LIVERPOOL JOHN MOORES UNIVERSITY

Efficiency optimisation to make port operations greener

Prof. Trung Thanh Nguyen T.T.Nguyen@ljmu.ac.uk

Clean Maritime Assembly –June 2025

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Global Centre for Maritime Innovation
LOOM research institute

40 academics
90 researchers

- £10M on-going grants
- Top 2% scientists, top 1% most cited
- 40 international projects (lead 4 EU projects)

Three core areas

- Large maritime engineering systems
- Safety, security, sustainability assessment
- Efficiency optimisation (AI, twins, automation)

UK's only in maritime

- European Research Council grant €2M
- Doctoral training centre £4.9M (w. UoL)
- Place-based Impact Acceleration £2.5M (w. UoL)
- Core research prog. digital twin £4.3M (w. Mdx)

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Global Centre for Maritime Innovation
LOOM research institute

Leading roles

- IAMU, WEGEMT, ESRA.
- UK-Malaysia University Consortium.
- MarRI-UK (autonomous ship)
- Maritime UK

Maritime & Marine Engineering Education

- 1 of 4 UK univ. MSc Maritime Op./Port
- 1 of 10 UK univ. Marine Engineering
- IMechE and CILT accredited
- 3 International Dual PhD programmes

First in maritime

- Equal first UK research impact (%4*/3*, REF 21)
- England first maritime university (200 years)
- UK first 360º bridge + engine simulators
- World-first: Remote port gate, Zero emission SOV (w. Bibby), Digitalised education prog. (with DMU)

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Efficiency optimisation to make port operations greener

An example: the berth allocation problem

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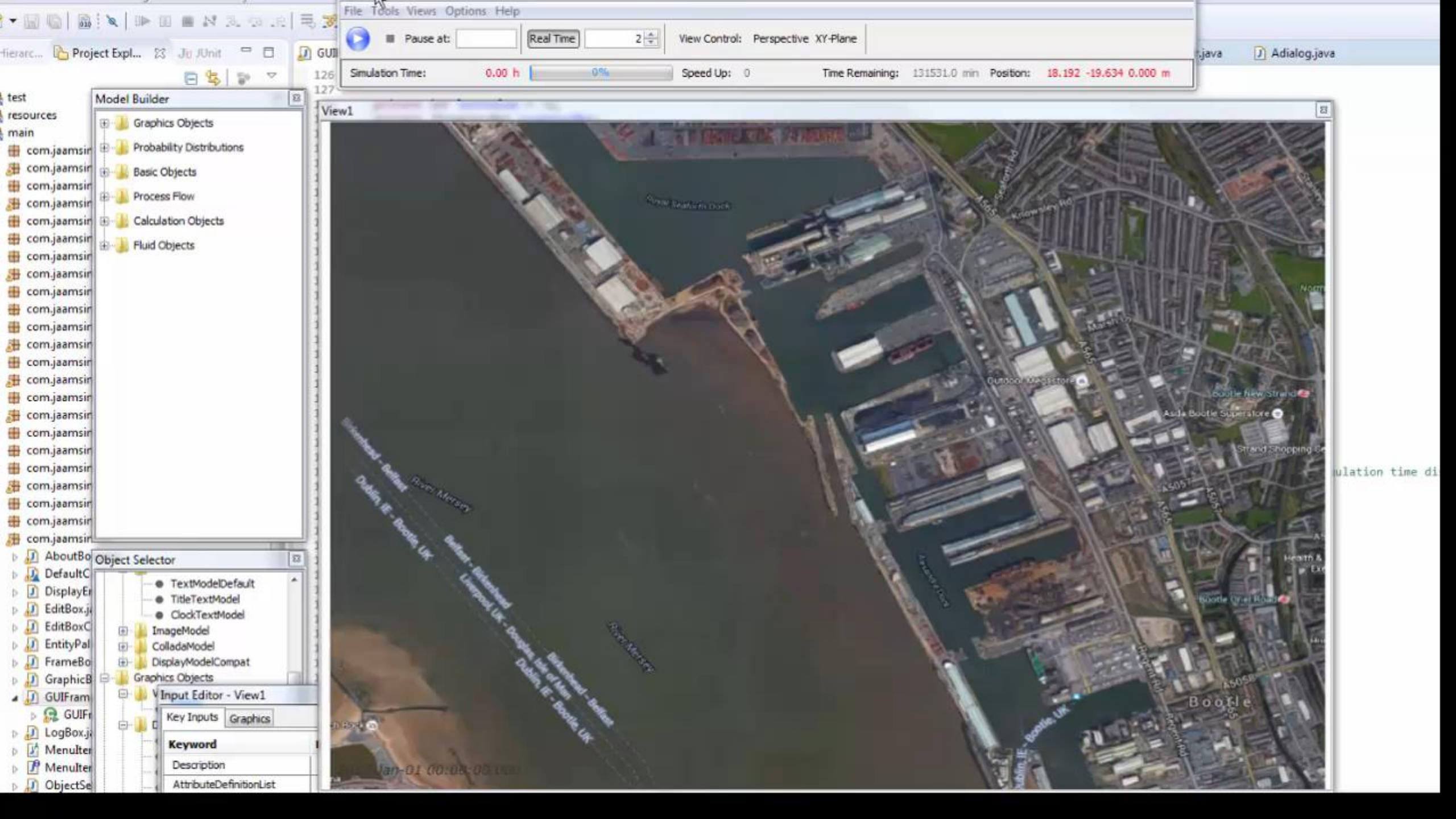
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Pause at:
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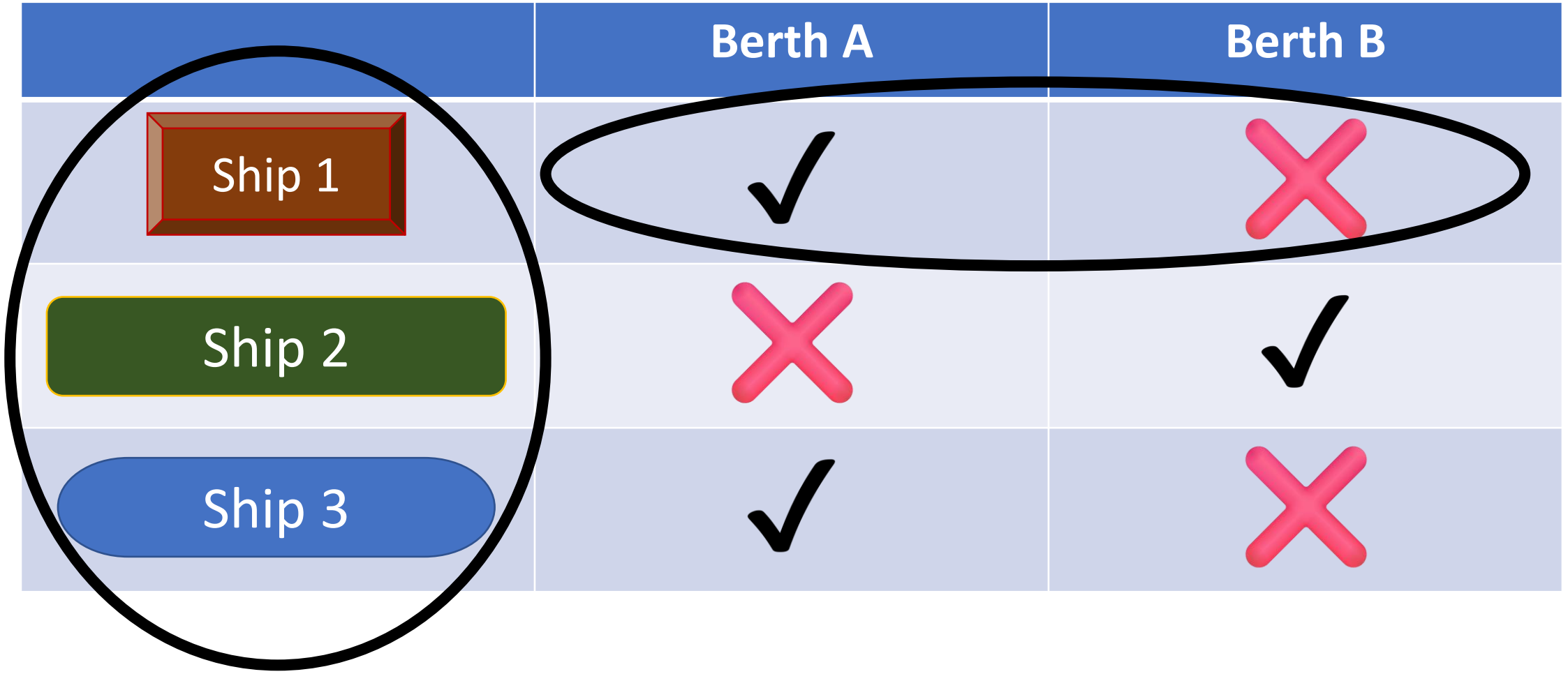
Model Builder
Graphics Objects
Probability Distributions
Basic Objects
Process Flow
Calculation Objects
Fluid Objects
View1
Object Selector
TextModelDefault
TitleTextModel
ClockTextModel
ImageModel
ColladaModel
DisplayModelCompat
Graphics Objects
Input Editor - View1
Key Inputs
Graphics
Keyword
Description
AttributeDefinitionList
Dublin, IE - Bootle, UK
Birkenhead - Belfast
Belfast - Birkenhead
Liverpool, UK - Douglas, Isle of Man
River Mersey
Bootle New Strand
Asda Bootle Superstore
Strand Shopping
Bootle

1	**Cost**	**~40,000 USD per day per vessel** at berth (for an average container ship - Chew *et. al.* (2011))
2	**Time**	**~94% delays** of vessels are due to port/terminal operations (Notteboom, 2006)
3	**Environment**	**3 tonnes CO2 per day (40K DWT)** – Budiyanto (2022) **73-271 kg NOx per day** – Ricardo (2018)

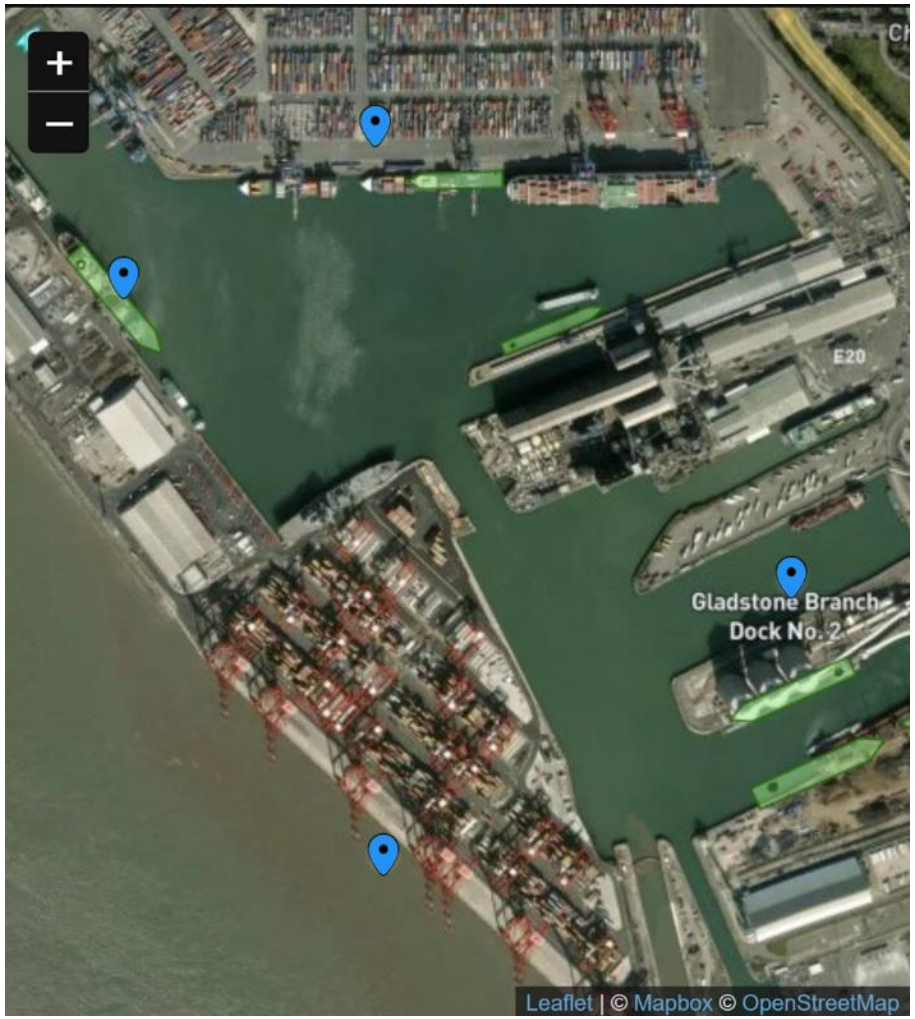
How to allocate berths to vessels?

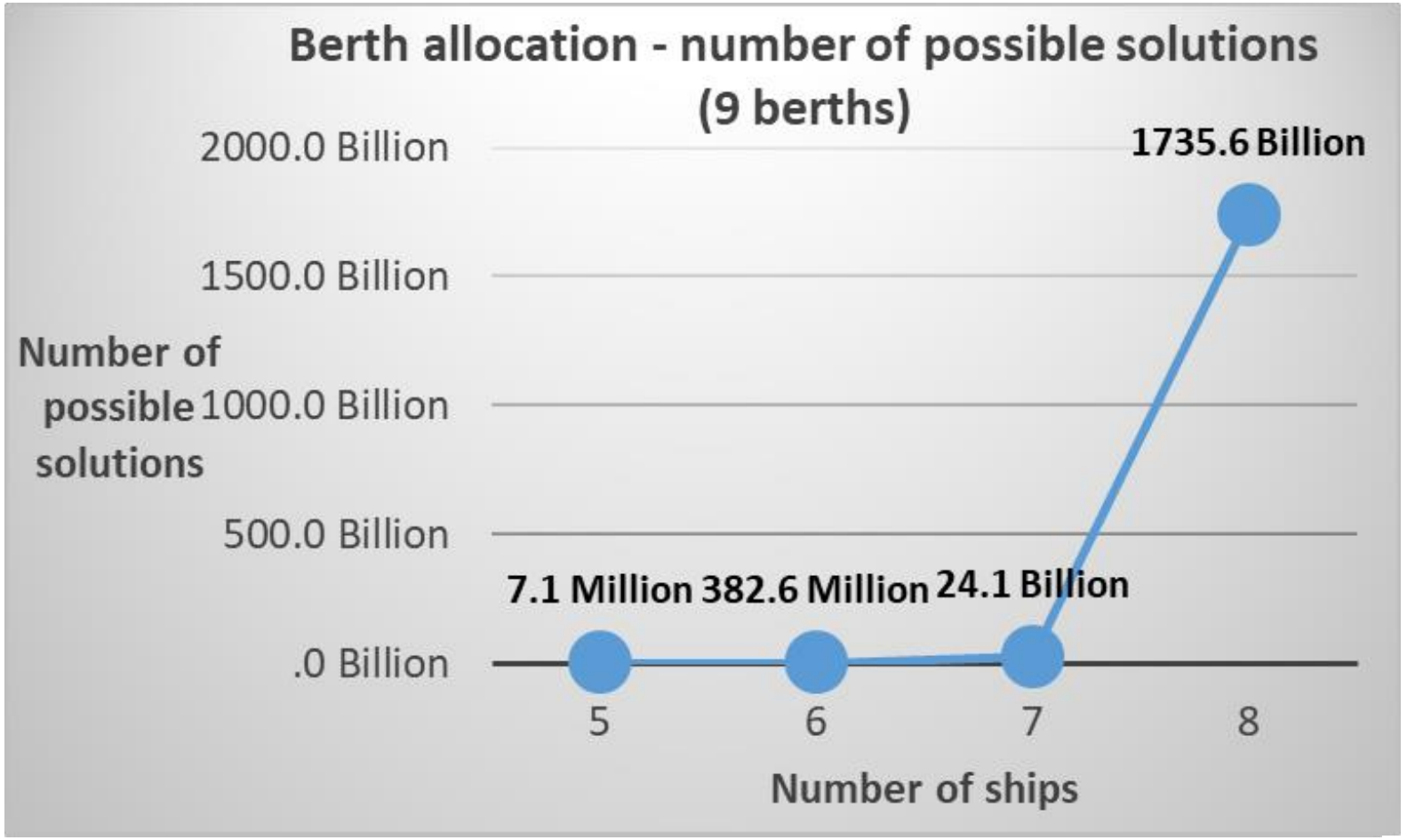


Which berth?

Which order?

Berth allocation for Liverpool, number of possible solutions





Berth allocation for Liverpool, number of possible solutions

$1.35*10^{20}$ solutions.

18 times grains of sand on Earth.

$1.58*10^{22}$ solutions.

1.6 times stars in the universe.

$5.59*10^{39}$ solutions.

13 million trillion trillion times the age of the universe (1 second to find a solution)

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Efficiency optimisation to make port operations greener

Berth allocation – LJMU solution

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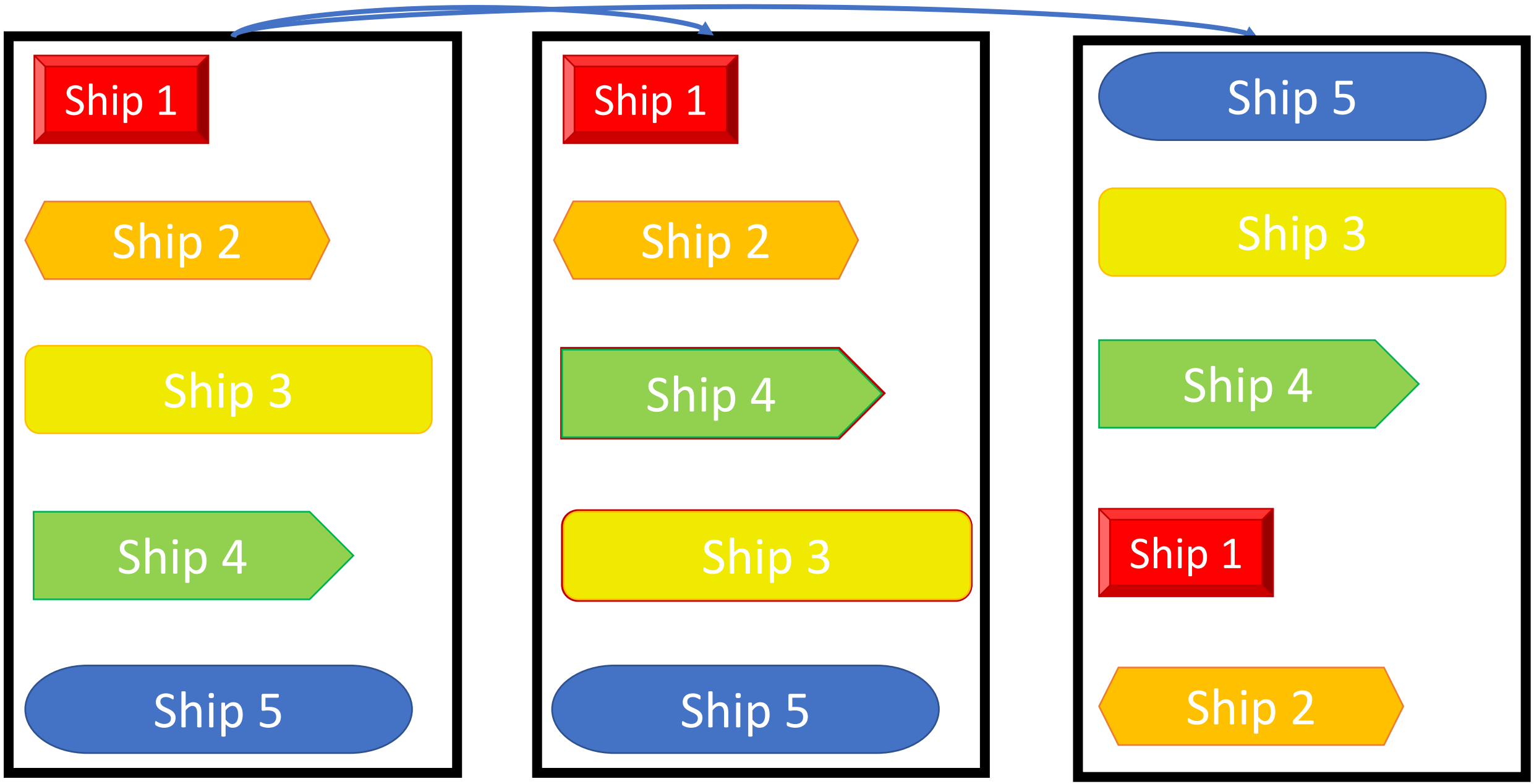
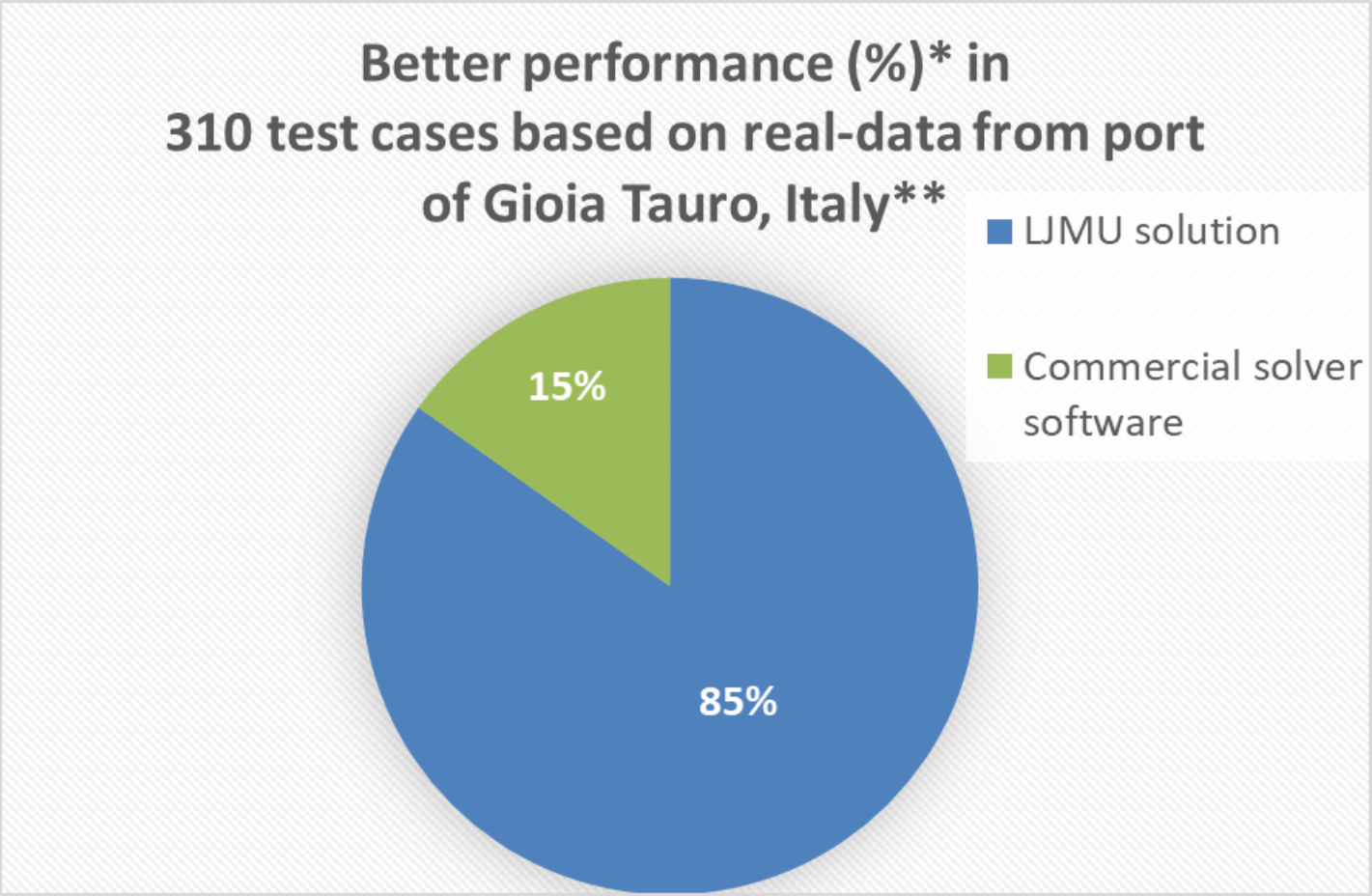

Original
Small Jump
Large Jump
Ship 1
Ship 2
Ship 3
Ship 4
Ship 5
Ship 1
Ship 2
Ship 4
Ship 3
Ship 5
Ship 5
Ship 3
Ship 4
Ship 1
Ship 2

Published in *Swarm and Evolutionary Computation*, 2019, vol. 44, 1003-1017

Reduction in vessel waiting time compared to initial solutions*: Up to 29%



*Better performance means that LJMU solution provides a schedule with the same or smaller cost than the commercial solver (within 5% error) but with a shorter running time.

** Reference: Jean-François Cordeau, Gilbert Laporte, Pasquale Legato, and Luigi Moccia. Models and tabu search heuristics for the berth-allocation problem. Transportation science, 39(4):526–538, 2005.

* Initial solutions are normally randomly generated.

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Efficiency optimisation to make port operations greener

Other areas for optimisation – an example of impact

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LJMU's optimization solutions on a real port

8 ICT Products

- Container stacking
- Berth planning
- Vessel stowage planning
- Port simulation
- Fleet sizing
- Container stuffing
- Congestion at port entrance
- Vehicle routing

Experiments Based on Port Data

▼ 23 %
reduction of cost of container handling

▼ 4.6 %
reduction of CO_2 emissions

▼ 5.5 %
reduction of NOx emissions

▼ 98 %
reduction of ship imbalance

▼ 21 %
reduction of trucks

Thank you!

Q&A?

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CATAPULT
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ENABLING NET ZERO PORTS

Clean Maritime Assembly 2025

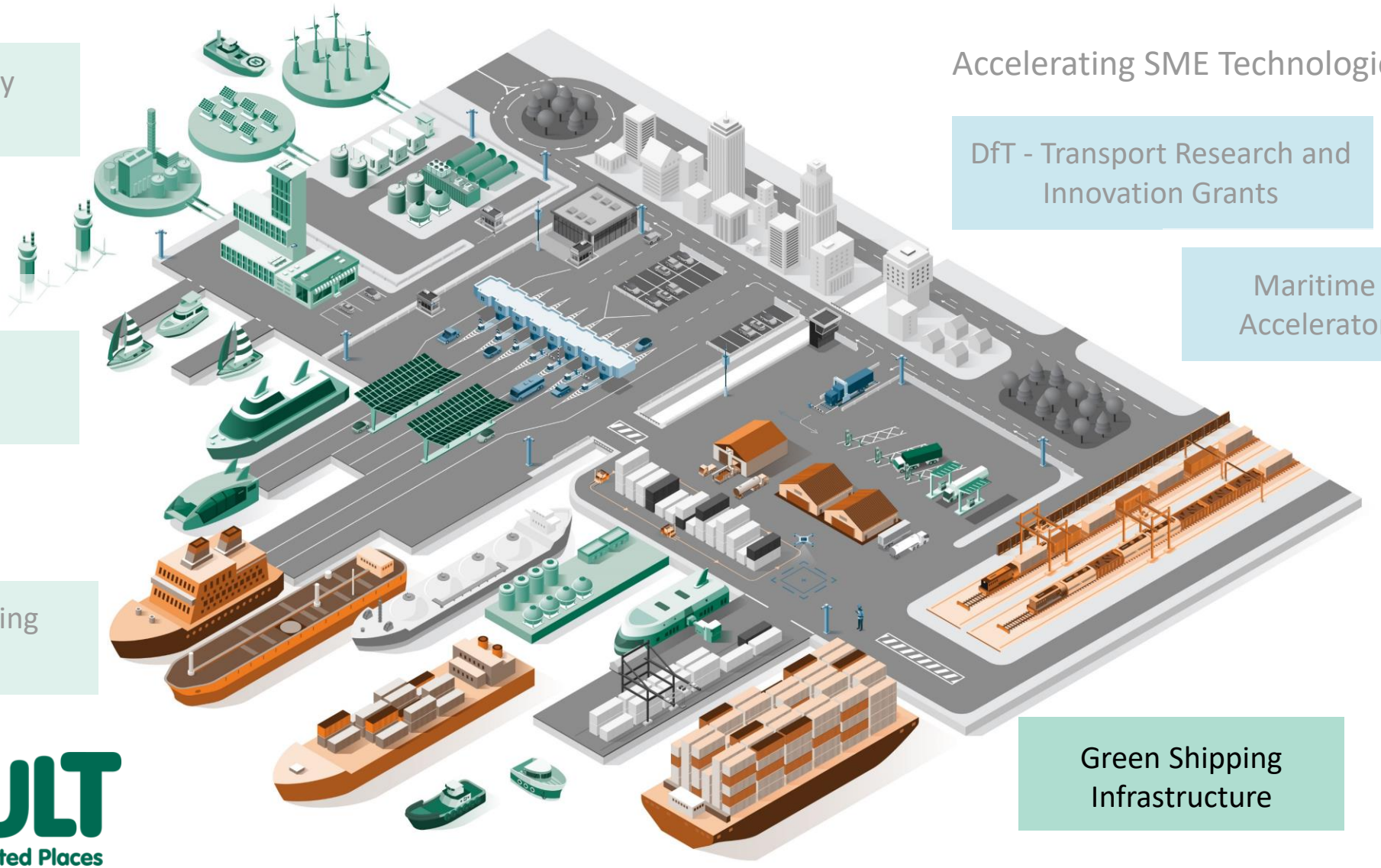
Kirsty Gouck, Maritime Consultant
Connected Places Catapult

ENABLING NET ZERO PORTS

Ports As Energy Hubs

ZEVI - Shore Power

Coastal Shipping



Accelerating SME Technologies

DfT - Transport Research and Innovation Grants

Maritime Accelerator

Green Shipping Infrastructure

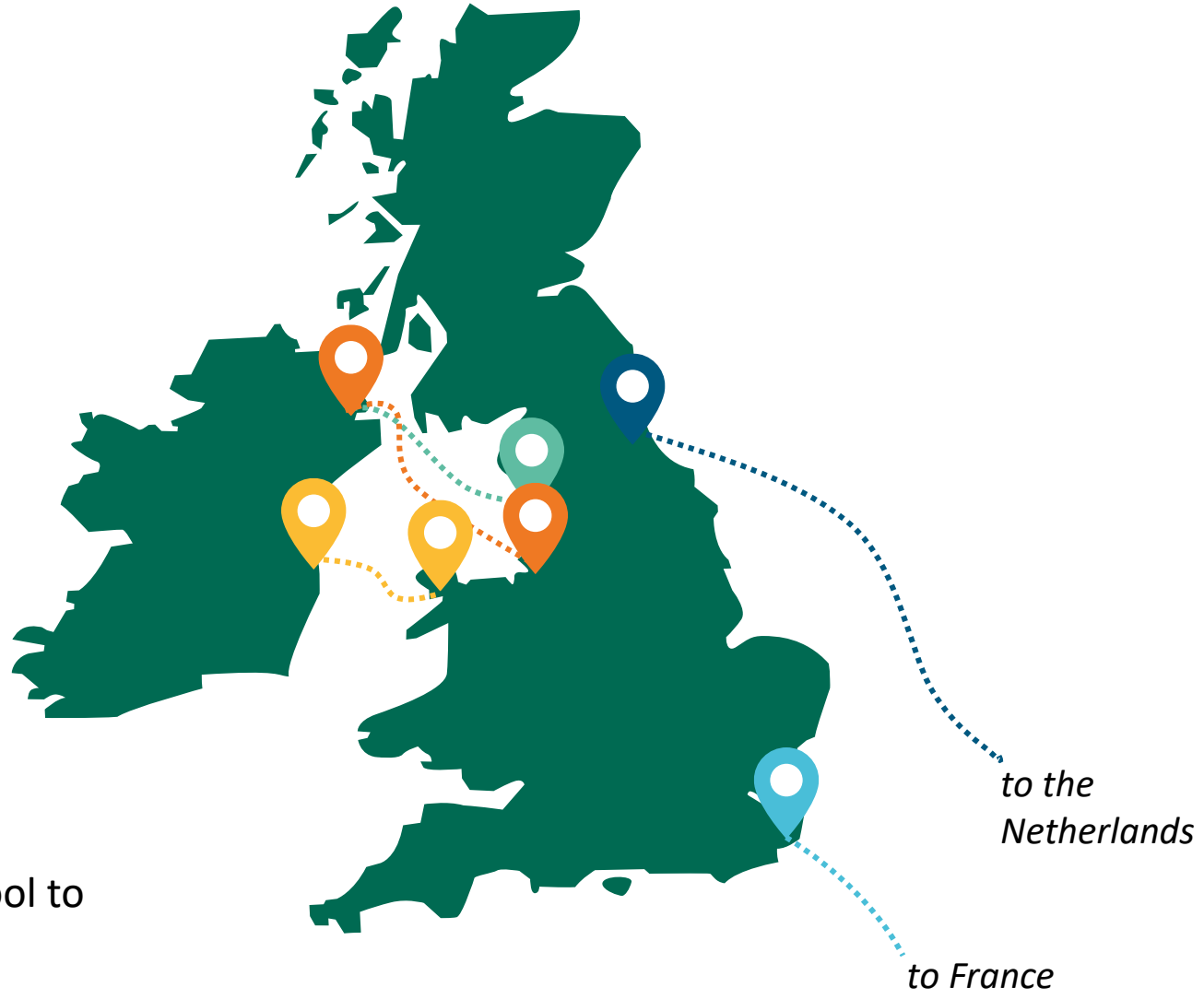
CATAPULT Connected Places

UK GREEN SHIPPING CORRIDOR DEVELOPMENTS

Aligning with the COP26 Clydebank Declaration

- Declaration of intent
- Feasibility studies
- Business cases
- Delivery planning

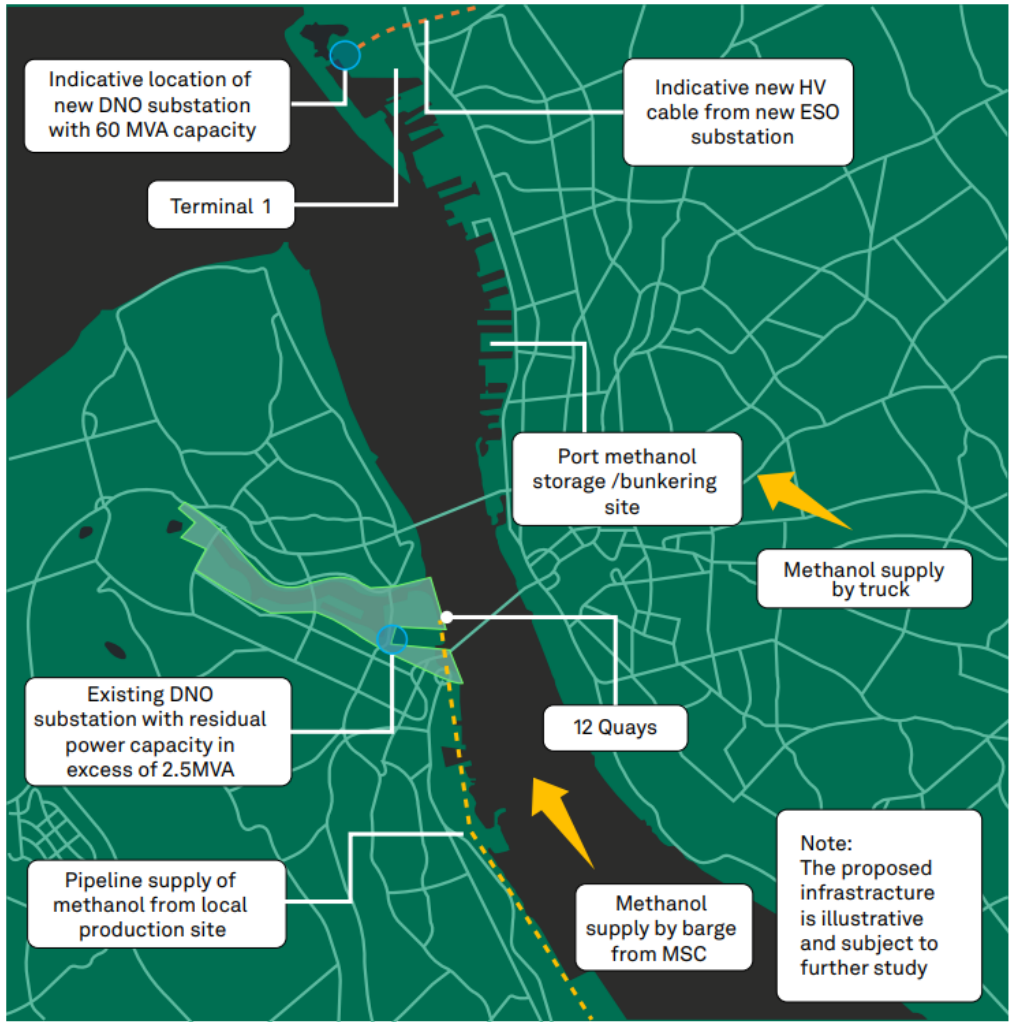
Spotlight on our work to enable a Liverpool to Belfast Green Shipping Corridor

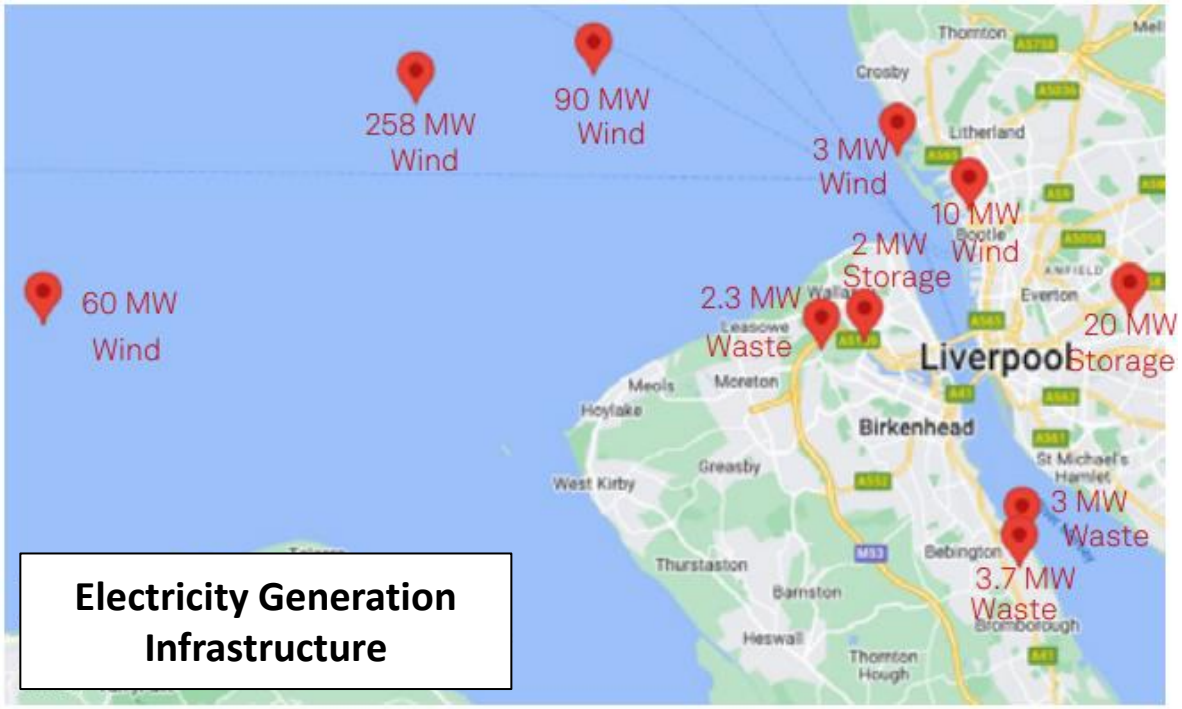


PORT INFRASTRUCTURE CONSIDERATIONS

- Electricity provision and associated cost
- Equipment charging and refuelling infrastructure
- Safe use and storage of new fuels
- Changing vessel calling and trade patterns

SPOTLIGHT: LIVERPOOL



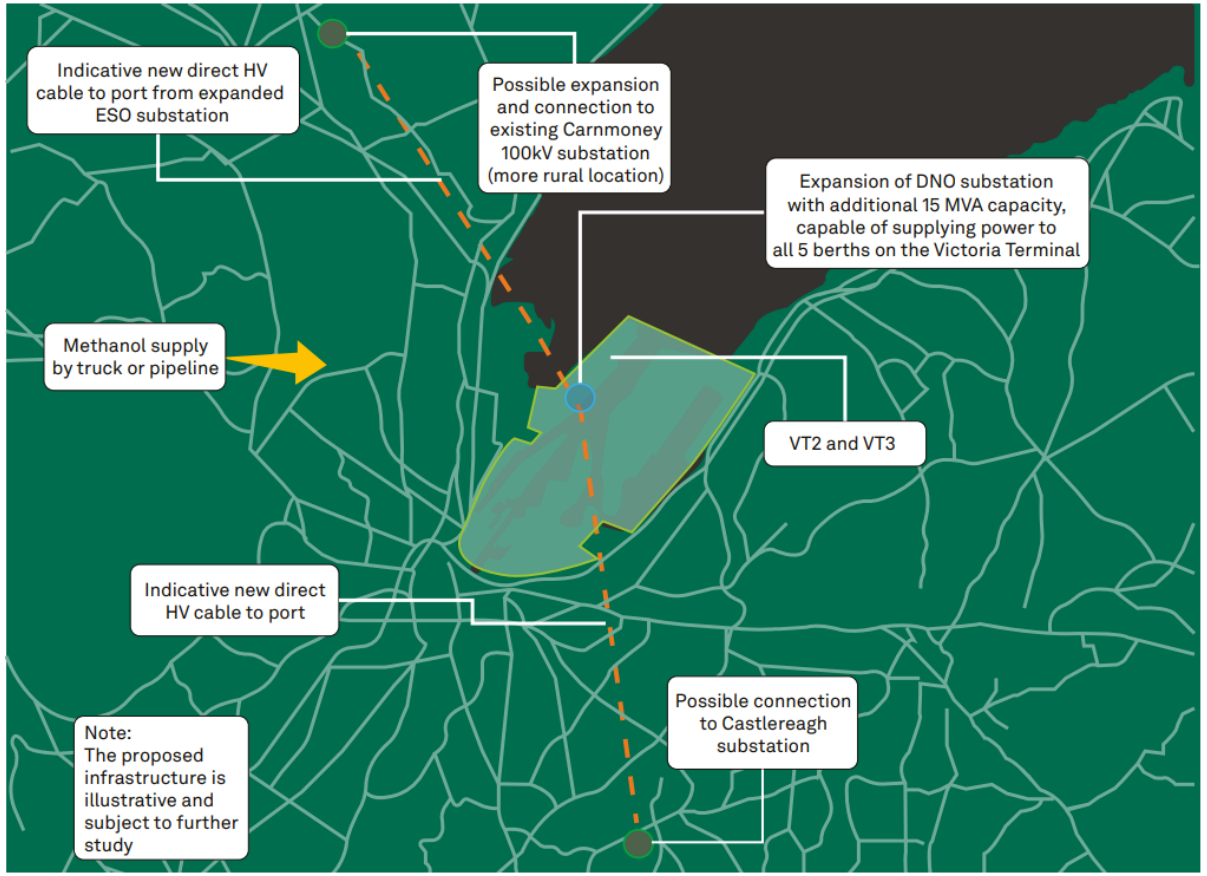


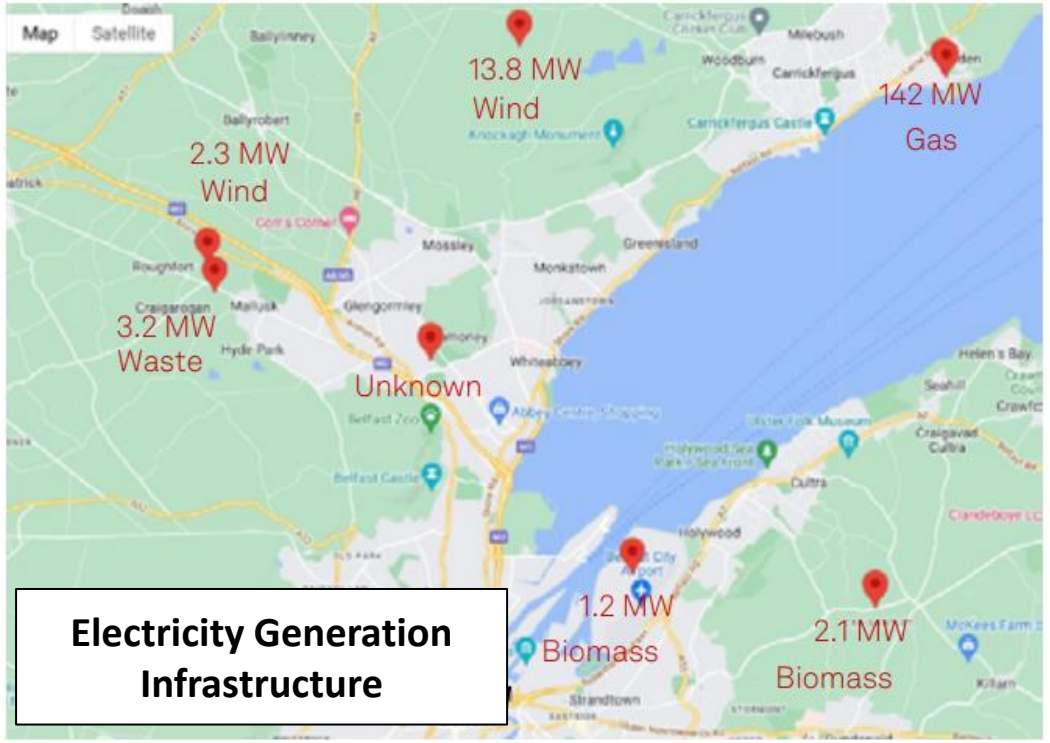
Electricity Generation Infrastructure

Full report available here

Source: Connected Places Catapult (2024), *Liverpool-Belfast Green Shipping Corridor.*

SPOTLIGHT: BELFAST





Electricity Generation Infrastructure

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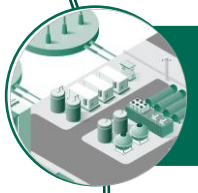
SECTOR PRIORITIES

Demonstration projects to accelerate net zero infrastructure



Net zero fuel regulation development

Improve commercial viability of shore power adoption

Increase availability of clean electricity for ports

Find out more about demonstration projects being explored here:

CATAPULT
Connected Places

THANK YOU

Kirsty Gouck, Maritime Consultant
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For follow up opportunities please contact:

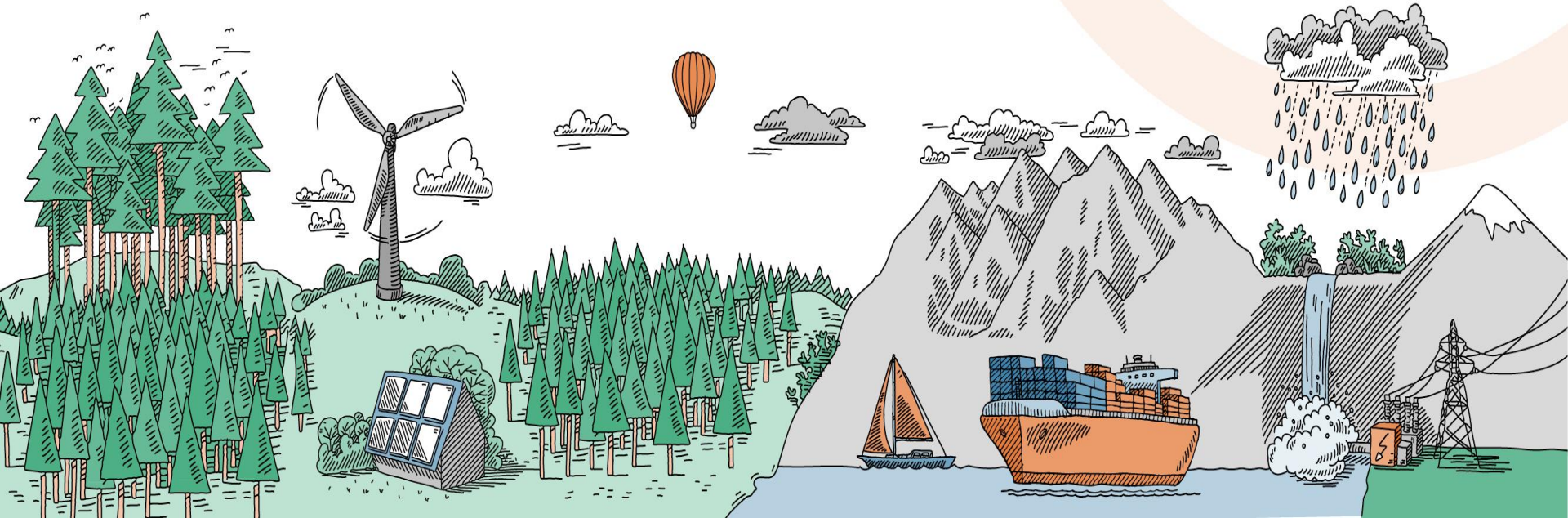
Callum Stone, Maritime Engagement Lead
Callum.Stone@cp.catapult.org.uk

Tyndall Centre for Climate Change Research

The University of Manchester

Decarbonising shipping: the case for focusing on the existing system

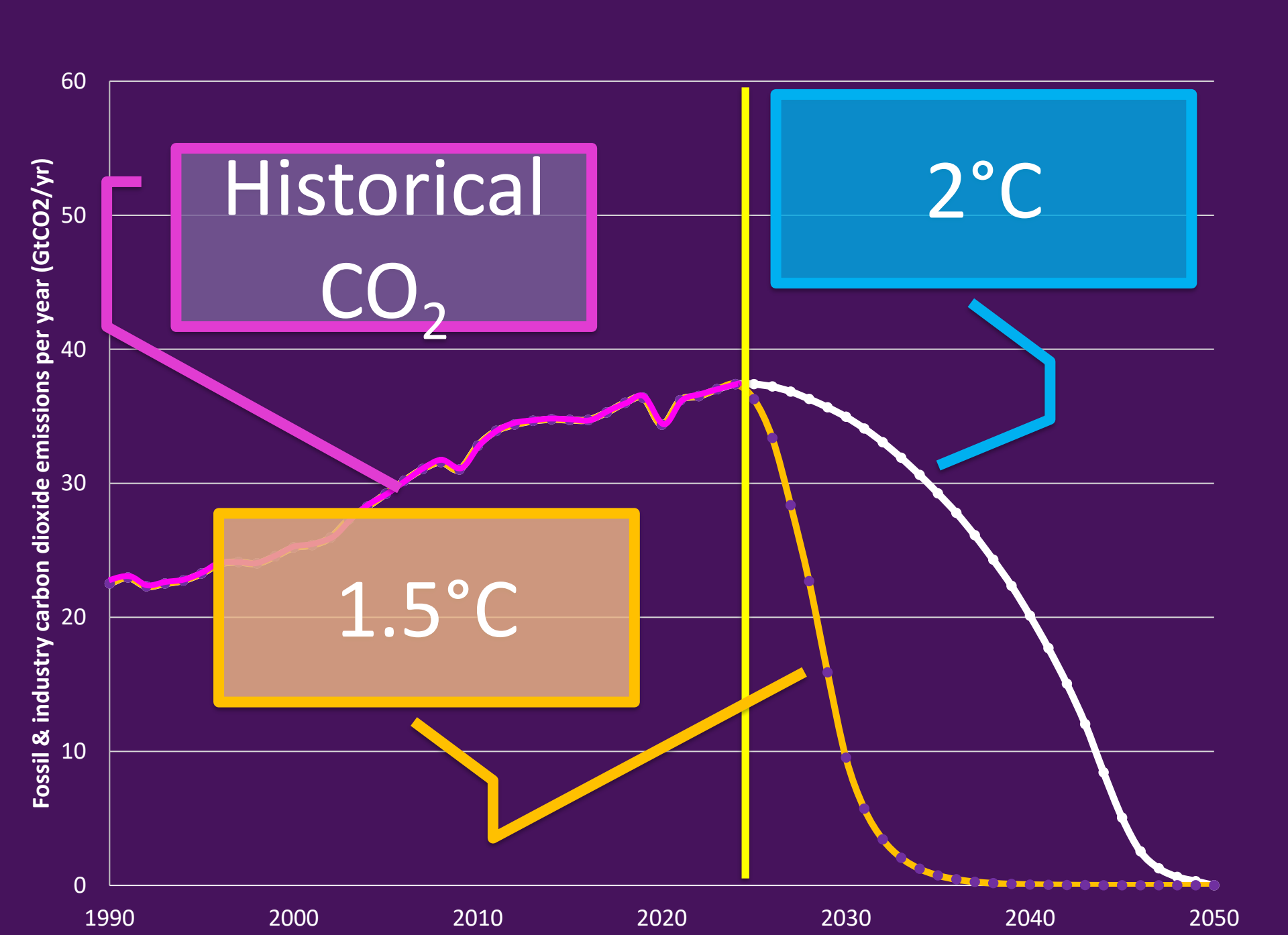
Prof Alice Larkin, Dr Simon Bullock, Dr James Mason, Paolo Della Moglie,
Tyndall Centre, School of Engineering, University of Manchester



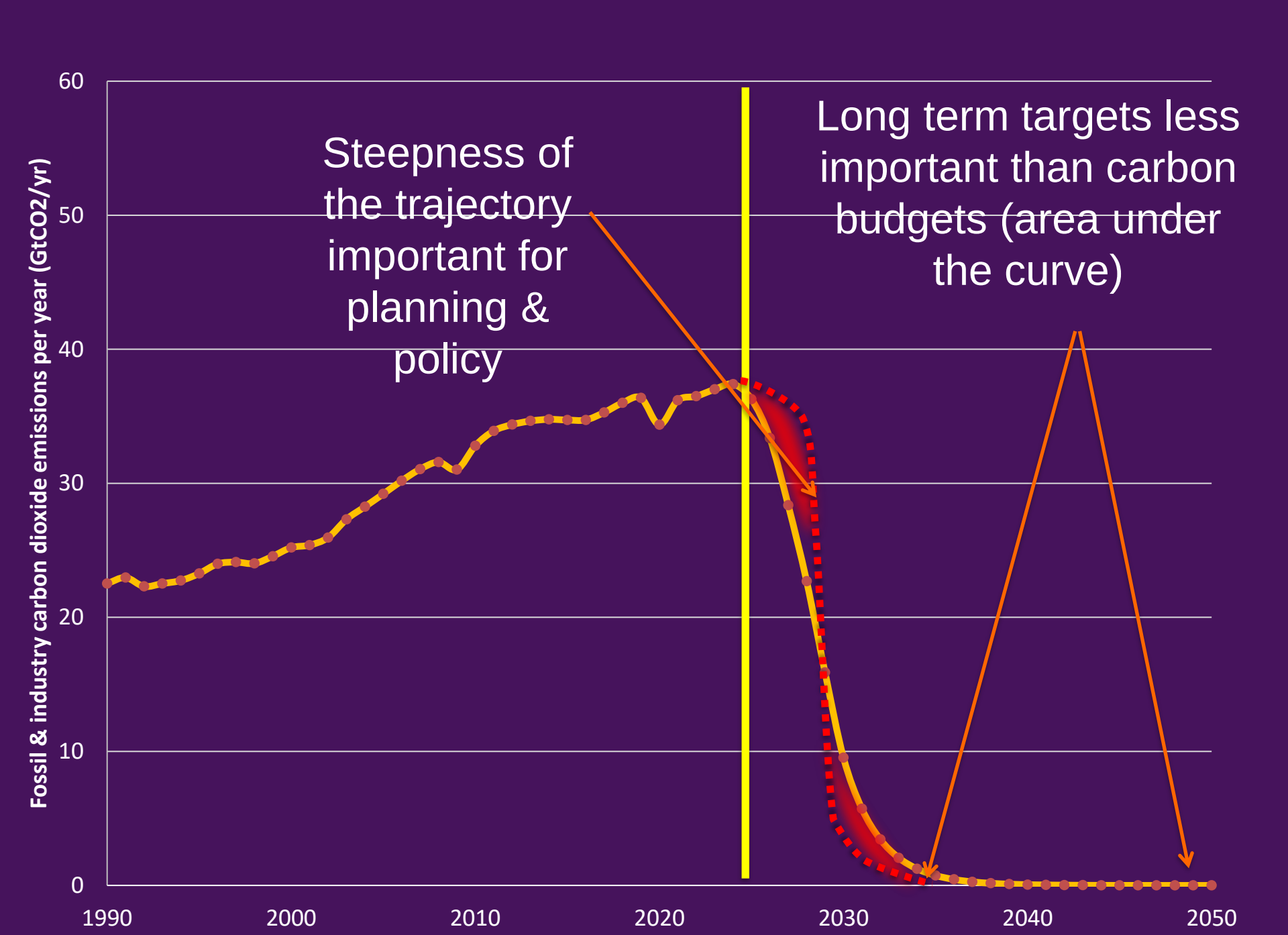
Spoiler take-aways…

1. Retrofit quickly
2. Energy efficiency is no-regrets

Importance of ‘cumulative emissions’



Anderson & Bows(Larkin), 2011, Beyond dangerous climate change: emission scenarios for a new world, *Phil. Trans. R. Soc. A* 2011 369, 20-4, 66% chance of avoiding 2°C. Historical from Friedlingstein.2024.



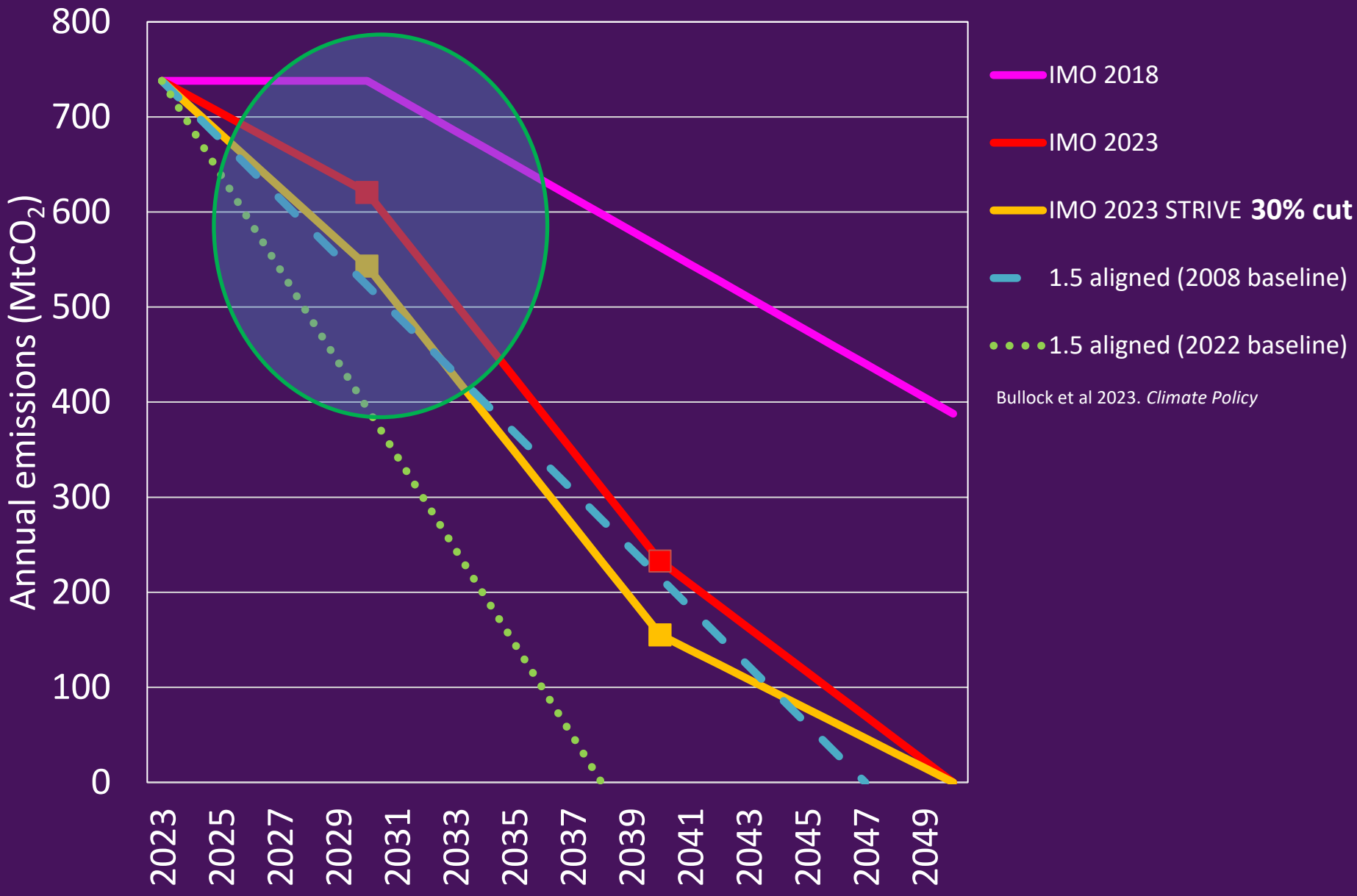
Anderson & Bows(Larkin), 2011, Beyond dangerous climate change: emission scenarios for a new world, *Phil. Trans. R. Soc. A* 2011 369, 20-4, 66% chance of avoiding 2°C. Historical from Friedlingstein.2024.

Implications of climate science

Rolling out large scale infrastructure such as new ports, building a whole fleet of ships, or developing carbon capture and carbon dioxide removal at scale will take decades

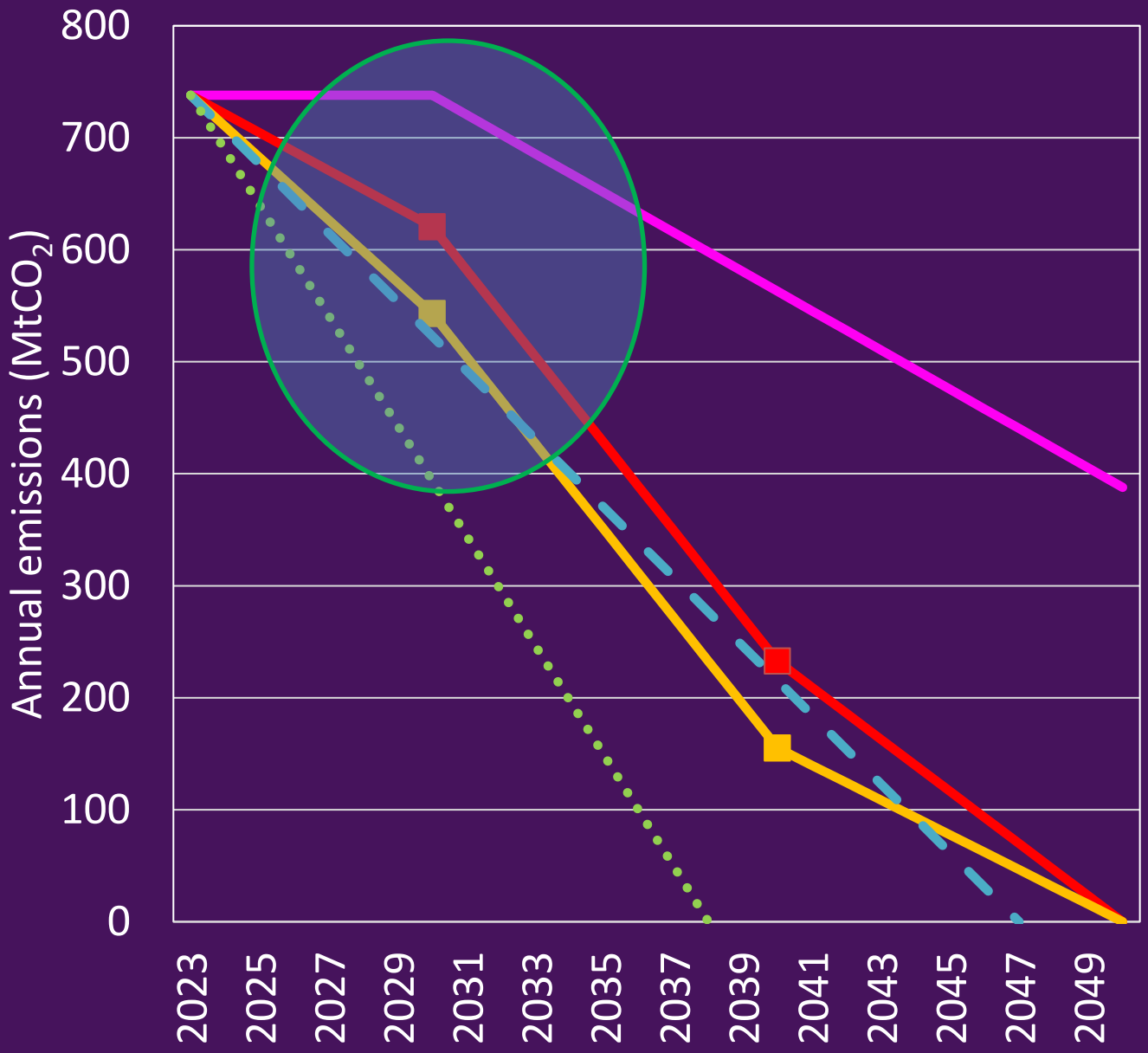
But we have years not decades

Shipping CO_2 goals



Bullock et al 2023. *Climate Policy*

Shipping CO_2 goals



Bullock et al 2023. *Climate Policy*

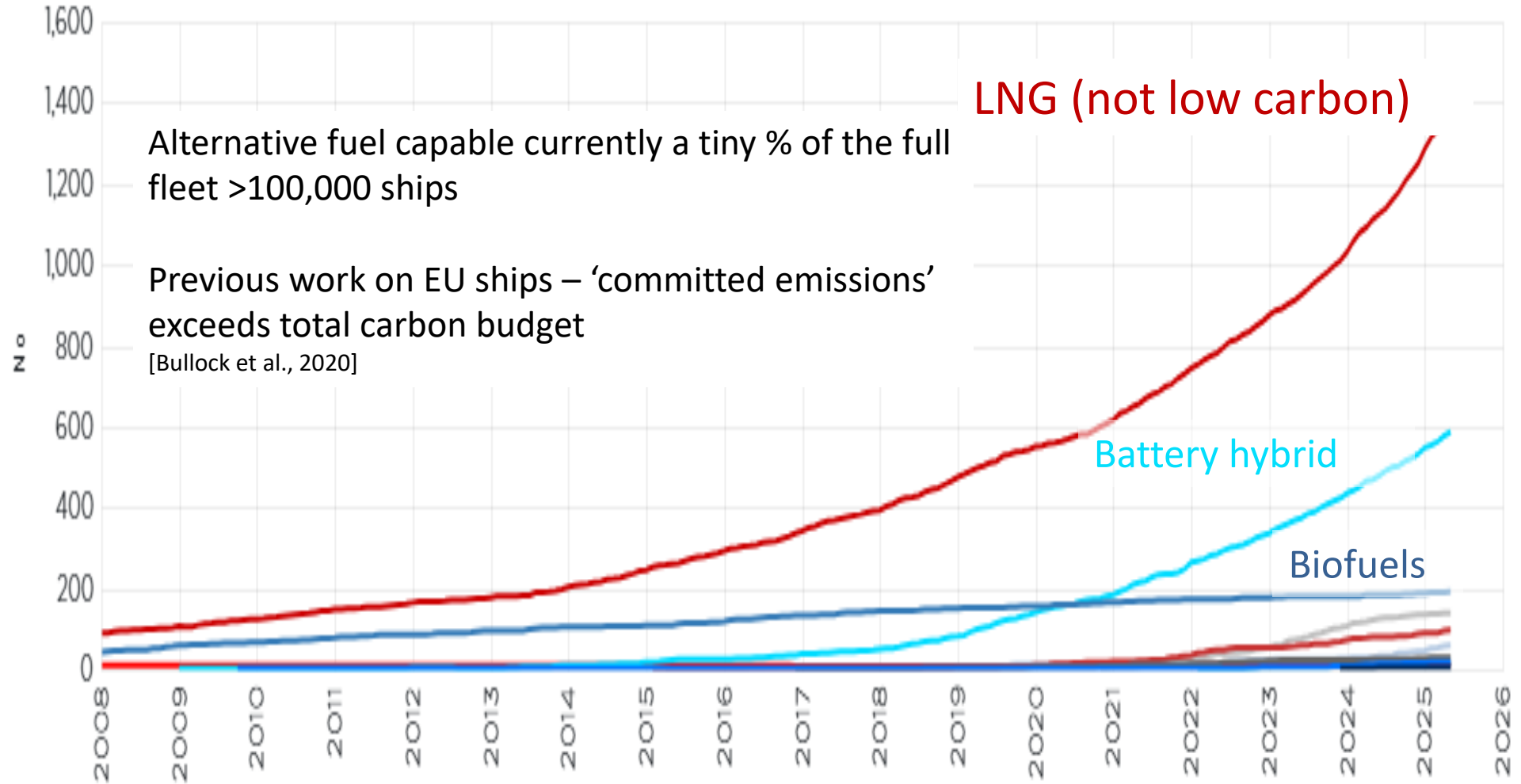
CII target is 40% cut by 2030 from 2008

With current growth and existing CII = *only* 10% absolute cut

Need CII target of **~55%**

Bullock et al 2025. *Climate Policy*

Number of alternative fuel capable ships



Alternative fuel capable currently a tiny % of the full fleet >100,000 ships

Previous work on EU ships – 'committed emissions' exceeds total carbon budget
[Bullock et al., 2020]

Data from Clarksons

What are some of the options to decarbonise shipping quickly?

Wind assist - retrofit

KITES

Can reach higher altitude wind currents

Narrow operational wind angle

FLETTNER ROTORS

Generate lift at wider apparent wind angles

Expensive manufacturing and maintenance

RIGID SAILS

Very low power consumption

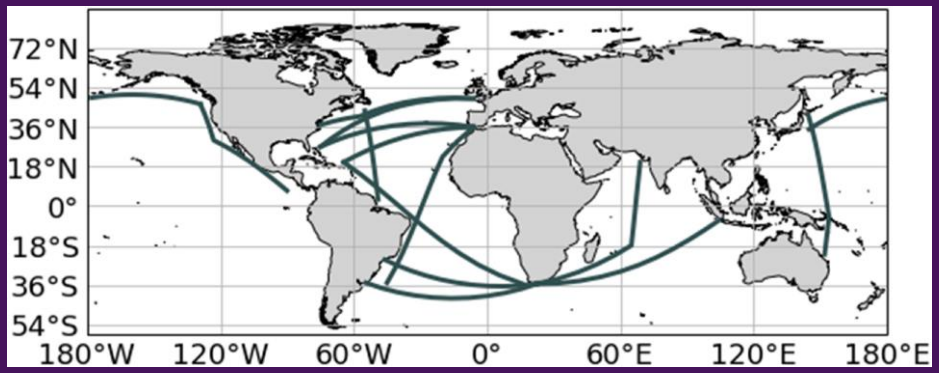
Generate less thrust compared to Flettner Rotors

SUCTION WINGS

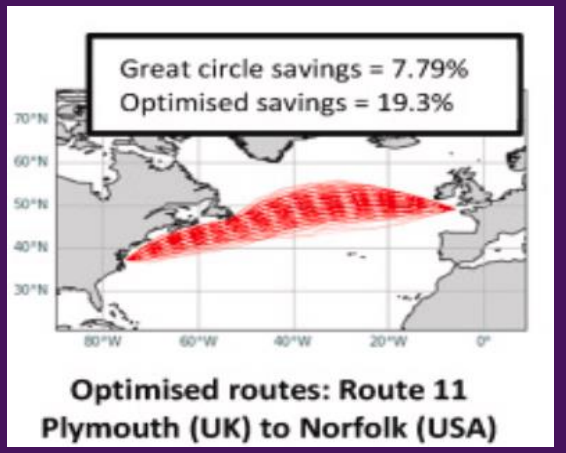
Generate more lift compared to standard rigid sails

Higher power requirement

Wind assist with voyage optimisation

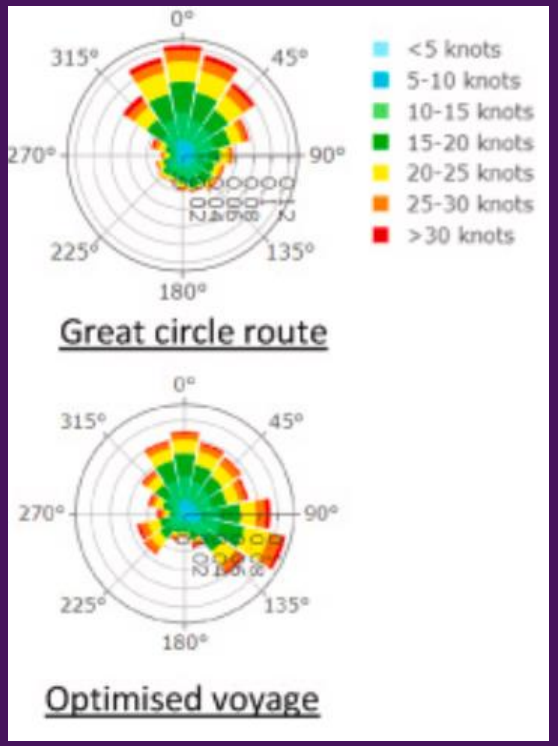


Great circle routes, weather data & performance of Flettner rotors, Mason et al., Marine Policy, 2024, **https://tinyurl.com/Shipwindfull**



Optimised routes: Route 11 Plymouth (UK) to Norfolk (USA)

…"voyage optimisation amplifies carbon saving to over 30% on ideal routes as ships exploit a critical dependency on wind speed and angle." Mason et al., Ocean Engineering, 2024.



Next steps: building in operational aspects – e.g. Blue Visby Solution (P. Della Moglie, Tyndall PGR)

Policy relevance – EU

- FuelEU units are CO_2/MJ so wind-assist is not directly captured
- A wind reward factor has been introduced reducing a ship's GHG intensity by up to 5%
- FuelEU penalty calculated per tonne of fuel burned; energy efficiency devices reduce penalty
- EU ETS also adds costs

Example cases

$2 million per year penalty from EU ETS from 2030
$1 million per year from FuelEU from 2030; rises to $2 million per year for consecutive year compliance failure

[DNV, 80,000 DWT bulker]

Bound4blue estimate wind-assist fuel cost savings of $283k, increased to $532k by 2027 with FuelEU+EU ETS (‘88% saving’)

[17,000 DWT LPG tanker; Antwerp to Houston @15 knots]

More test cases needed to build confidence

Conclusions

Too late to avoid 1.5°C?

Need for damage limitation – aim to avoid 1.6°C or 1.7°C

Current CII will *not* meet IMO absolute targets

CO_2 mitigation needs to focus on existing ships, infrastructure & operations as assets are long-lived

Energy efficiency - 'no-regrets'

Building new is just a small part of the picture

Useful links

Committed ship emissions: Bullock et al., *BMC Energy*, 2020 https://tinyurl.com/CommittedShips

Shipping targets 1: Bullock et al 2022. *Climate Policy*, https://tinyurl.com/IMOClimate

Shore power: Bullock et al., 2023, *Marine Policy*, https://tinyurl.com/SPAberdeen, www.britishports.org.uk/shore-power-tyndall/

Wind-assist: The Conversation, 2023, https://tinyurl.com/shipwindblog

Shipping targets 2: Bullock et al., 2024. *Climate Policy,* http://tinyurl.com/IMOtargets

LCA of fuels: Tomos et al., *Marine Policy*, 2024, https://tinyurl.com/LCABTfull

Wind assist: Mason et al., Marine Policy, 2024**,** https://tinyurl.com/Shipwindfull

Green ammonia barriers: Fullonton et al., *Marine Policy*, 2025 https://tinyurl.com/4mbe397d

Beyond fuel: Bullock et al., 2025, Climate Policy, https://tinyurl.com/BeyondFuel

Thank you

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Smart Operations, a Net Zero enabler

Reduced Power in Manoeuvring

Tuur Killaars - Senior Sustainability Specialist

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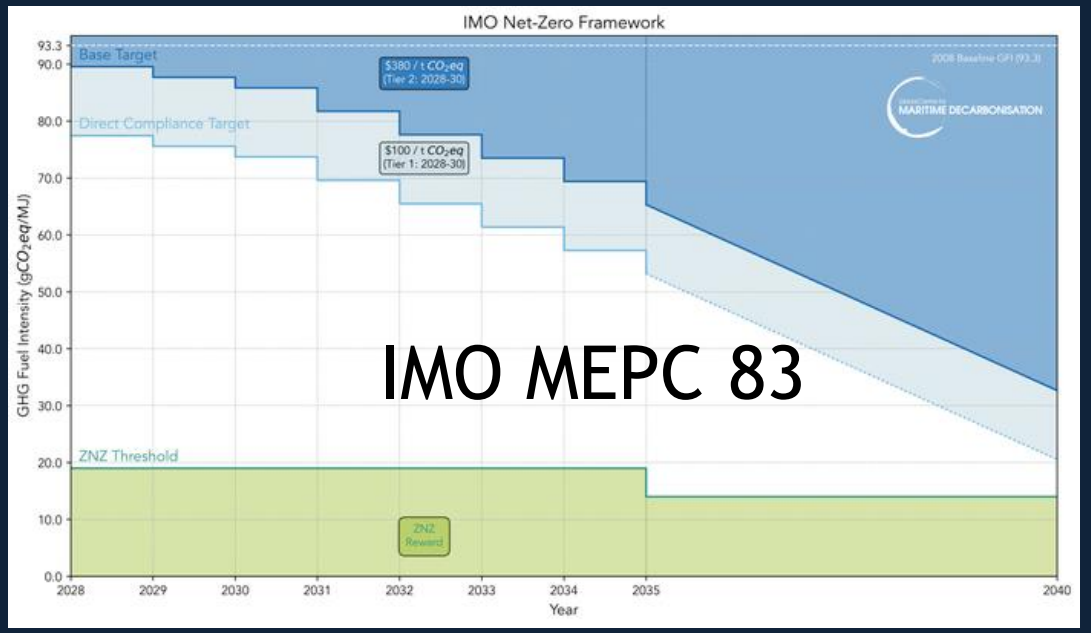
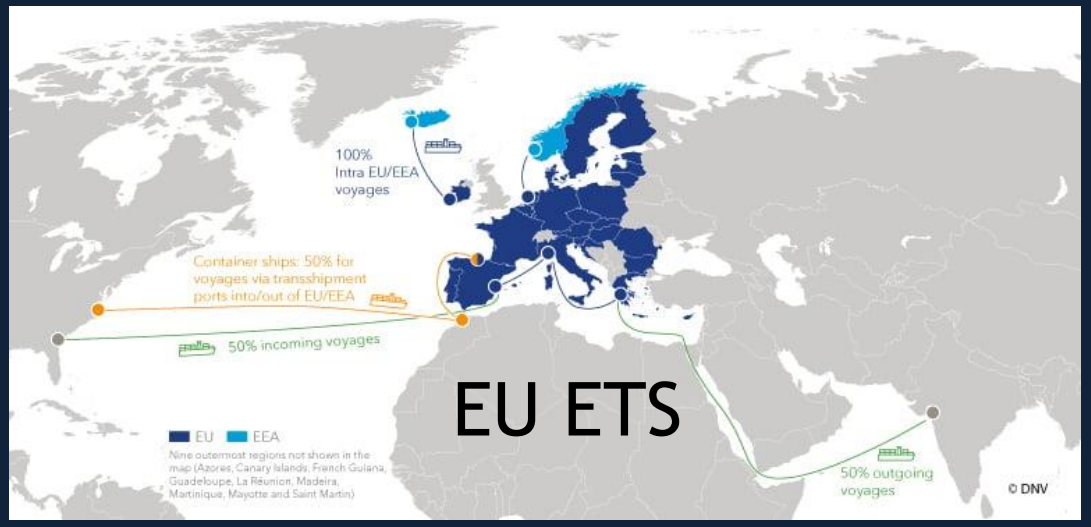
FuelEU Maritime



IMO MEPC 83



EU ETS

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NEWBUILDING

CONVERSIONS

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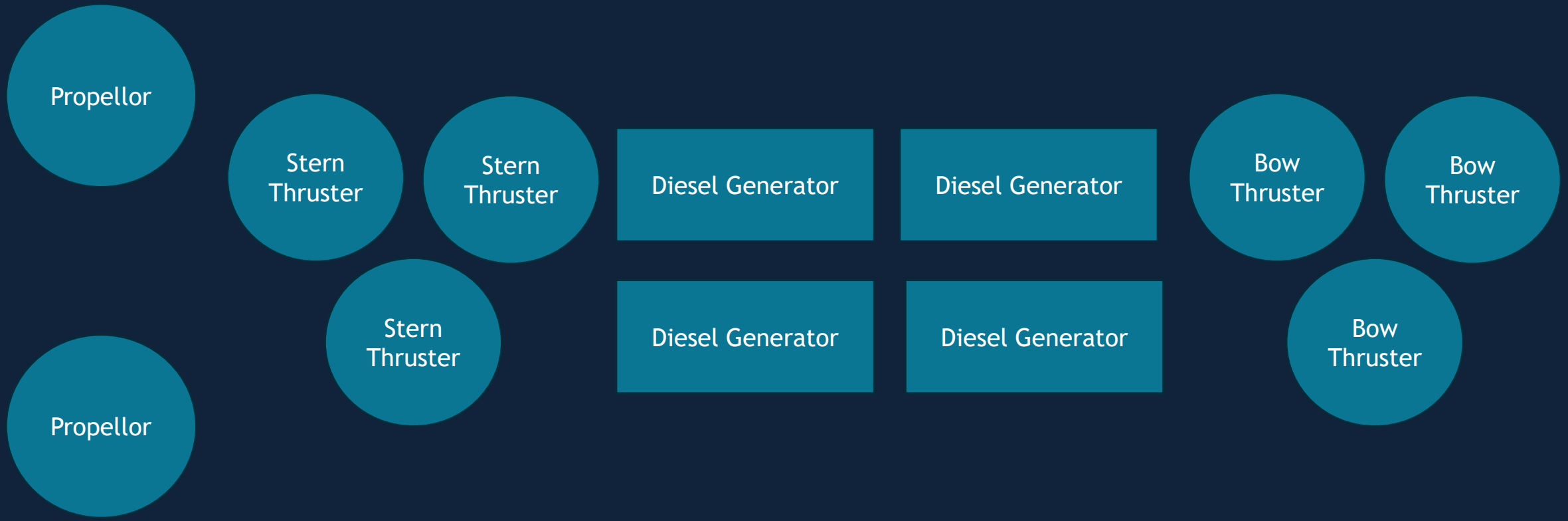
Smart operations example

- Reduced power in manoeuvring
- Analyse detailed operational data to reduce fuel consumption

Reduced power during manoeuvring

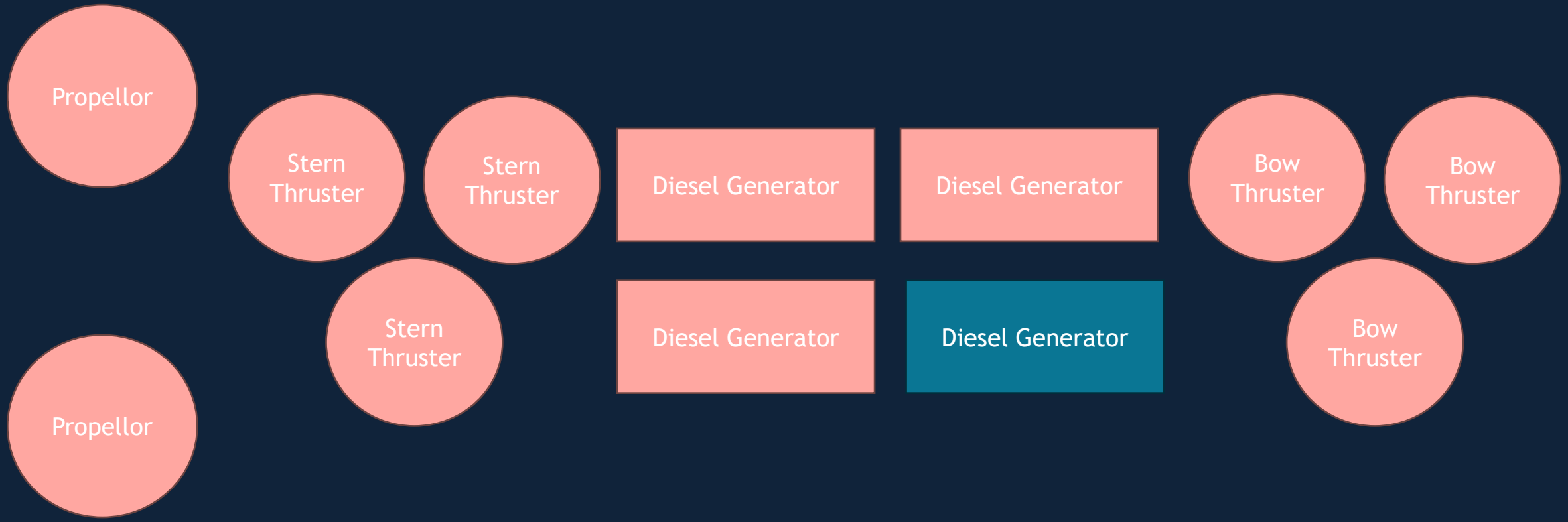
- Cruise ship propulsion system



FORESHIP

Reduced power during manoeuvring

- 3x Diesel generators operate at an average 31.6% engine load => high fuel consumption at low loads



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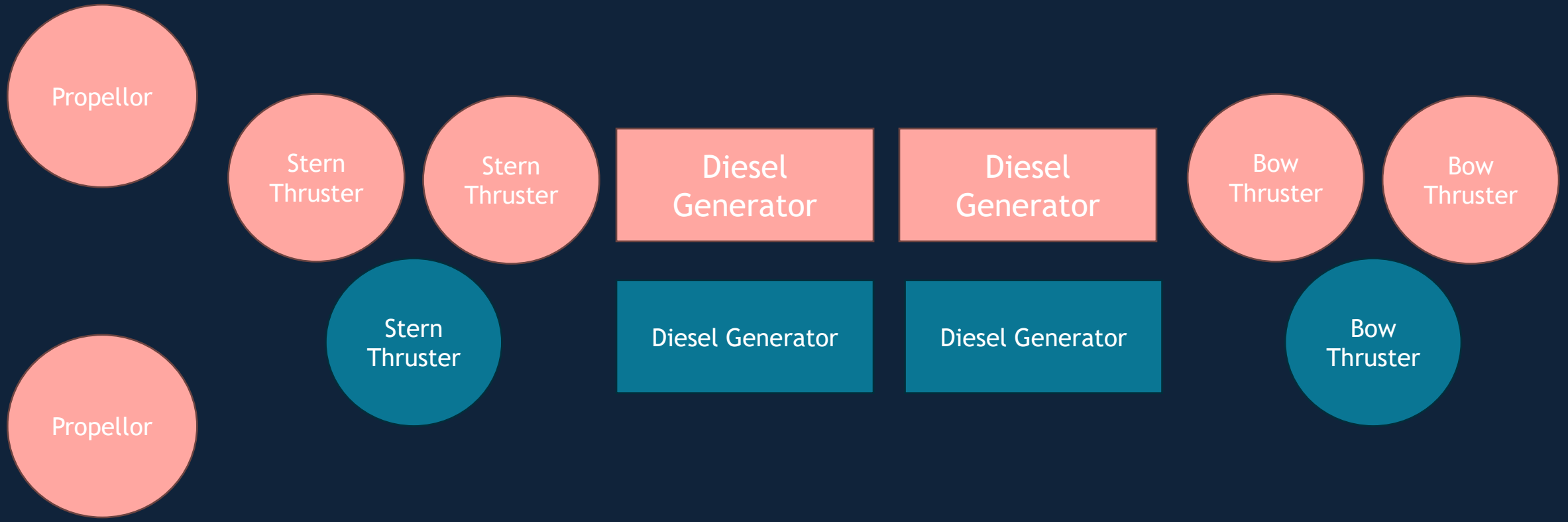
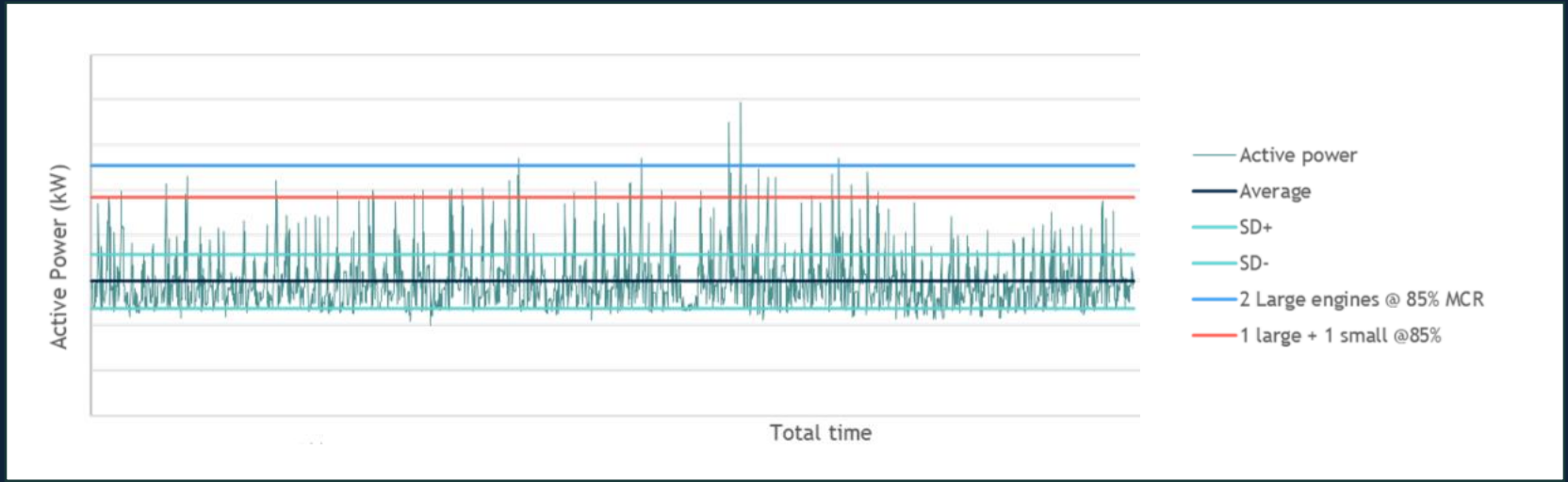
Reduced power during manoeuvring

- 2x Diesel Generators
- Increase average engine load => reduce fuel consumption
- Is this possible?



Operational data analysis

- Approx 1% of time where 2 Diesel Generators are insufficient



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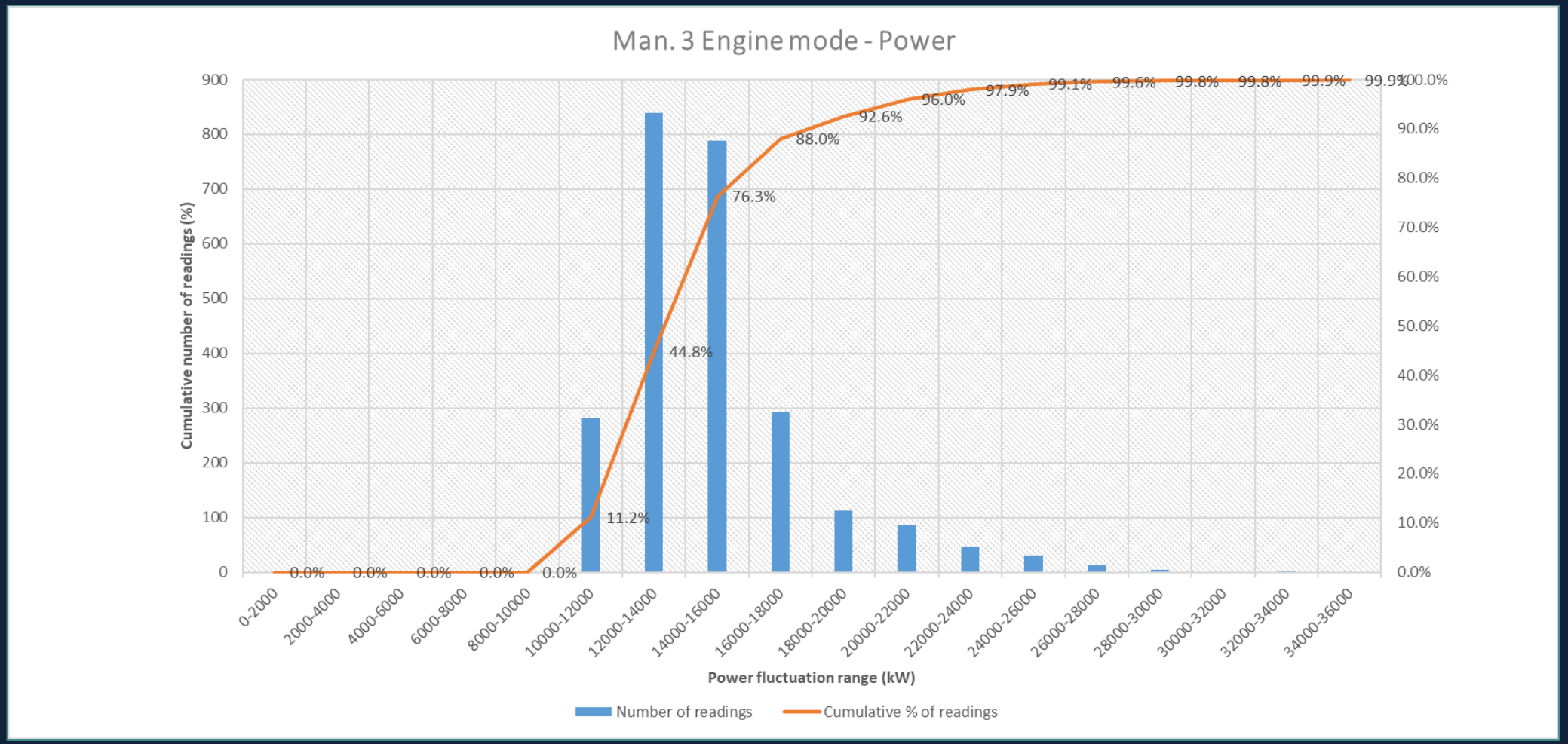
Operational data analysis

- 88% of the time, the power demand is up to 18 MW, with specific ports potentially showing even lower peak demands.



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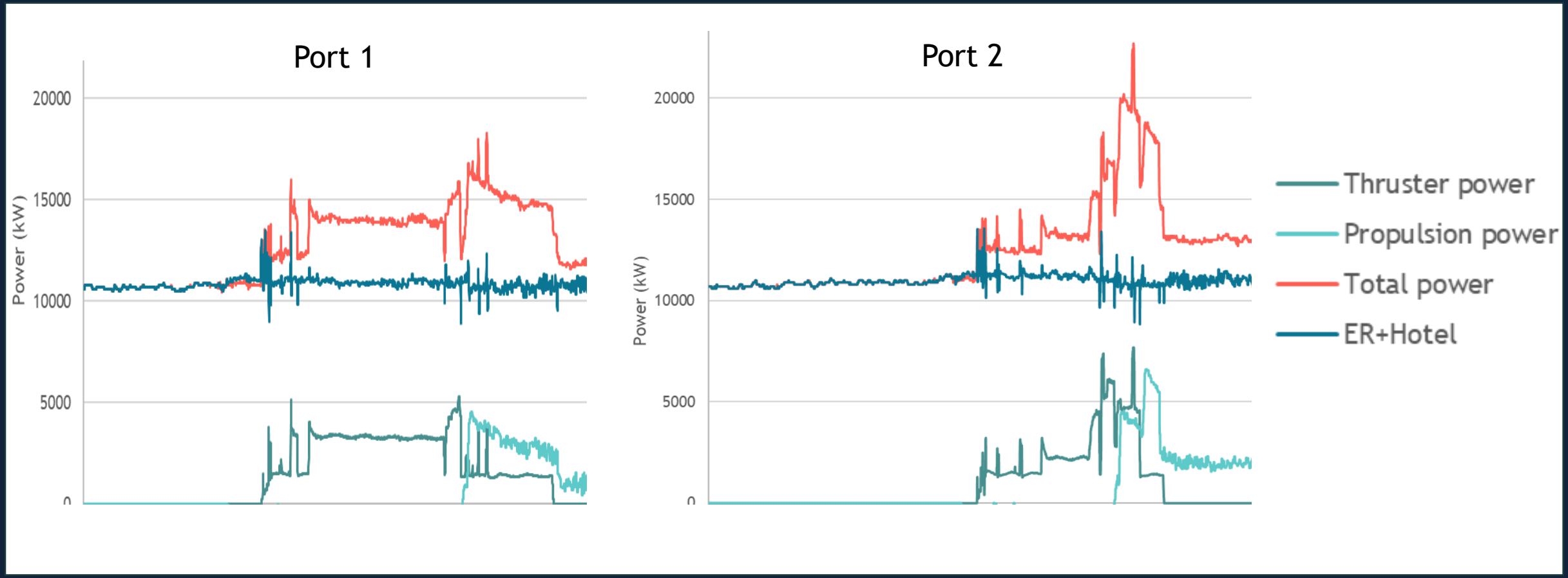
Operational data analysis

- Specific ports



Findings from data

Approx. 10% reduced fuel consumption during manoeuvring

Reserve power to be increased i.e. Battery Energy Storage Systems

Crew behaviour and decision play a significant role on vessel operations

Large discrepancy between design point and actual operations

Operational data enables

Reduced fuel consumption

Analysis of new technologies

Support crew decision making

Improved ship design

FORESHIP

Operational data enables

Reduced fuel consumption

Analysis of new technologies

Support crew decision making

Improved ship design

Path to Net Zero

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HOW DOES DATA & DIGITIZATION DRIVE DECARBONIZATION?

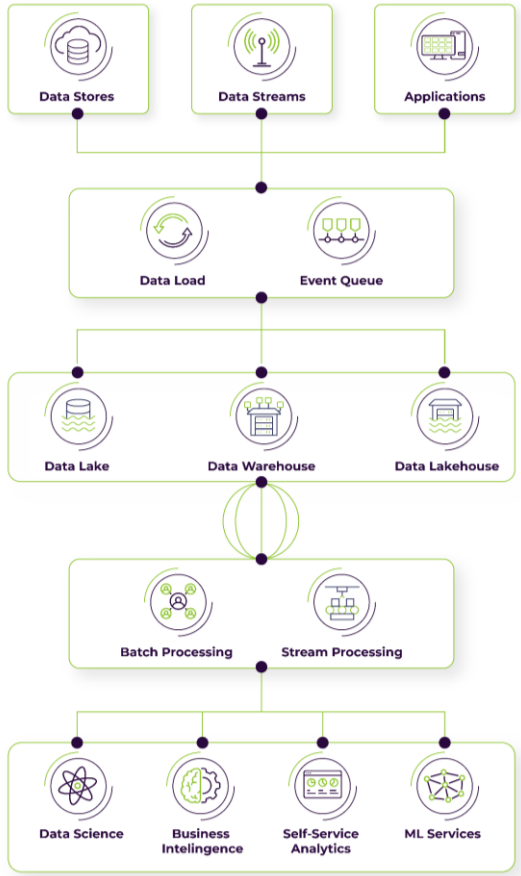
MATTHEW NAPLETON
CCO – ZIZO SOFTWARE

zizo

All organisations are collecting more & more data

When we combine data, we get more insights

COLLECT



COMBINE

CHANGE

CONTEXT

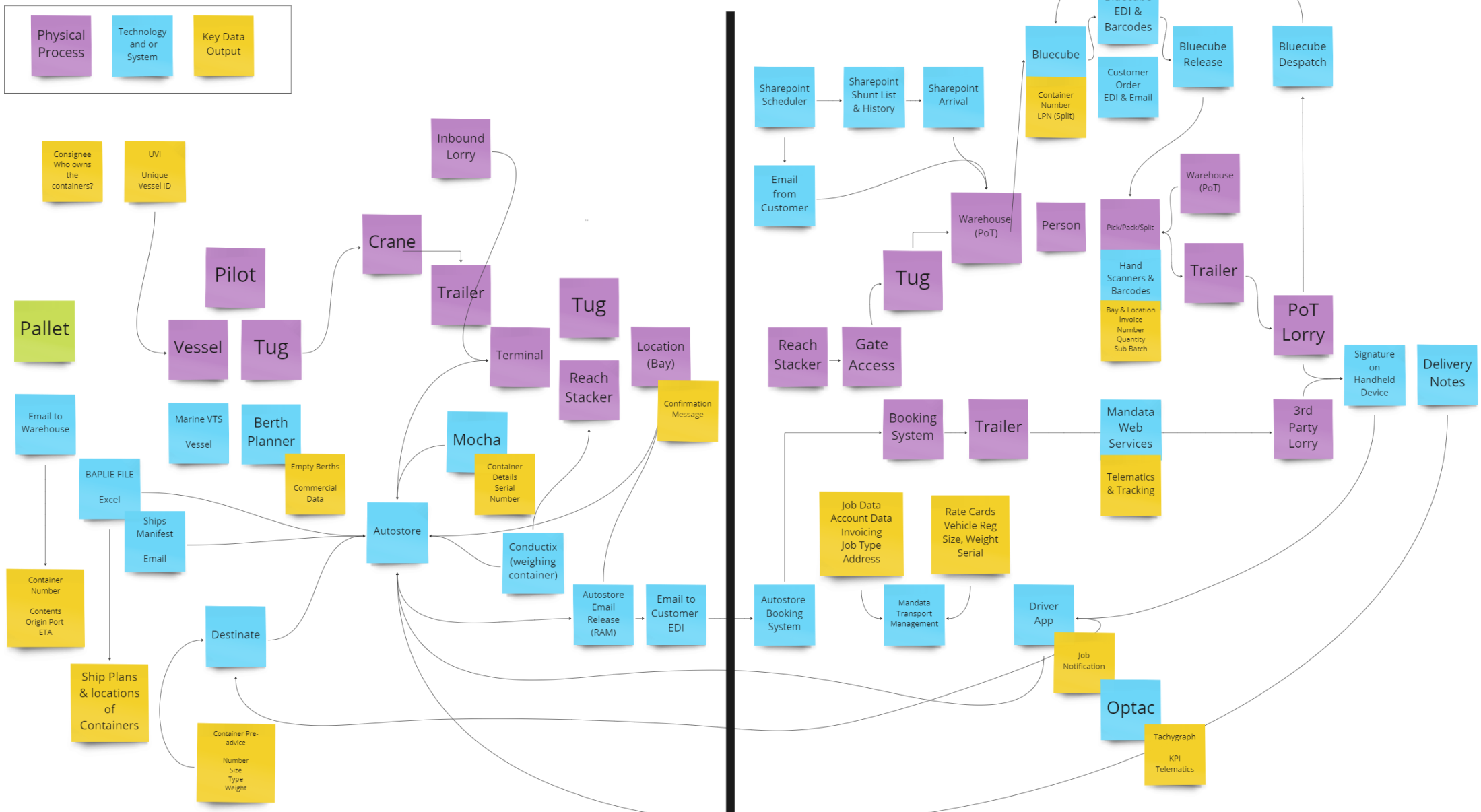
Which can drive real change; including collecting more data!

With data context we can provide better outcomes

zizo

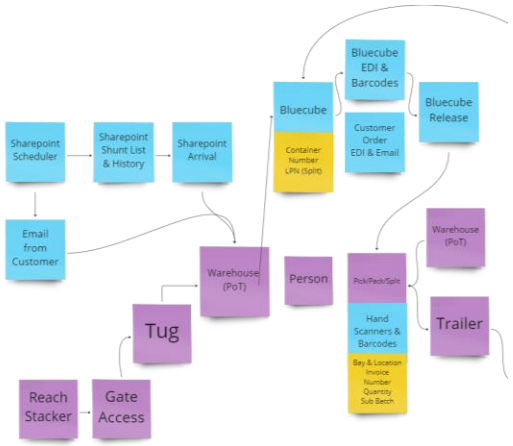
MARITIME IS A COMPLICATED INDUSTRY FOR DATA

zizo

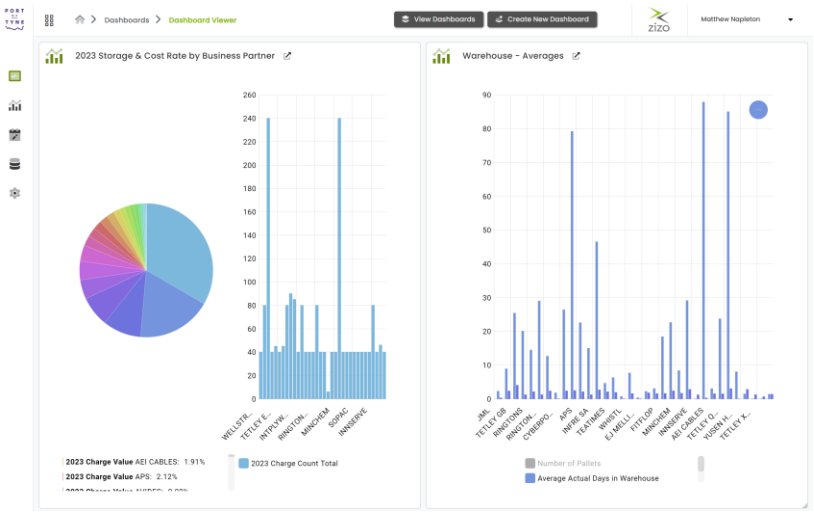


Major UK Port Analysis

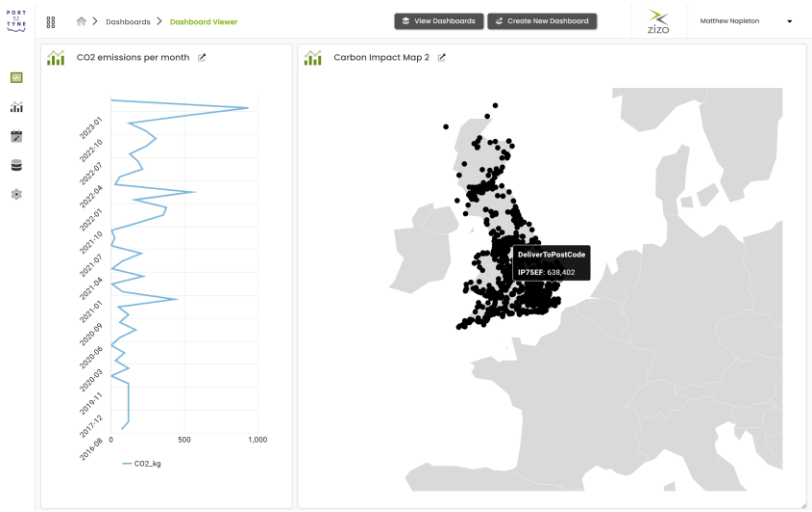
UK Port Case Study



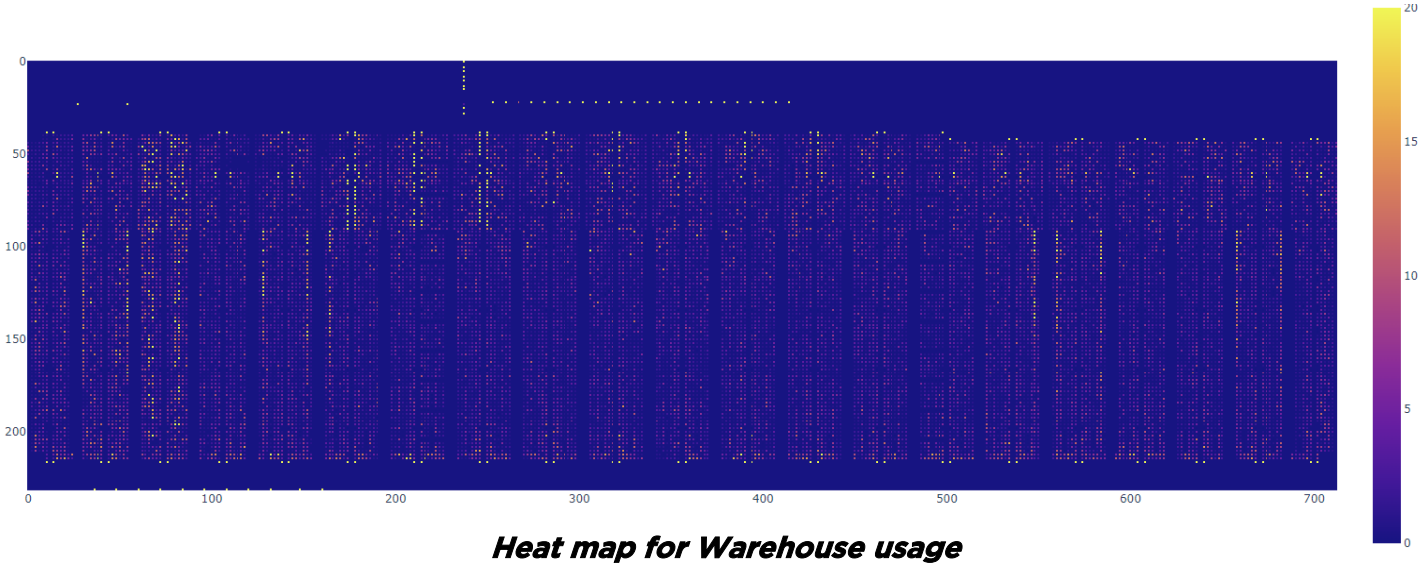
Data analysed from Warehouse & logistics



Customer Data Analysis



Carbon Footprint Analysis

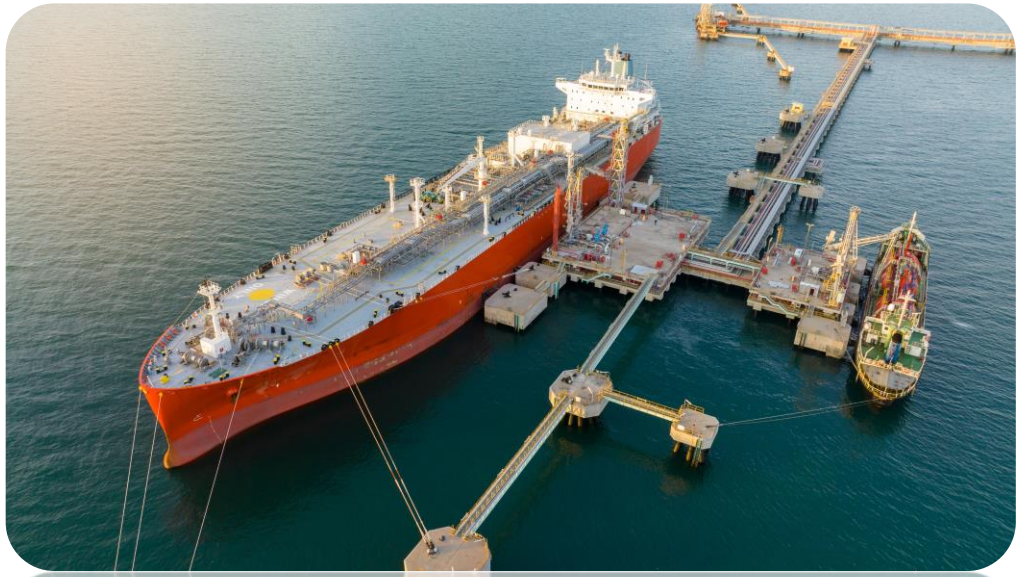


Heat map for Warehouse usage

Fuel efficiency by voyage planning

Efficient voyage planning can be revolutionized by advanced fleet management systems leveraging real-time data on weather, sea conditions, port congestion, berthing availability, and scheduling to minimize idle time and maximize operational efficiency.

These systems, incorporating IoT, satellite communication, and analytics, empower shipping companies to chart the most fuel-efficient routes, resulting in significant reductions in greenhouse gas emissions, thereby minimizing environmental impact and operational costs.



Carbon tracking and reporting

In the era of regulatory changes mandating carbon intensity indicators, real-time data streaming technologies have emerged as essential tools.

They enable continuous monitoring of vessel operations and to set and track emission reduction targets transparently, fostering accountability and informed decision-making to meet sustainability objectives. A study by the World Maritime University (WMU) suggests that real-time data monitoring can help shipping companies reduce emissions more than traditional reporting methods.

Remote smart maintenance

Integrating IoT sensors and machine learning transforms maintenance practices, allowing remote monitoring of ship systems.

Predictive analytics, facilitated by AI algorithms, enable proactive monitoring of equipment health and performance, minimizing downtime, and optimizing fuel consumption. This approach enhances operational efficiency while curbing unnecessary emissions associated with maintenance activities.

Promoting autonomous ships development

AI-driven situational awareness systems and predictive analytics accelerate the development of autonomous vessels, powered by renewable energy sources.

These technologies optimize routes, enhance safety, and reduce fuel consumption, contributing to a more sustainable maritime industry with significantly reduced carbon emissions.

2 things are vital to success....

1. Connectivity
   - In order to analyse the data – we need to be able to get it!
   - Whether that be on the vessel or across a port, investment in this area is crucial

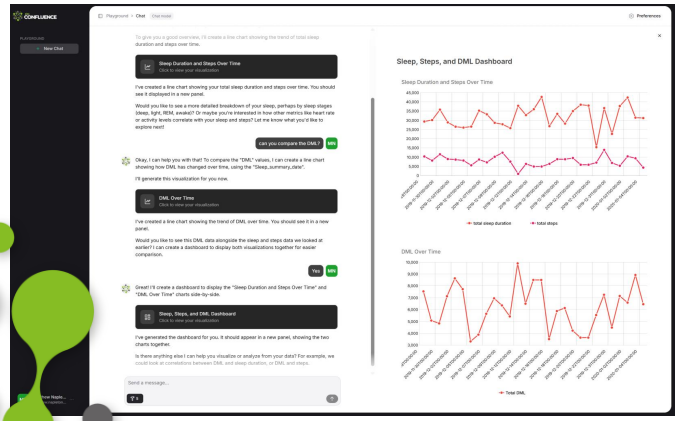
2. Easy access to the correct data
   - Putting the right information in the right hands at the right time to make the right decision
   - Not as simple as ‘employing more data scientists’
   - AI platforms can help us, but only if they are providing trusted data!

What is zizo CONFLUENCE ?

‘Confluence brings together the latest advances in analytics and AI to deliver rapid & trusted data exploration through a simple UI, delivered through a scalable, secure environment.’

‘Building on the success of the Zizo Data Platform, Confluence is what happens next to analytics.’

Safe. Secure. Scalable. Trusted.



Easy access to Data using AI

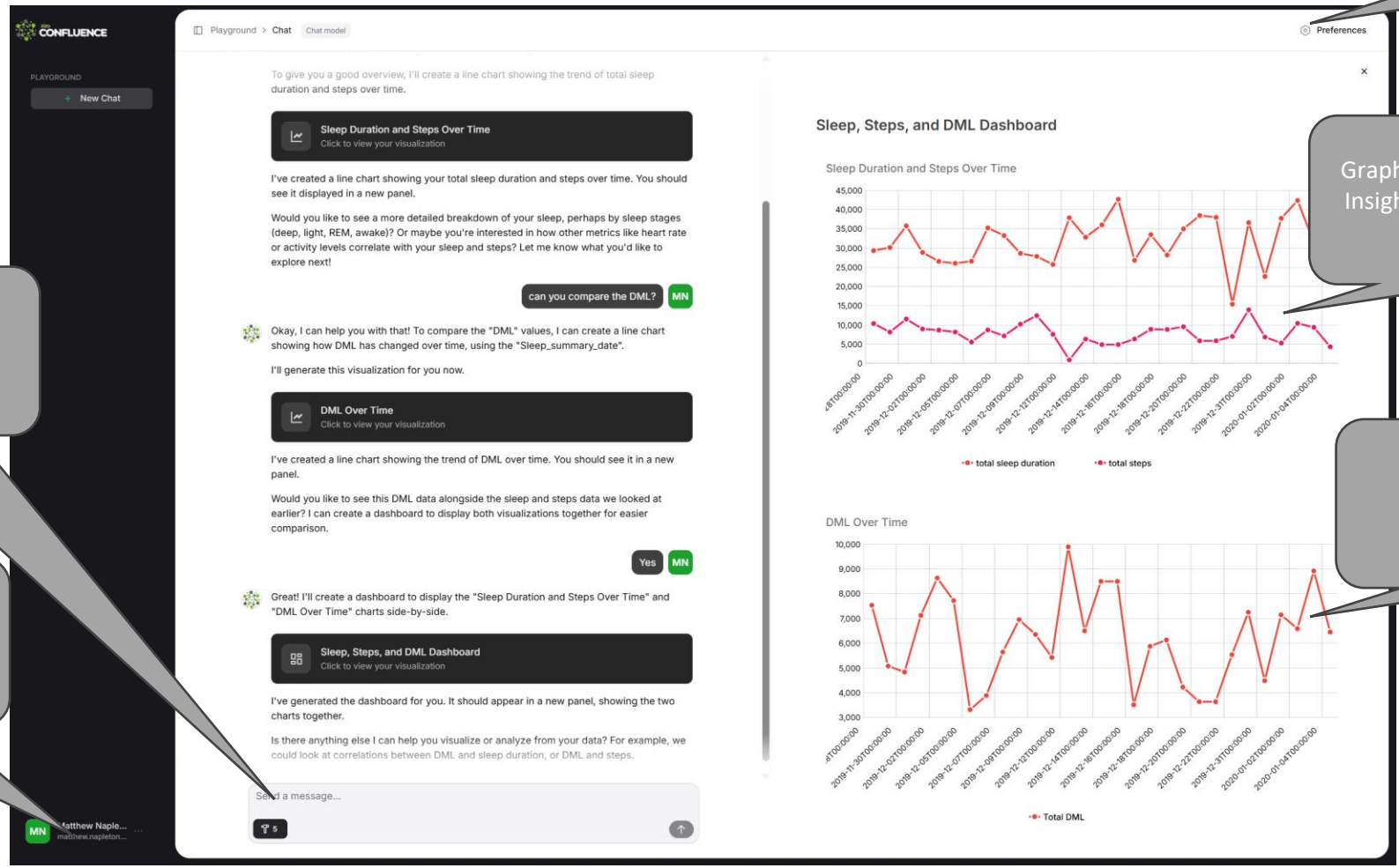
Ability to select from industry leading models, such as Claude Sonnet, Gemini, ChatGPT & others

Graphs & grids pulled from Zizo Insight, ensuring data accuracy & repeatability

Create dashboards from multiple visual objects

Simple to use chat interface

Individual user access for data & prompts



Thank You!

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Legal Aspects of Decarbonising Shipping

Dr Pia Rebelo

Clean Maritime Assembly,

26 June, Liverpool

John Moores University

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Outline of Session:

A) Regulatory Developments

1. International
2. Regional
3. UK

B) Voluntary Initiatives

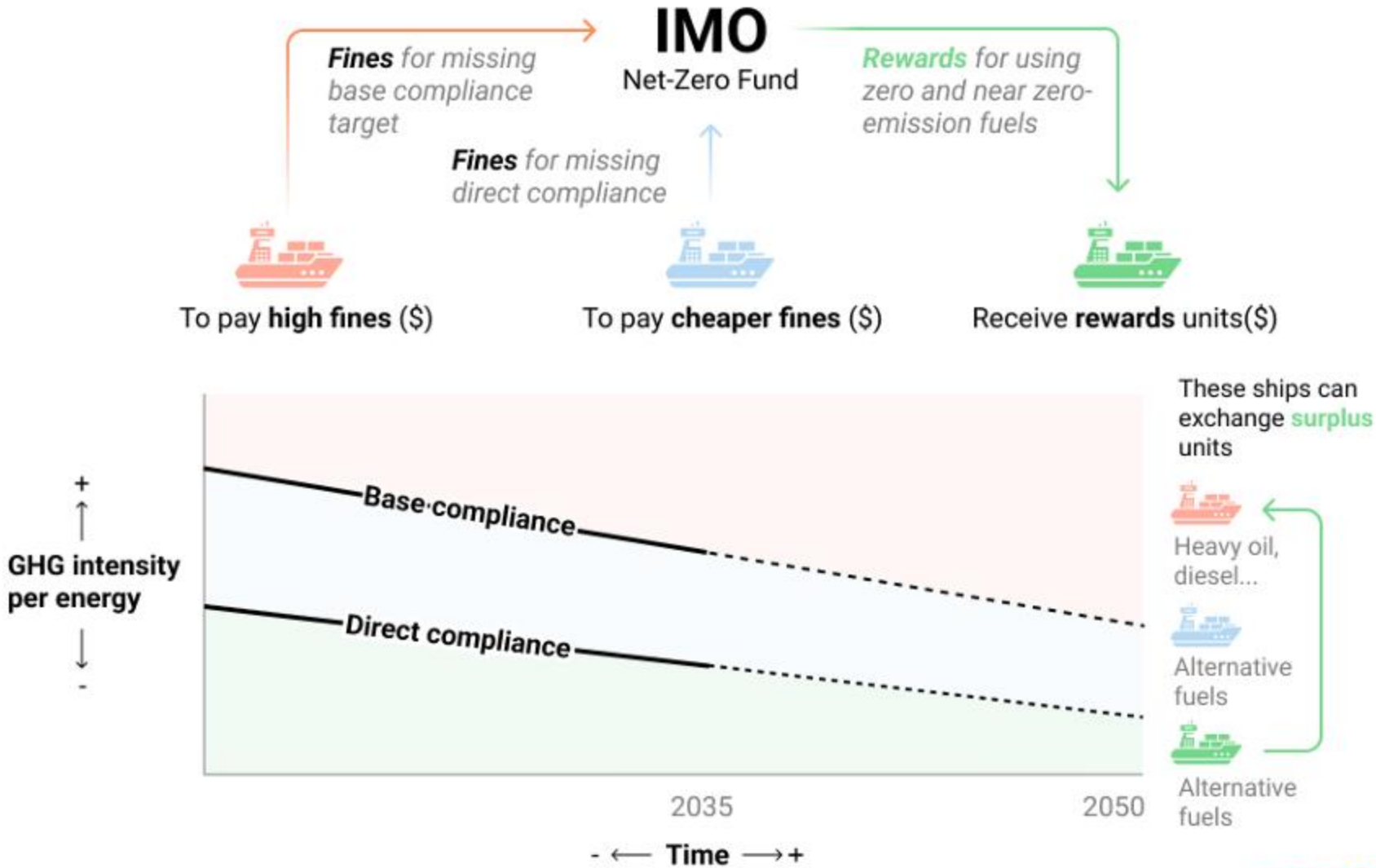
1. Sustainable Finance Frameworks
2. GHG Reporting initiatives
3. Voluntary Carbon Markets
4. Blue Visby Solution

International Regulatory Developments:

- **Current Measures:** EEXI, CII, SEEMP

- MEPC83: ‘net-zero framework’
  - Global Fuel Intensity (GFIO
  - Trading of compliance (MBM)
- 2024 LCA Guidelines for marine fuels – well-to-wake

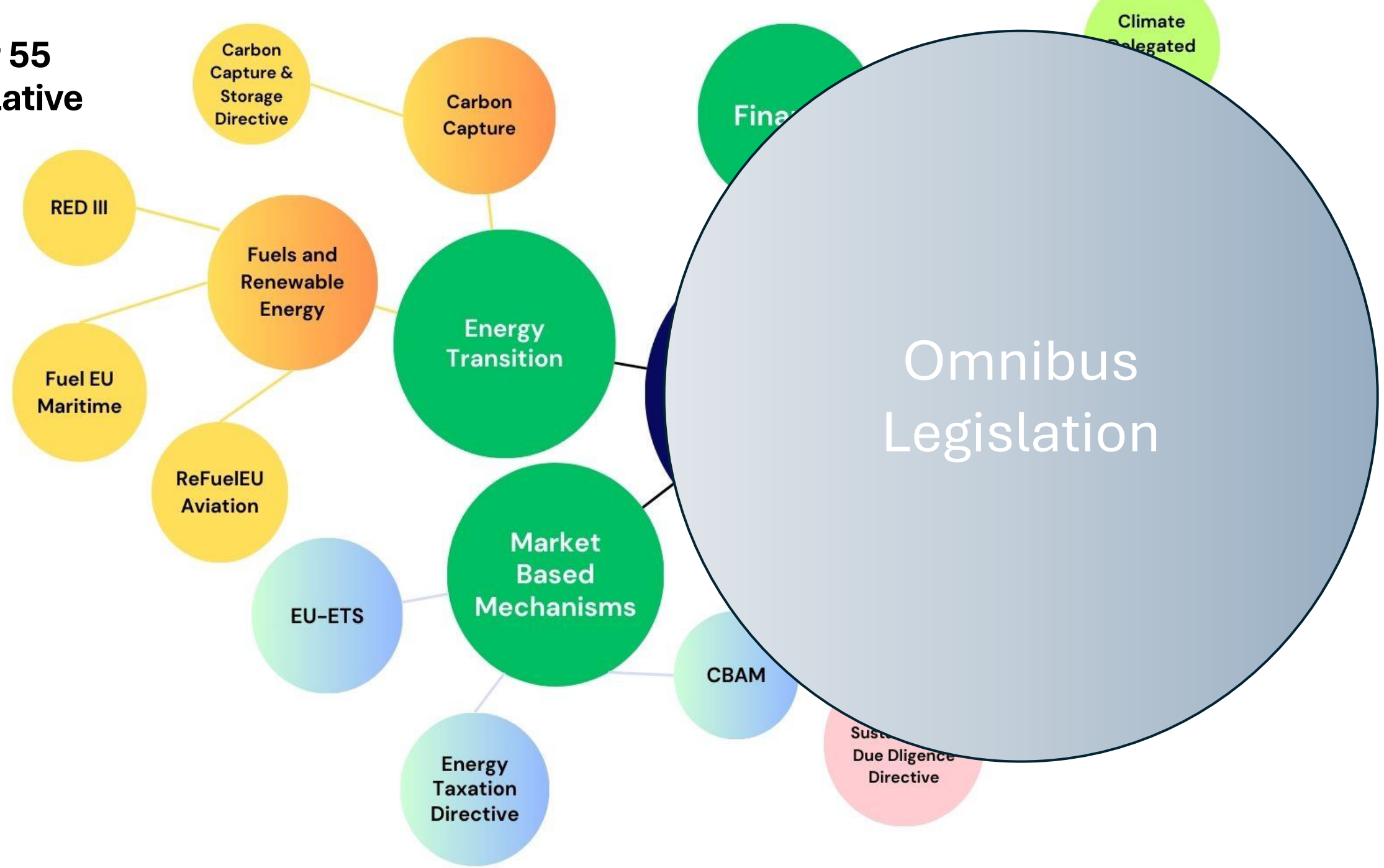
Functioning of the IMO Net-Zero Framework



Source: T&E

T&E

Fit for 55 Legislative Suite



UK ETS

UK: ETS

- A UK Emissions Trading Scheme (UK ETS) replaced the UK's participation in the EU ETS on 1 January 2021.
- From 2026: UK ETS will be expanded to domestic shipping
- The European Commission and the United Kingdom share the view that a functioning link between carbon markets would address many of the issues raised in respect of trade and a level playing field and would give effect to Article 392(6) of the Trade and Cooperation Agreement.

1. Voluntary Green Finance Frameworks:

- IDFC Common Principles for Climate Change Adaptation Finance Tracking (mainly for development banks)
- International Capital Market Association (ICMA): Sustainability-Linked and Green Bond Principles
- Loan Market Association's Green Loan Principles and the Sustainability Linked Loan Principles
- Climate Bonds Initiative (CBI) certification standard:
- Equator Principles
- Individual Banking initiatives

2. Voluntary Reporting and Due Diligence

1. GHG Protocol (guidelines for corporate accounting)

- Corporate Standard Accounting and Reporting Standard
- Corporate Value Chain (Scope 3) Accounting and Reporting Standard International Standards Organisation

2. CDP (formerly known as the Carbon Disclosure Project); Science Based Targets initiative (SBTi) – uses GHG Protocol; ISO 14064:2018 Greenhouse gases – also certification standard; The International Sustainability Standards Board (ISSB): GHG reporting standard (IFRS S2) 2023

3. Shipping/Transport specific: Transparency initiatives (Poseidon Principles, Sea Cargo Charter, PP Marine Insurance); Smart Freight Centre – GLEC v.3.1; ISO 14083

3. Voluntary Carbon Markets:

Environmental Attributes: offsets, allowances, avoided emissions, renewable energy credits, emissions reductions

These are certified by certification schemes like:

- SBTi; The Verified Carbon Standard (VCS); VERRA's Verified Carbon Standard and the Gold Standard

Enabled by Accounting Models systems:

- Mass balance reporting
- Physical Segregation of EAs from actual fuel – chain of custody models.
- E.g. Book and Claim (Insetting) – E.g. The Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping
- Smart Freight Centre, Voluntary MBMFramework for Logistics Emissions Accounting and Reporting (GLEC v3.1)
- Wild wild west! Companies creating and trading all sorts of “tokens” and EAs

4. Blue Visby Solution

- Eradicating SFTW will allow ships to reduce speed, thereby **reducing the carbon footprint** of the maritime industry by about **15% or overall 45 million tonnes of CO_2** across the tanker fleet and bulker fleets, based on figures for 2019.
- Reduces hull fouling.
- Reduces underwater noise pollution and whale strike risk.

Conclusions:

Contractual preparation is key.

Inevitable disputes where carbon clauses are vague, ineffective, or altogether absent.

Contracts are sites for allocating the risks associated with both regulatory uncertainty and greenwashing.

Green shoots in contract law.

Thank You!

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Maritime Decarbonisation - the insurer's perspective

Helen Barden

DIRECTOR - EXTERNAL AFFAIRS, NORTHSTANDARD

Clean Maritime Assembly 2025

26 June 2025

NorthStandard

P&I Clubs

What is a P&I Club?

- An Association of Shipowners providing third party liability insurance cover
- Is a mutual insurer (sharing of risks)
- Owned and controlled by their shipowner members
- Non-profit making
- Exist solely for the benefit of their members
- A service provider as well as providing insurance

P&I marine liabilities

We cover marine liabilities arising from vessel operations including:

Collisions with vessels

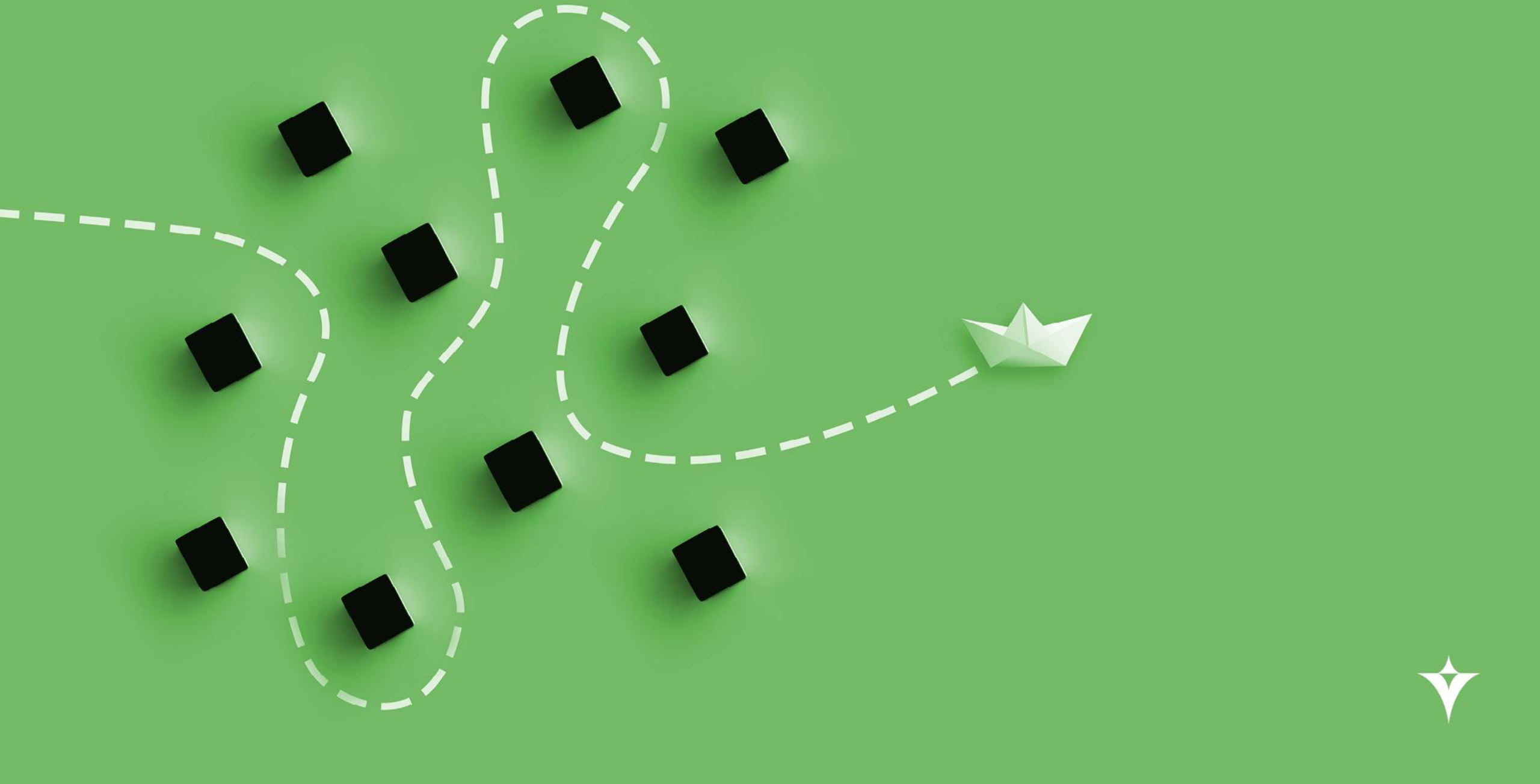
Damage to fixed and floating objects

Loss of, or damage to cargo

Pollution from the vessel, or its cargo.

Loss of life and injury to crew, passengers and third parties.

Wreck removal



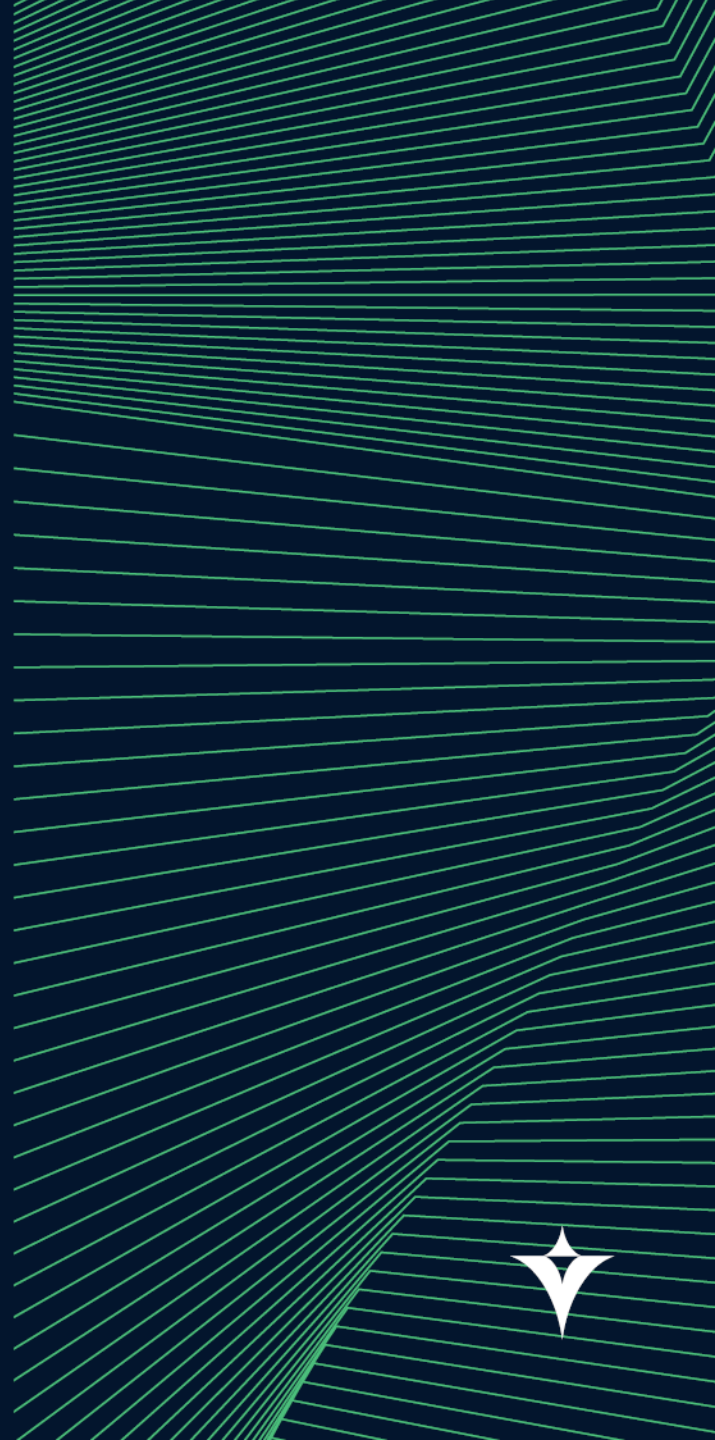

PIVOTAL
"achieving commercial insurability is pivotal"
Domenic Carlucci, ABS


"
Without commercial liability insurance... we will be stuck where we are today
"
Mikal Boe, COREPOWER

"None of this can happen without insurance... The insurance industry is a key enabler in the transition."

Sean McGovern, Chief Executive Officer, UK & Lloyd's, AXA XL

There is no global liability and compensation regime in the event of an incident arising out of future fuels



Global liability convention for low carbon fuels

Why is that a problem?

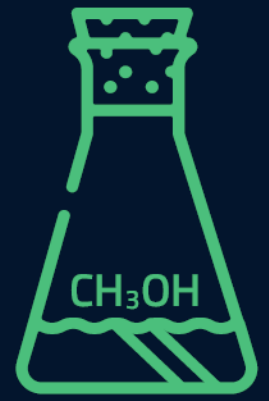
Different fuels

Biofuel

LNG

Hydrogen

Ammonia



Methanol

Maritime Decarbonisation - the insurer's perspective

Thank you

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- Cost Barriers
- Derisking 1st Movers/Early Adopters
- Transition Funding

Get in touch

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Book time with me

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