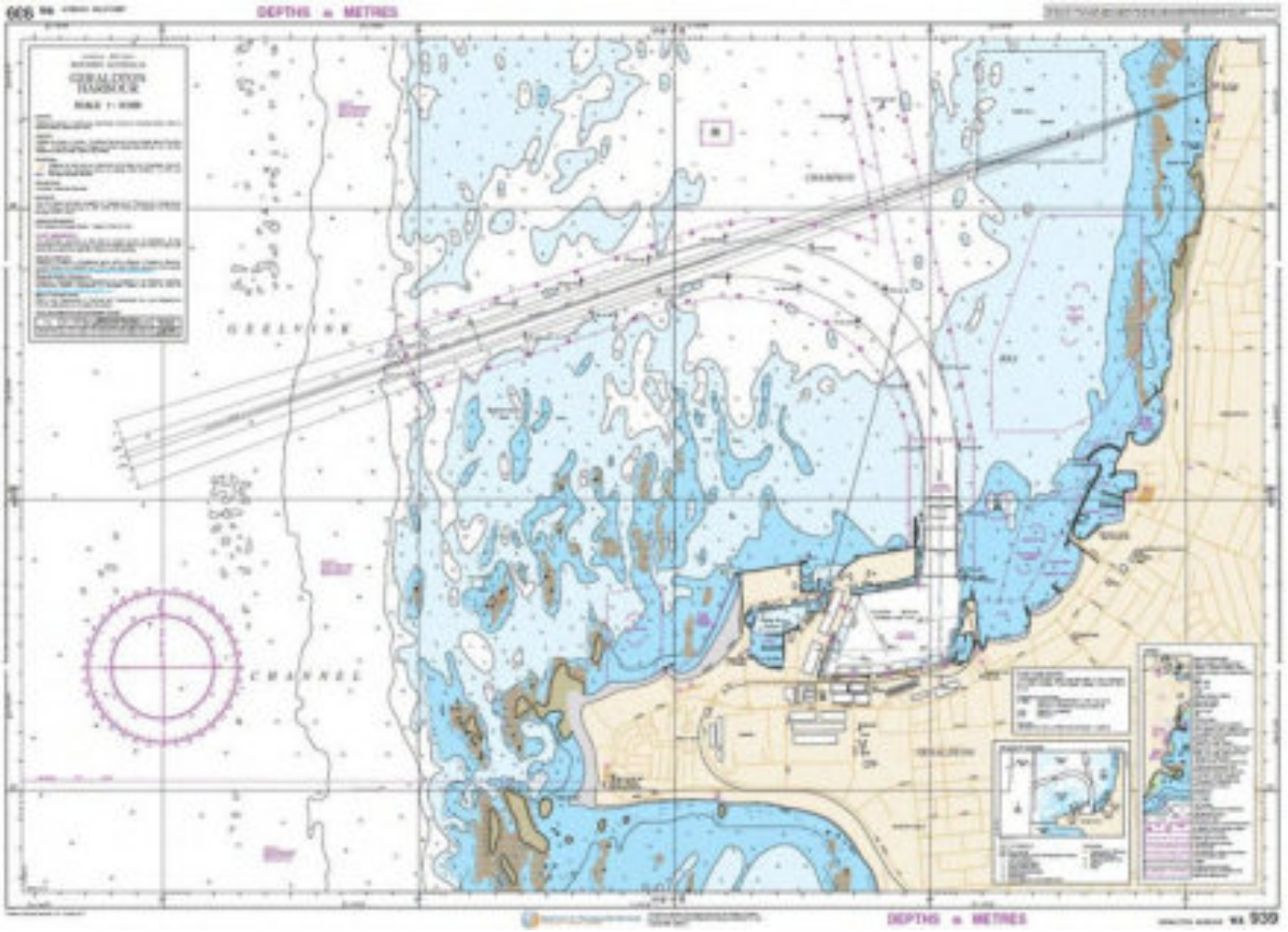
HARBOR PARADOX

By John Miles[1] and Walter Munk[2]

SYNOPSIS

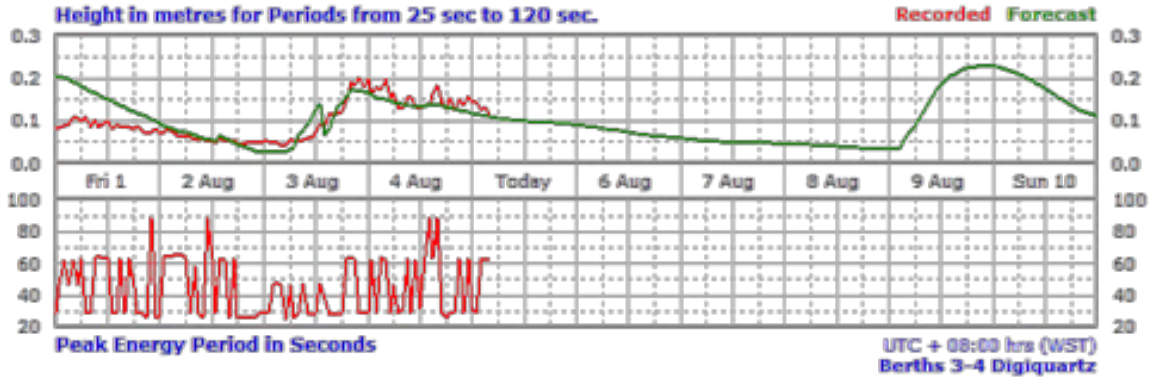
INTRODUCTION

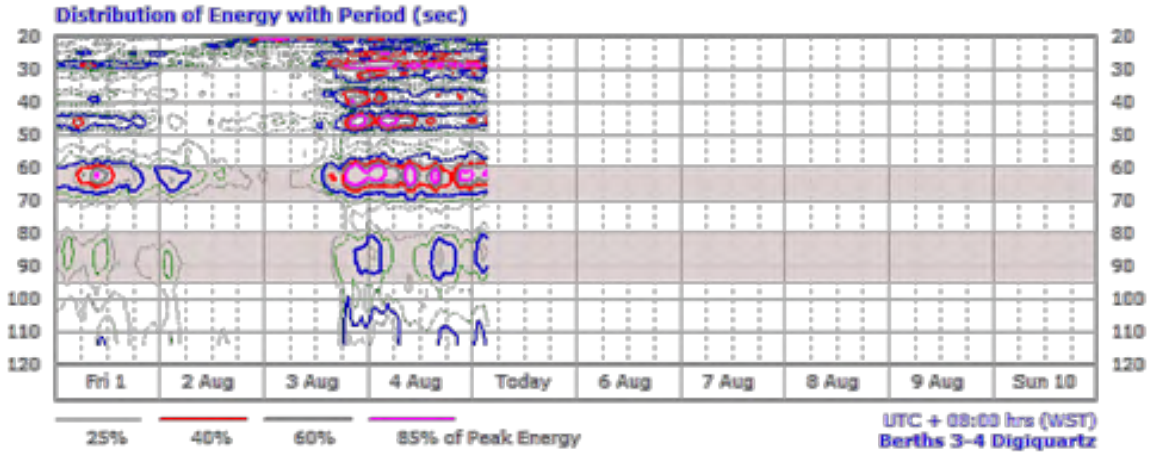
Marine Chart

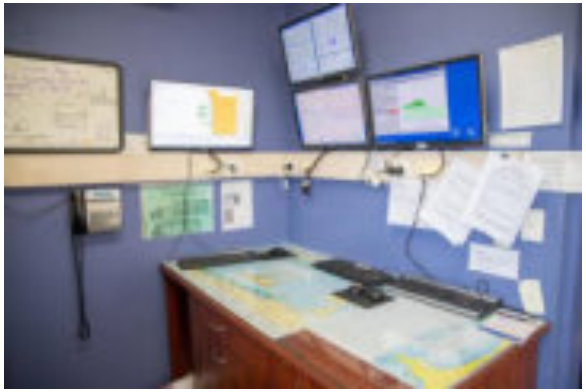


West Coast, Southern Ocean Swells and Fringing Reef

Modern Ship Mooring Techniques – Our Climate







New Technology Driving Environmental Improvements

New Technology Driving Environmental Improvements

- Clean
  - Rotating Containers
- Efficient
  - Carbon Reduction from improved berth occupancy
- Safe
  - Elimination of manual handling
- Feed the planet
  - Agriculture, fishery, and aquaculture

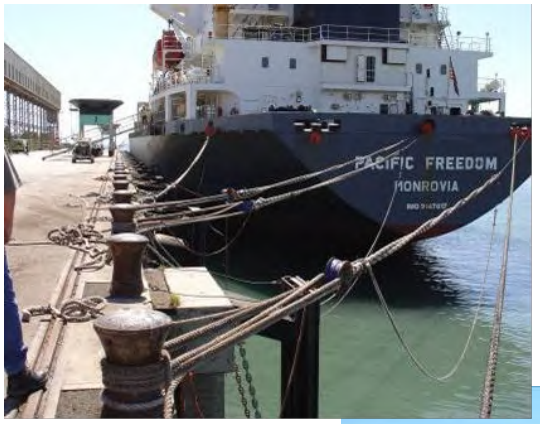
The spectrum at Geraldton Port

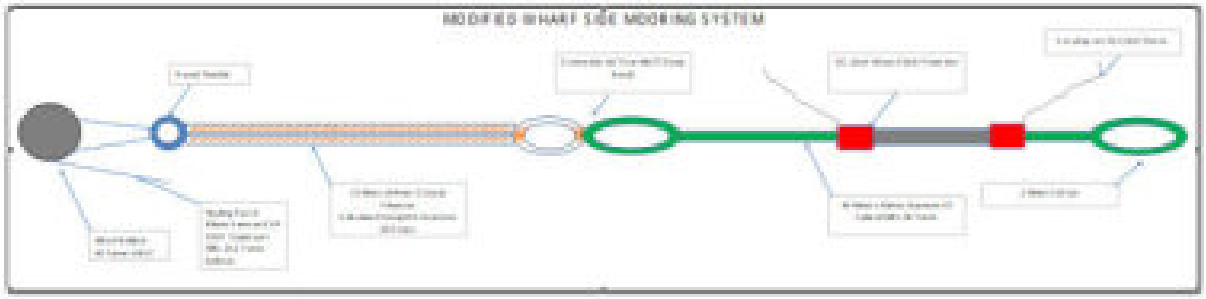
- Manual handling and labor intensive processes
  - Moorings, plant cleaning
- State of the art
  - Vacuum excavation, drone inspections, rotary train unloading
- New Technology
  - Moorings, roof top solar and other initiatives

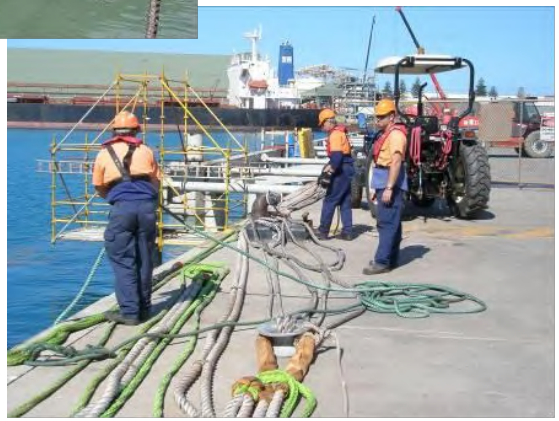
Modern Mooring Techniques – The Geraldton Journey

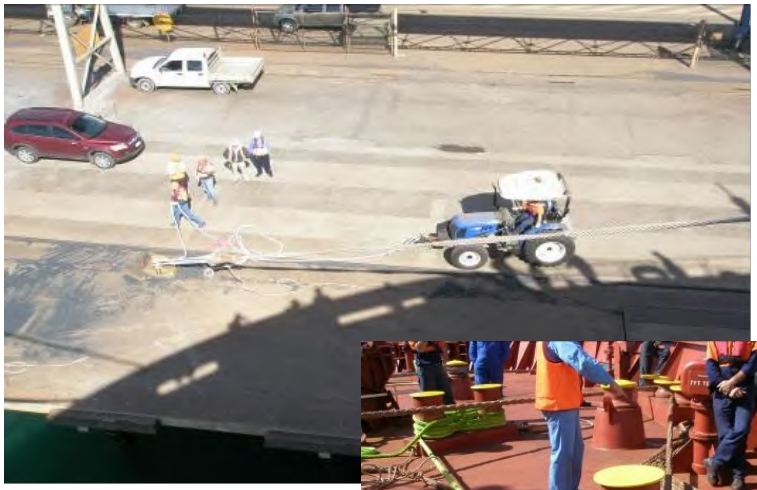
- Ship's Rope to Quay
- "Shore Mooring"
- Berth Forecasting and Limit Thresholds
- MoorMaster
- International Symposium
- Vessel Motion Monitoring
- ShoreTension Units
- "Smart Bollards"
- Artificial Intelligence
- Accelerometer measurements of berth decks

“Shore Mooring”



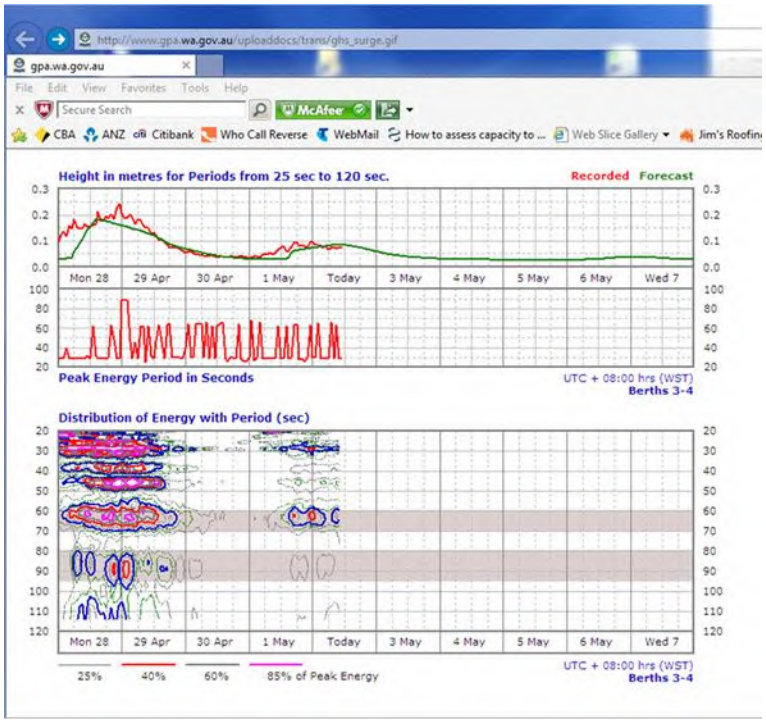






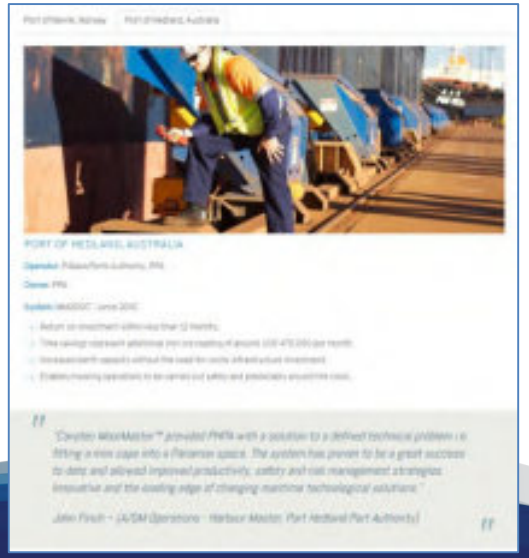
Berth Forecasting and Limit Thresholds

- Swell Period
- Vessel Characteristics
- Rising or Falling
- Duration

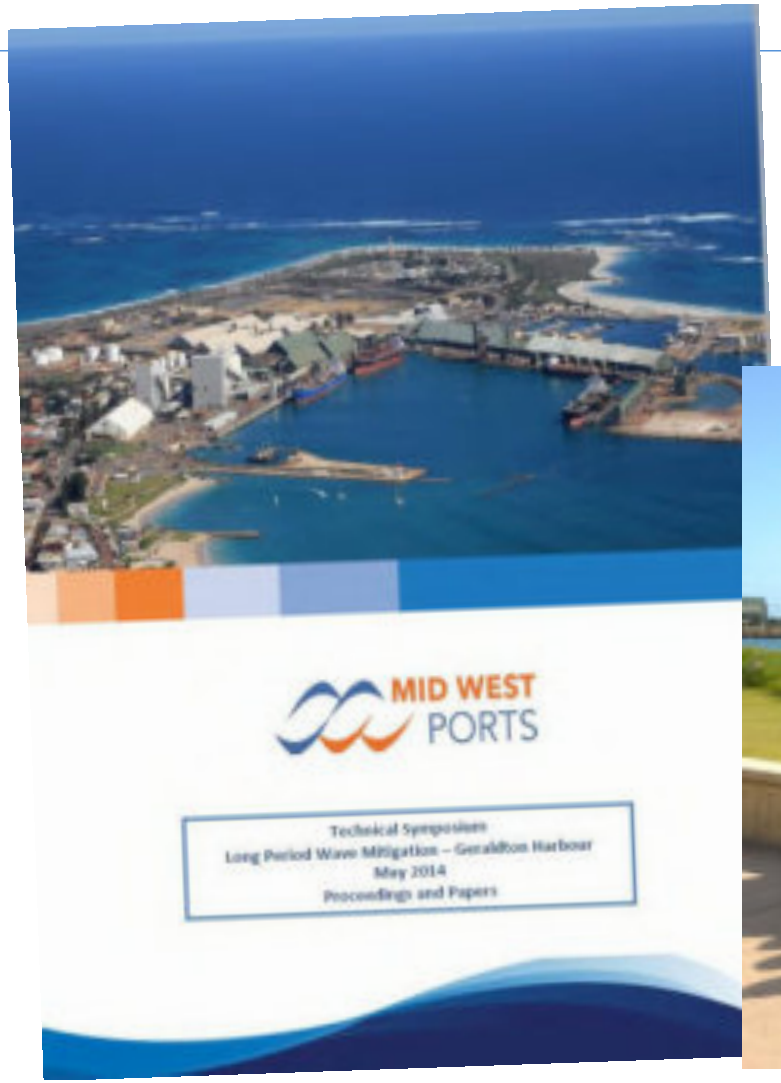


MoorMaster


PORT OF NARVIK, NORWAY



International Symposium



Vessel Motion Monitoring

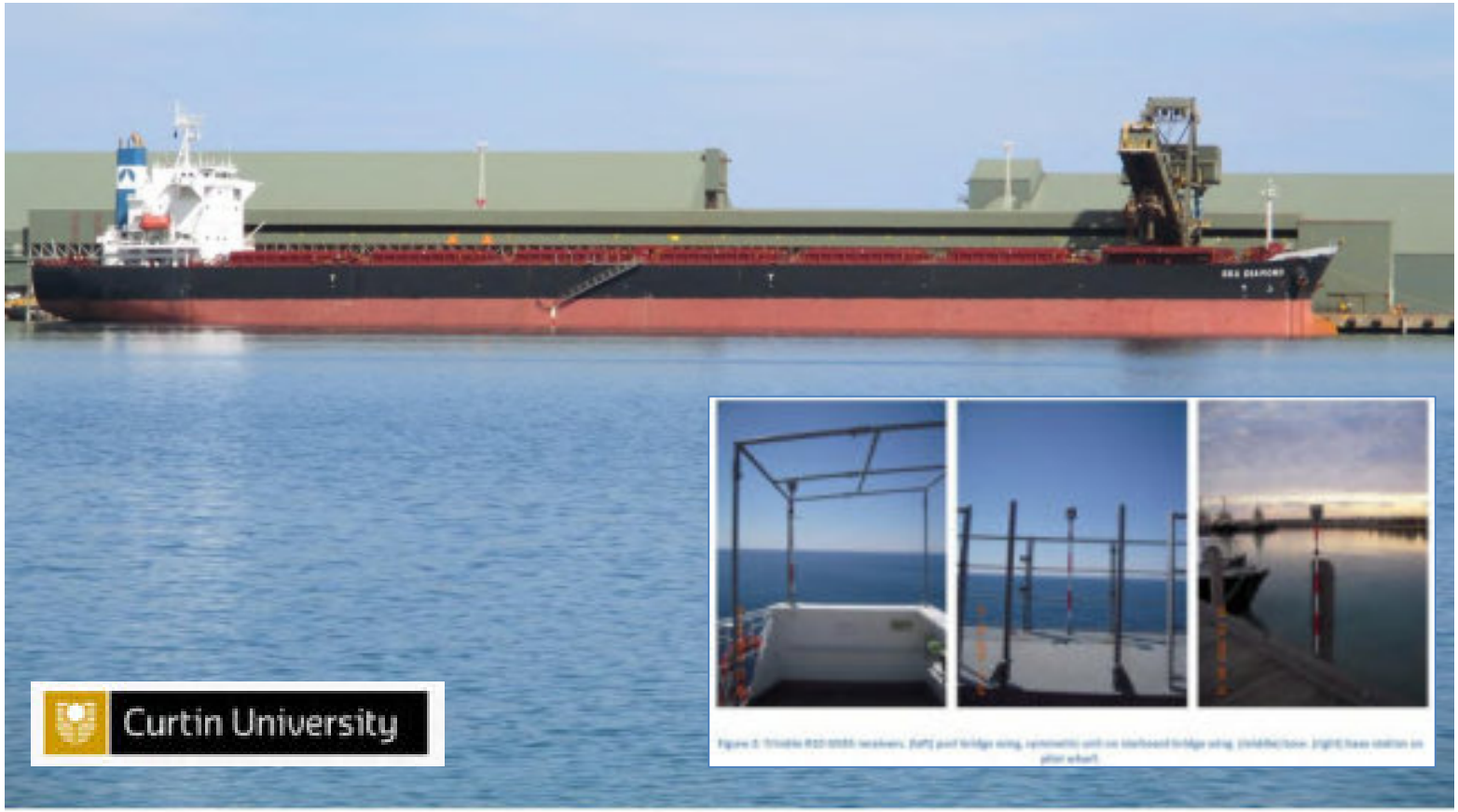


Figure 1: Profile view of MV Sea Diamond during motion measurements at Berth 5

ShoreTension
DYNAMIC MOORING SYSTEM

MID WEST PORTS

When was innovation triggered

- Rotterdam 18 January 2007
- Bft 10 storm
  - –Mean hourly wind speed: 25 m/s
  - –Strongest wind gust: 35 m/s
- Despite all precautions, Ms Claudel (34622 DWT) moored at a Container Terminal breaks out from its mooring lines and crashes into opposite Maasvlakte Oil Teminal.
- 1600 m^3 oil spil
- Estimated damage: over € 120 million

ShoreTension

ShoreTension®

Safe Mooring How it works Specifications Installation

GERALDTON, AUSTRALIA

ShoreTension® proudly announces the order it received from the Port of Geraldton, WA. With its geographical location, directly exposed to the harsh environment from the Indian Ocean, Geraldton is well known for the long swell wave periods which have a significant influence on the Port.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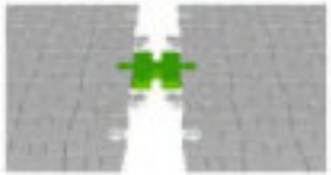
ShoreTension



3 Pollution through external energy

The challenge

Conventional tension winches on deck prevent mooring lines from snapping and provide a certain pre-tensioning. This conventional system can cope with wind, gusts, tidal elevations, (off)loading of the vessel and suction caused by passing ships. The major disadvantage however is that these tension winches are engine-driven and require a lot of external energy.

Our Solution

The ShoreTension® only requires external energy at the moment the ship berths to put the right tension on the mooring lines. Whilst paying out the line, the ShoreTension® stores energy internally. When the peak loads are over, the ShoreTension® heaves in the line with the energy stored and returns to its initial position.

1 Self regulating without external energy

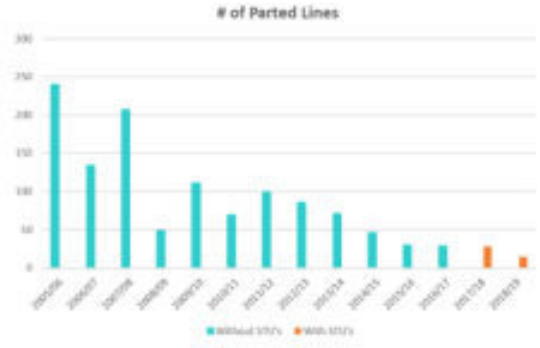
The cylindrically shaped ShoreTension® exerts the same, constant tension to the ship's mooring lines which are fastened to the bollards on the quay. This requires no electricity except for an external hydraulic system which only needs to be used once to get ShoreTension® at the correct setting. After that, the cylinder of ShoreTension® hydraulically moves along with the forces which the mooring line is exposed to. This process continues perpetually without the need for additional energy.

ShoreTension® aims to keep all mooring lines at the same, constant tension, also in case of swell, waves, wind and passing vessels - particularly crucial for the safe and stable mooring of vessels. It is the differences in tension between the different mooring lines which cause a ship to move and potentially cause the mooring lines to snap.

STU® - Geraldton Port

The Port of Geraldton received a spike in harbour surge events post the dredging campaign completed in 2003. This resulted in a significant increase in parted mooring lines (240 reported in 2005/06).

In response, the Port of Geraldton closed berths in severe periods of surge, reducing the number of parted mooring lines to 29 in 2016/17. However, significant delays in the berthing and loading of vessels emerged, with vessels often returning to anchor during extreme surge events. These delays increased the costs for customers and vessel owners to ship cargo through the Port of Geraldton.



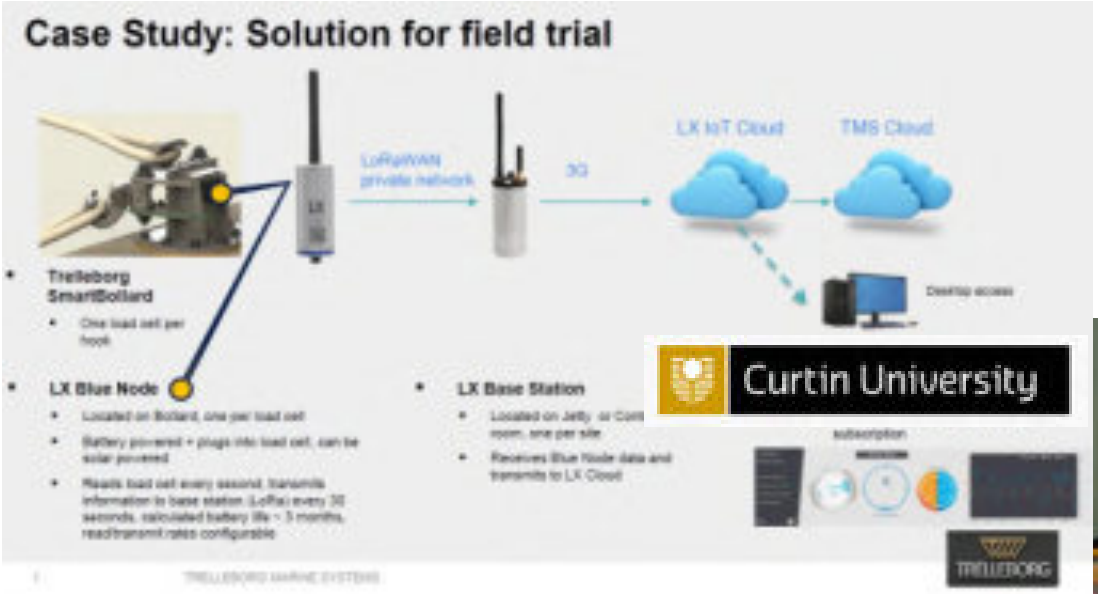
MWPA purchased two sets of 2x STUs in 2017 to reduce the impact of surge events on port operations from ShoreTension B.V. The STUs are mechanical devices, placed on the quay to prevent vessels from surging along the berth in periods of severe weather, reducing the risk of mooring lines parting and personnel being injured or killed.

The STU's have been used 91 times since July 2017 and have proven to be successful solution to the extreme surge experienced at Geraldton. In many cases, it has allowed vessels to continue loading / unloading and has negated the requirement to return to anchor, reducing the potential increase in costs to customers and congestion.

	Cruise ship	Cargo vessel	Cattle Vessel	Times used
Berth 1				0
Berth 2	3		4	7
Berth 3	5	43		48
Berth 4		20		20
Berth 5				0
Berth 6		15	1	16
Total	8	78	5	91

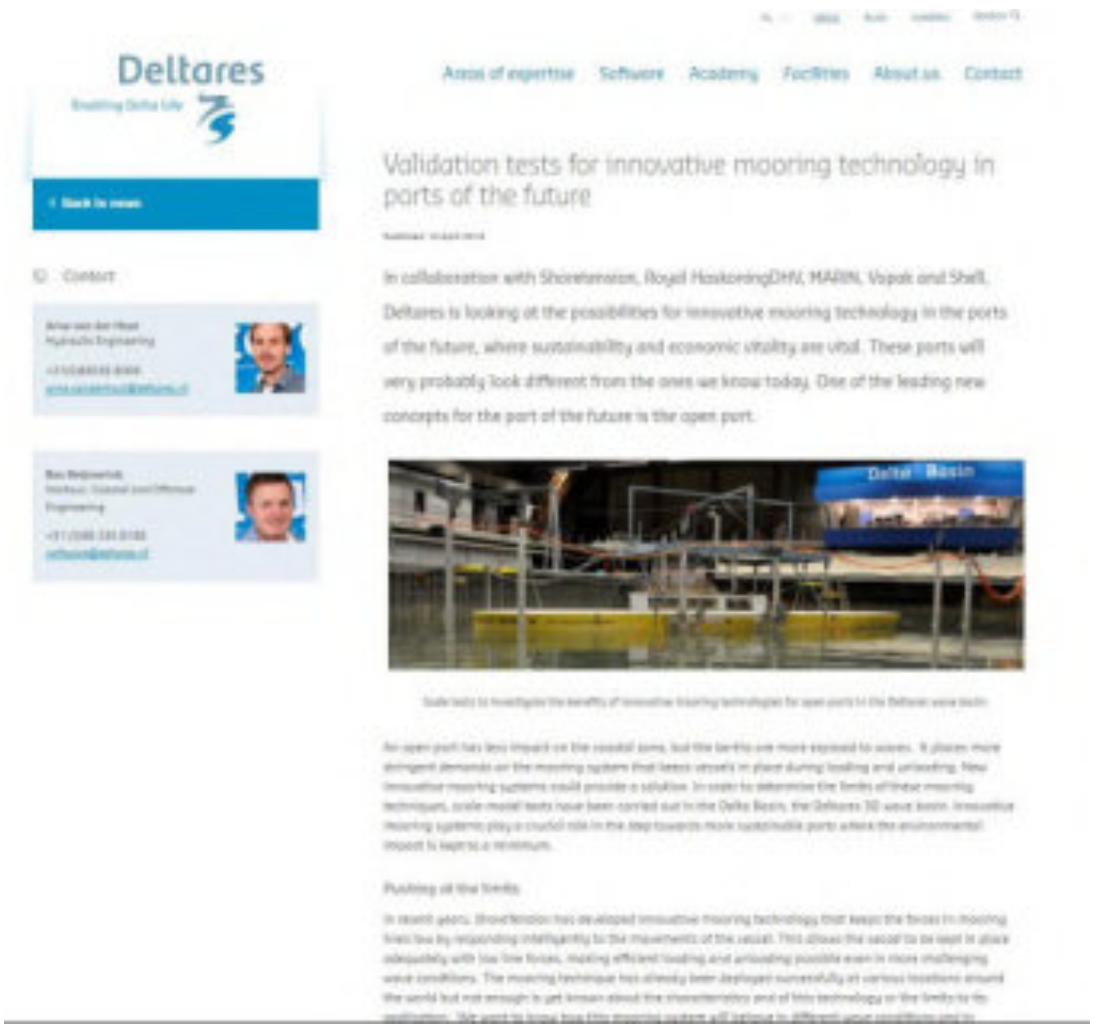
Modern Ship Mooring Techniques - Next Steps

- “Smart Bollards”



- Artificial Intelligence/Machine Learning (Pawsey Supercomputer) -Forecasting
- Accelerometer measurements of berth decks

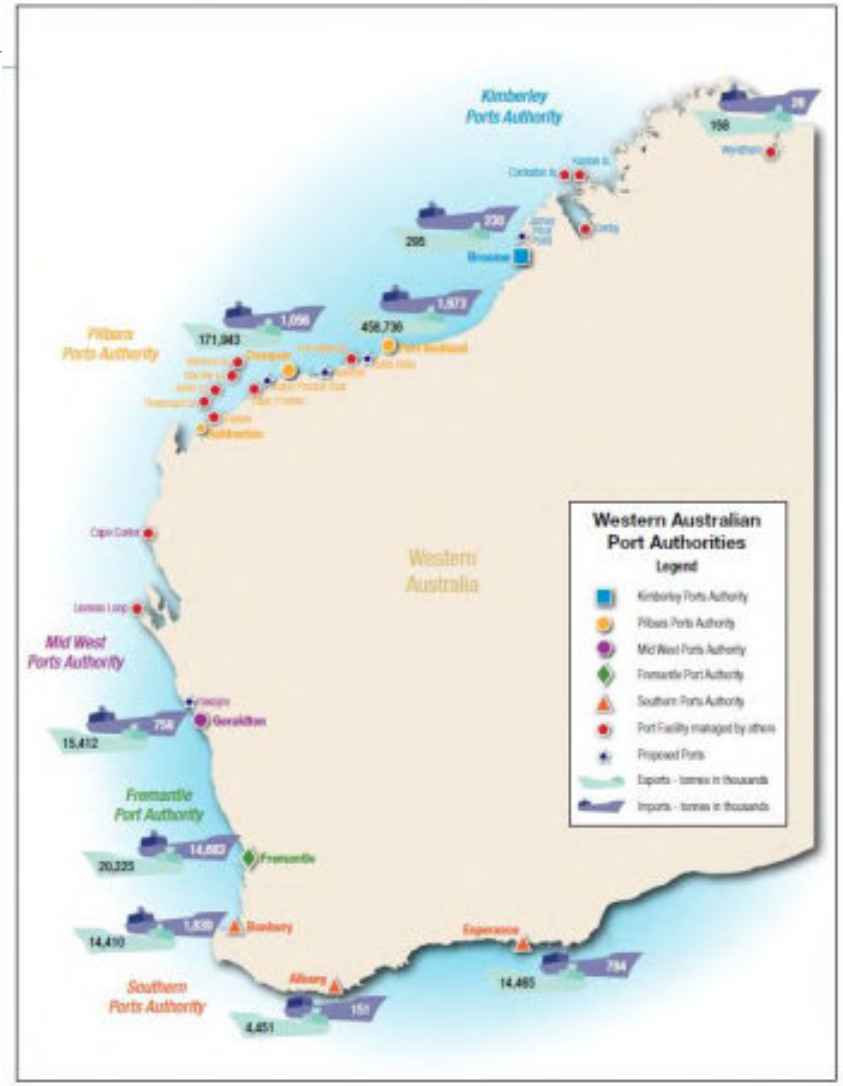
Pushing the limits



Other Applications of Technologies

1. Large Scale ship handling model with Wave Generation (Port Ash)
2. Community Engagement for Port Planning
3. Passive Concrete Cathodic Protection
4. Autonomous Vehicle Monitoring
5. Hydrogen Fuel Trials
6. Remote Site Sensing
7. New lighting technologies - e.g. LED, sensors, timers etc reducing light spill and impact on marine fauna.
8. Monitoring technologies – Drones, remote controlled submersibles, better network capabilities etc making remote sensing more reliable, low impact and safer to operator.
9. Automatic samplers – marine water quality
10. Improved modelling – sediment and dust through dynamic modelling / drifting sensors rather than fixed point. (Artificial Intelligence options) or studies like the ARC Ultrafine Particle grant work – real time dust monitoring / speciation
11. Green energy options - Solar, wind and wave
12. Water efficiencies - harvesting rainwater, desalination and waste water recycling
13. Designing with Nature – solutions for coastal stability and restoration of habitats (sediment traps, dredge / sea dumping, contaminated sites remediation, aqua culture options such as artificial reefs etc)

Western Australian port authorities 2015/16 trade volumes



Community Engagement

- Pre-Project Master Planning Survey – Materiality Matrix

What else?

1. Automation of plant wash downs
2. Self diagnosis of mechanical equipment
3. Calibration of Belt Weighers

The ~~End~~.

Beginning