Designing Future Ships and Marine Systems for Future Operating Conditions with a Low Carbon Intensity

John Calleya, Santiago Suarez de la Fuente, David Trodden, Rachel Pawling

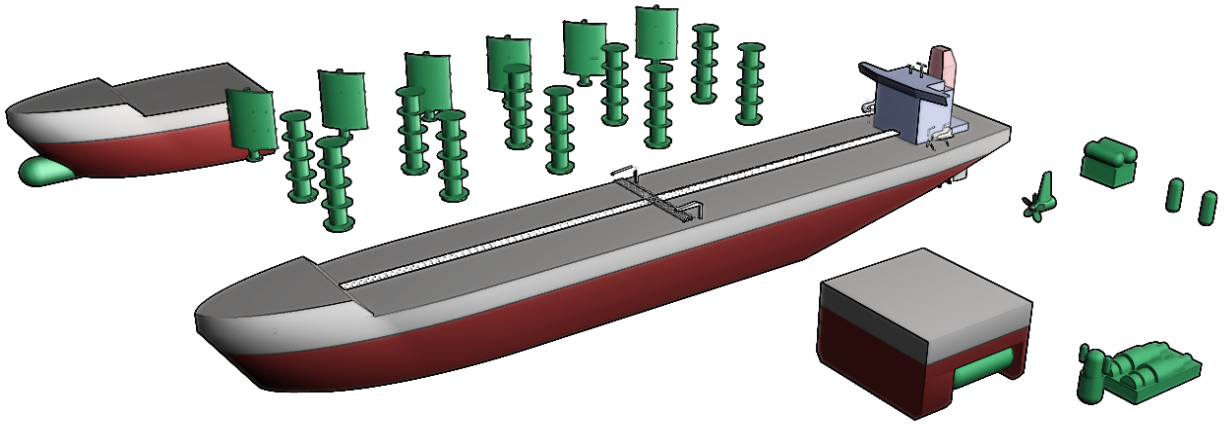


Image created by Rachel Pawling

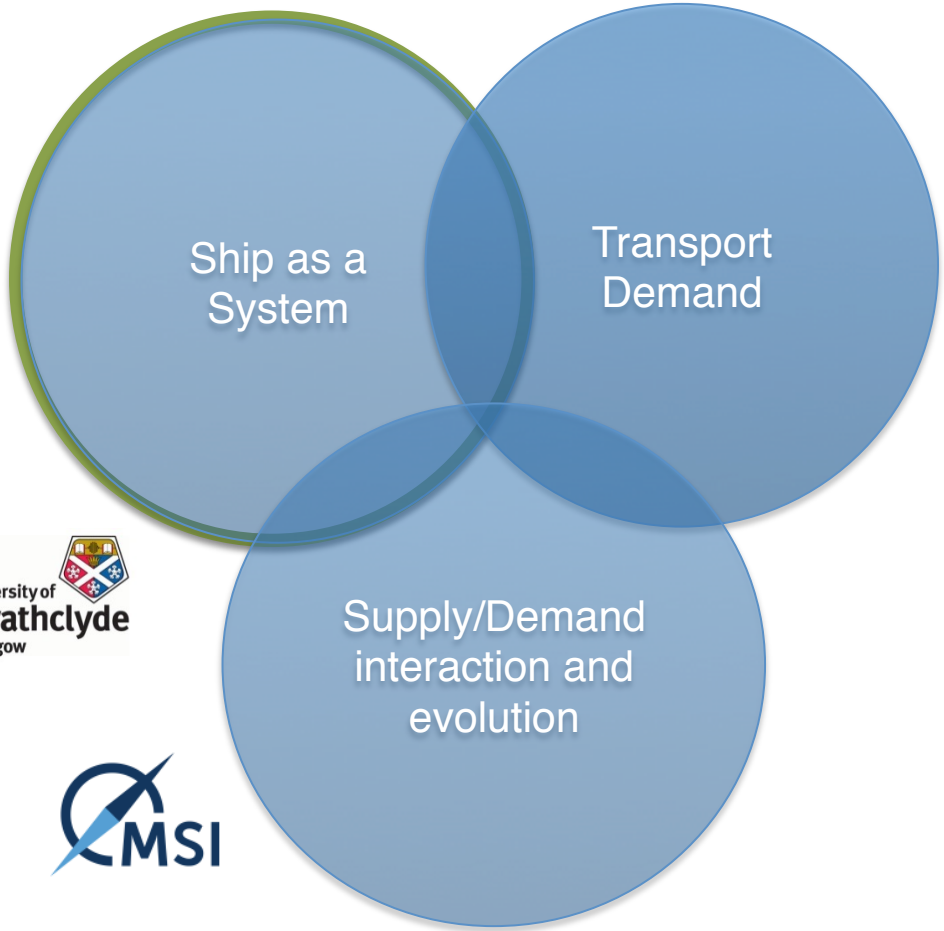
Shipping in Changing Climates

- £3.5m funded by UK Research Council.
- Between UK Universities:

University of Southampton, Newcastle University, UCL, The University of Manchester, University of Strathclyde Glasgow

- Supported by UK Industry:

BMT Group, MSI, Shell, Lloyd's Register, Rolls-Royce



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Future Energy Efficiency Trends in the Maritime Industry

- Only Regulation at the moment is EEDI, which is not that stringent (approx. 10% reduction).

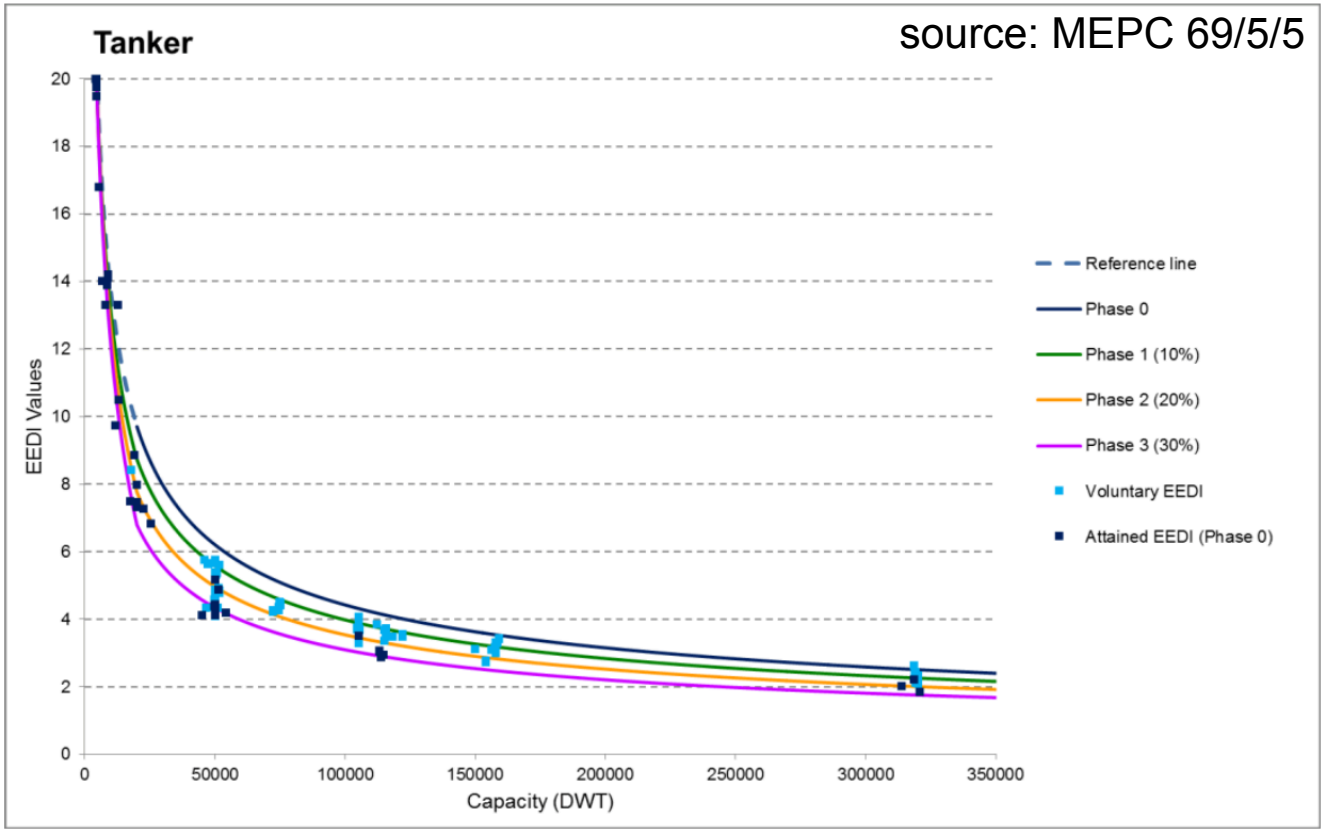


Figure 3: EEDI database for tankers (database as of 27 May 2015)

Future Energy Efficiency Trends in the Maritime Industry

- Only Regulation at the moment is EEDI, which is not that stringent (approx. 10% reduction).
- …but the Paris agreement CO2 emissions need to “peak and rapidly decline”.
- …if shipping were to decarbonise in this manner this would mean designers would have to design ships with a 75% to 90% reduction in the emissions of individuals ships in 2050 (Traut et al. 2015).

Futu… …the Mari…

- Fut…
- The… …verall incr… …es in:
  - C…
  - F…

Shipping 'progressives' call for industry carbon emission cuts

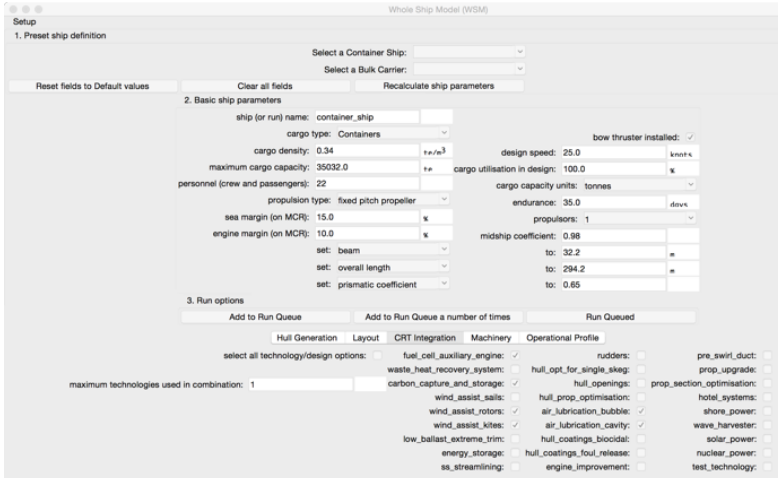
Some of the world's biggest shipping groups say 'ambitious' action is needed at a key UN meeting to bring the industry in line with Paris climate goals

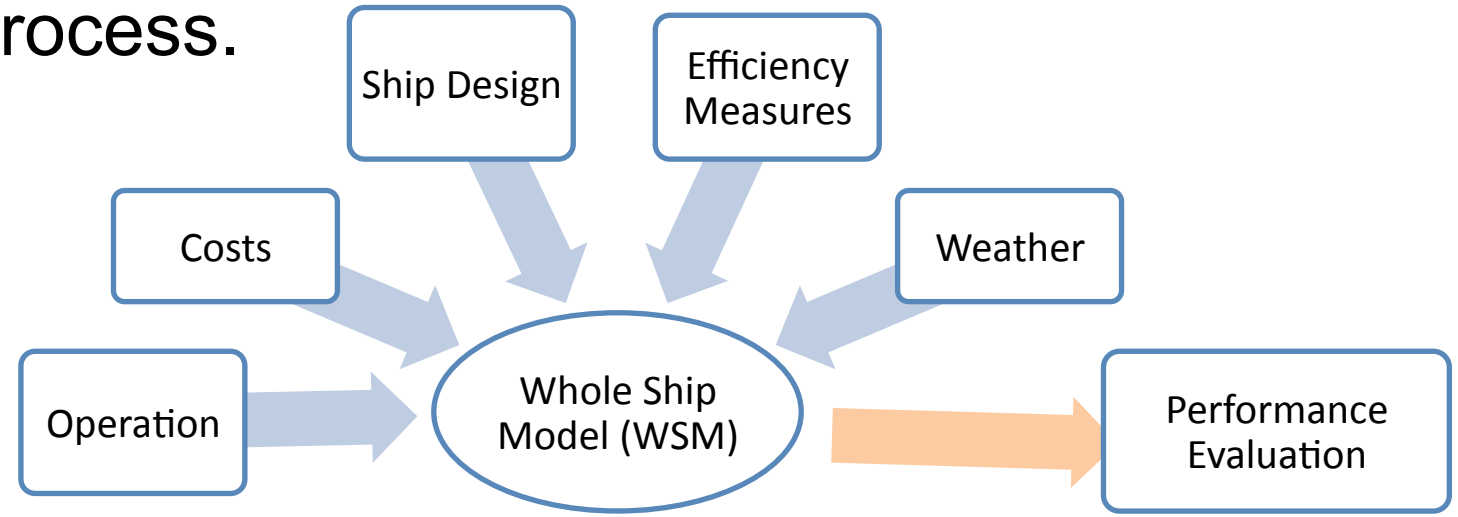
Maersk is among the organisations saying shipping must play its part in holding global temperatures rises to less than 2C. Photograph: Ingo Wagner/EPA

source: The Guardian 19th October 2016

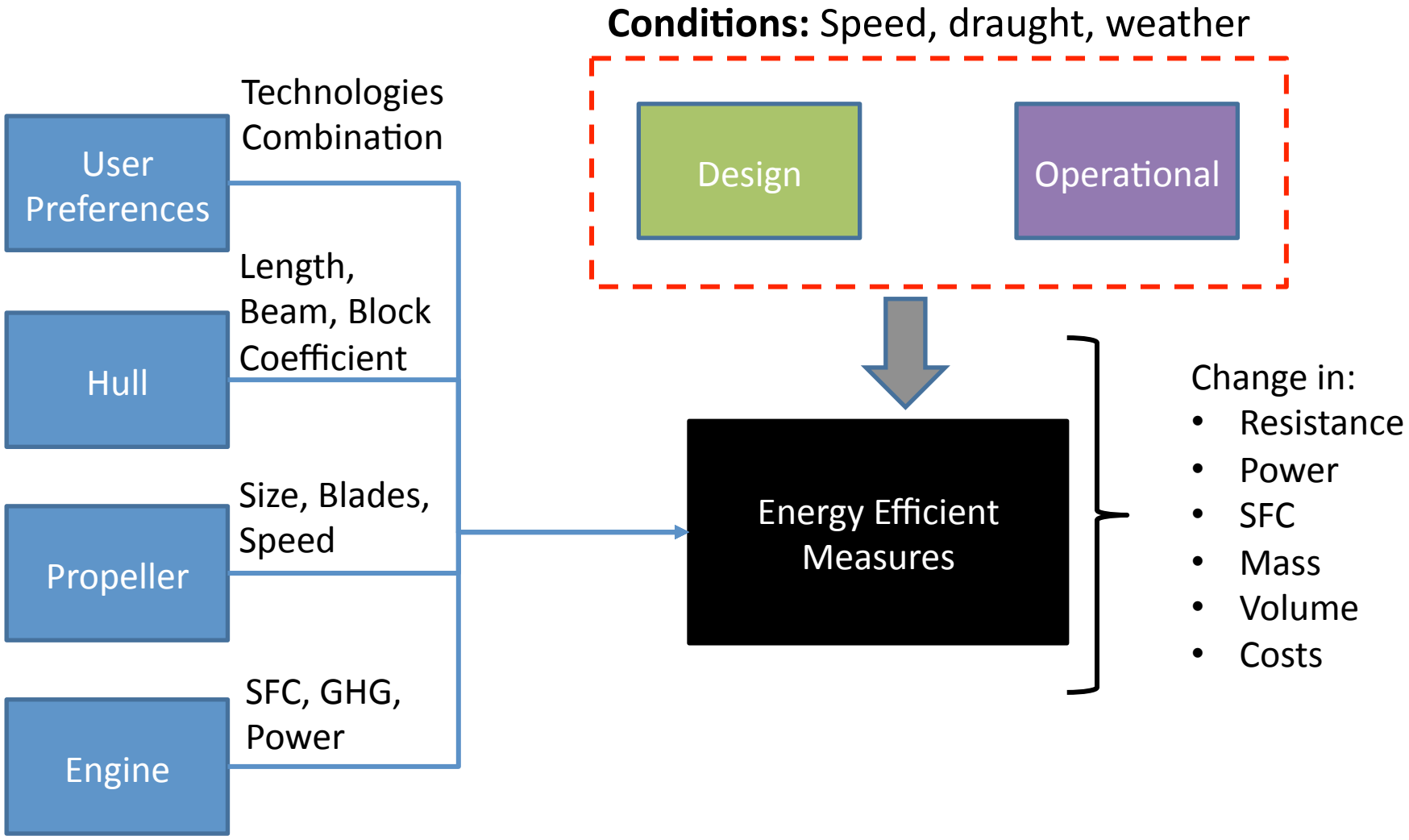
Whole Ship Model

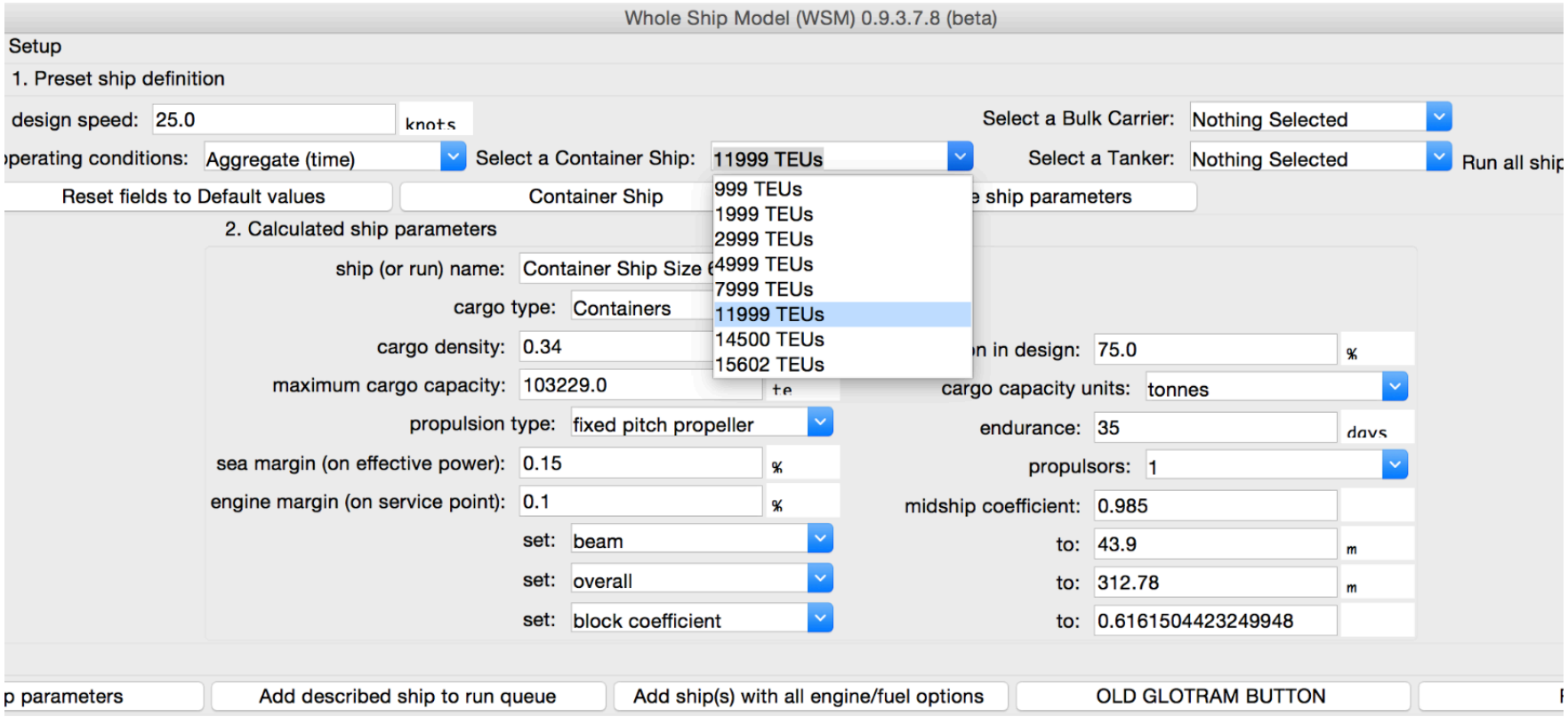
- Decision Making Tool:
  - Complex sub-models.
  - Both a design process and an operational performance evaluation process.



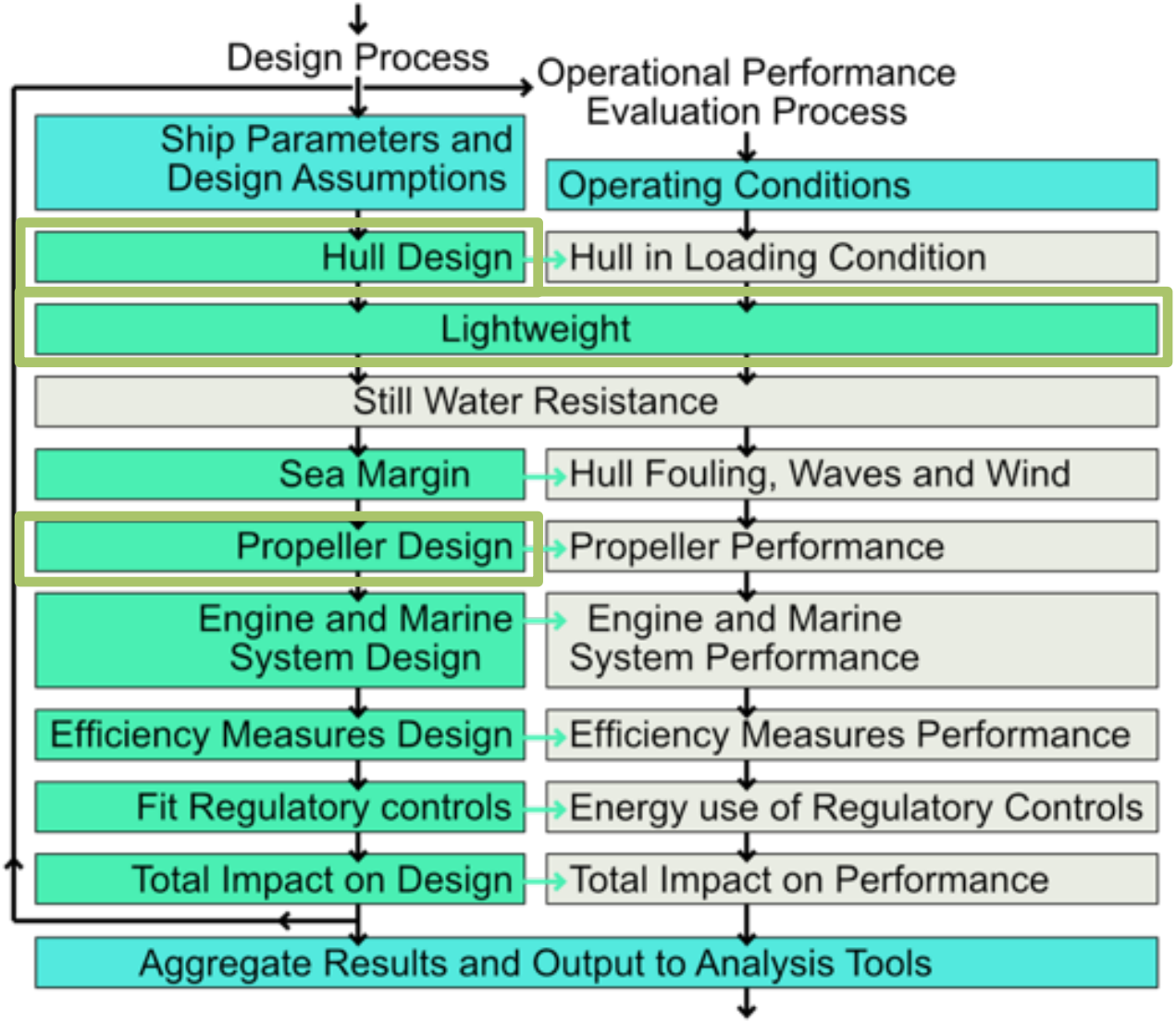


Whole Ship Model



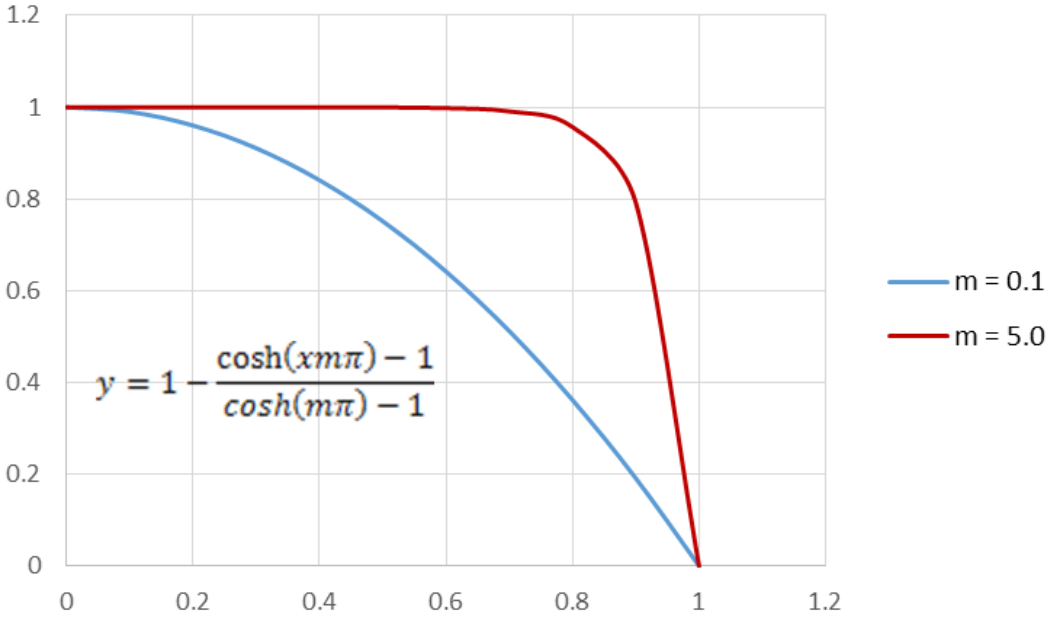

Whole Ship Model (WSM) 0.9.3.7.8 (beta)
Setup
1. Preset ship definition
design speed: 25.0
knots
Select a Bulk Carrier: Nothing Selected
operating conditions: Aggregate (time)
Select a Container Ship: 11999 TEUs
Select a Tanker: Nothing Selected
Run all ship
Reset fields to Default values
Container Ship
ship parameters
2. Calculated ship parameters
ship (or run) name: Container Ship Size
cargo type: Containers
cargo density: 0.34
maximum cargo capacity: 103229.0
te
propulsion type: fixed pitch propeller
sea margin (on effective power): 0.15
%
engine margin (on service point): 0.1
%
set: beam
set: overall
set: block coefficient
999 TEUs
1999 TEUs
2999 TEUs
4999 TEUs
7999 TEUs
11999 TEUs
14500 TEUs
15602 TEUs
in design: 75.0
%
cargo capacity units: tonnes
endurance: 35
days
propulsors: 1
midship coefficient: 0.985
to: 43.9
m
to: 312.78
m
to: 0.6161504423249948
p parameters
Add described ship to run queue
Add ship(s) with all engine/fuel options
OLD GLOTRAM BUTTON

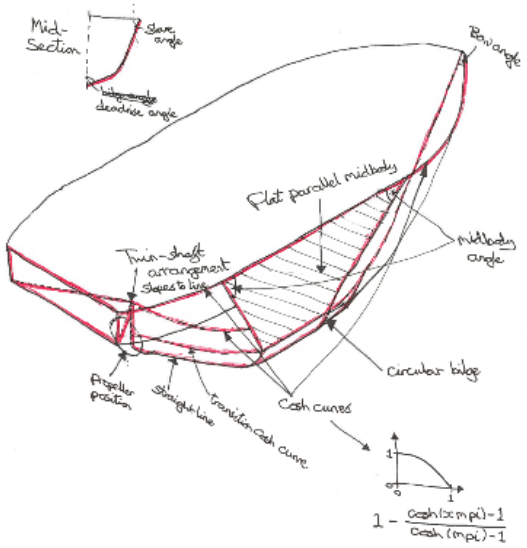
Whole Ship Model



Hull Design

- Equations of generic curve sets making up the hull form are adjusted to meet the deadweight requirement (this allows Cb to be an input).
- Output is to provide waterplane characteristics.





Lightweight

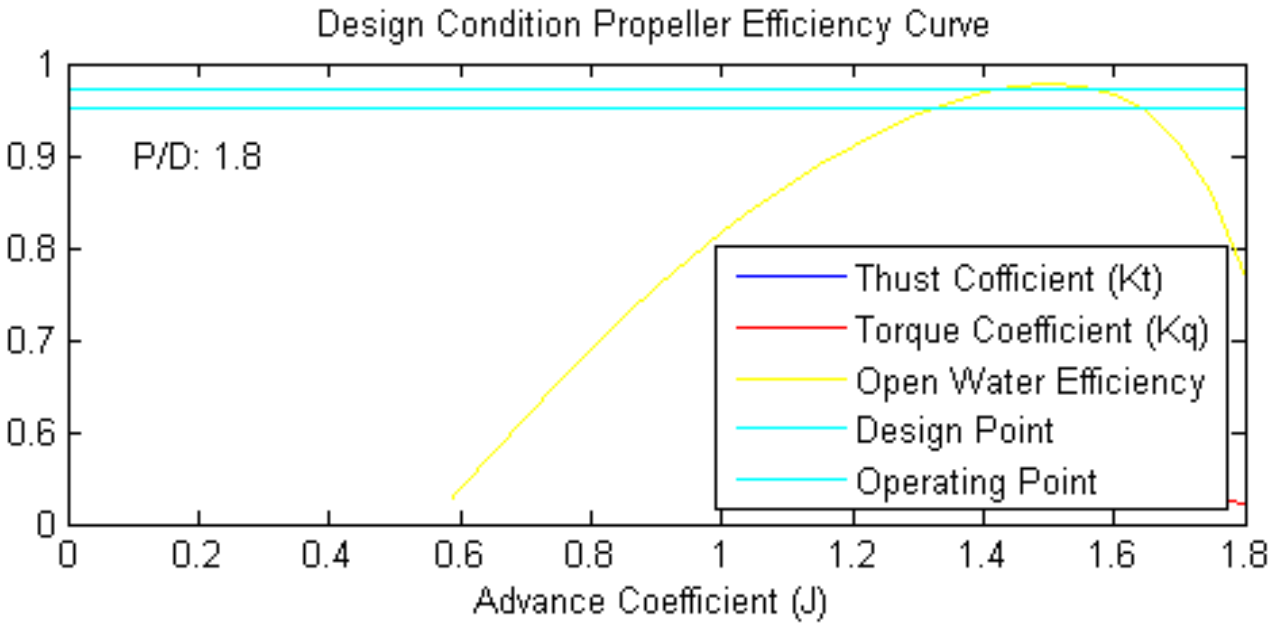
- Lightweight of existing ships is calculated based on design “deadweight/cargo”.
- This is based on work by Hans Otto Kristensen.

Still Water Resistance

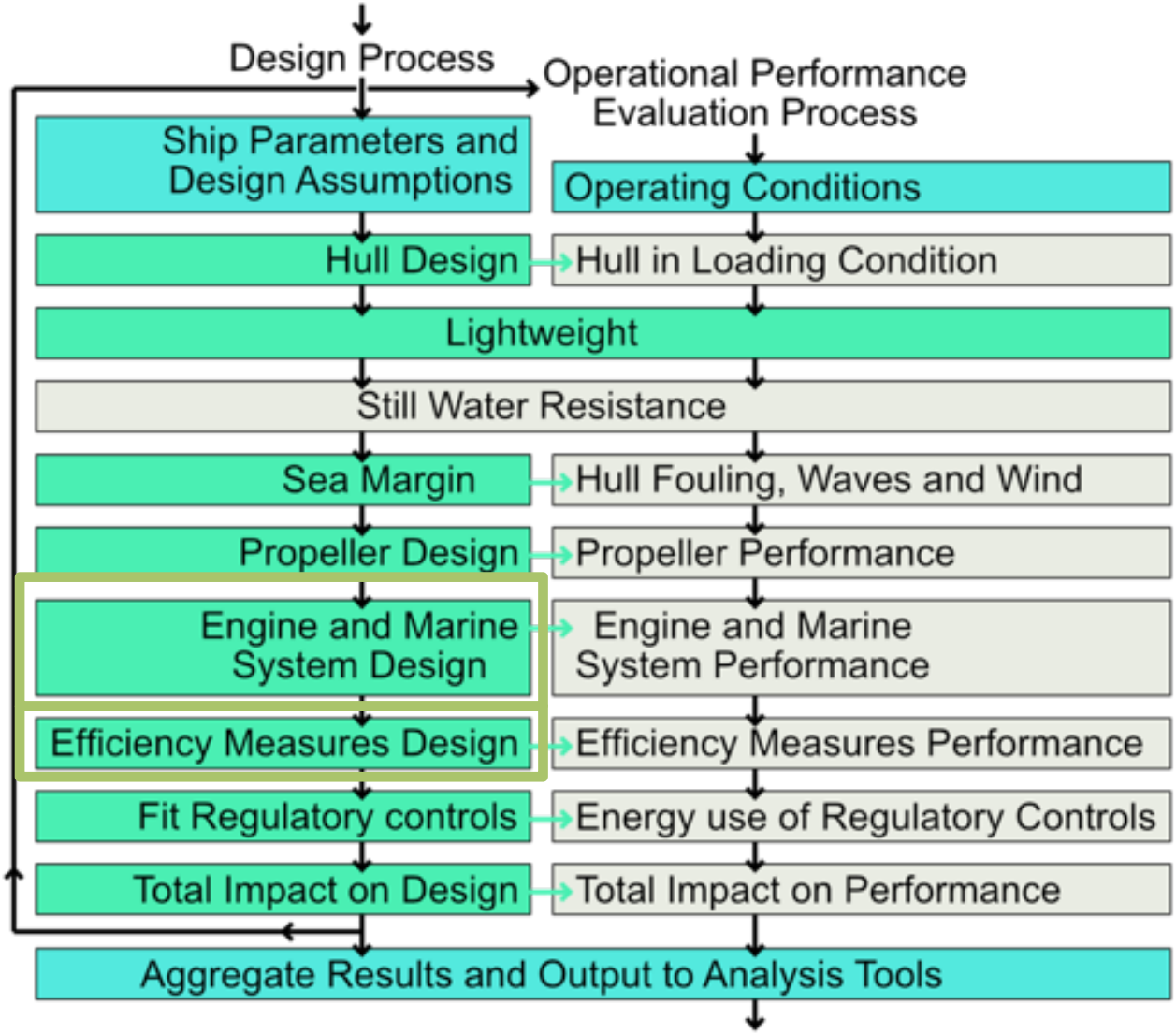
- Holtrop-Mennen is used with some adjustments to match current ships, this model has been used by Rolls-Royce and for other projects.

Propeller Design

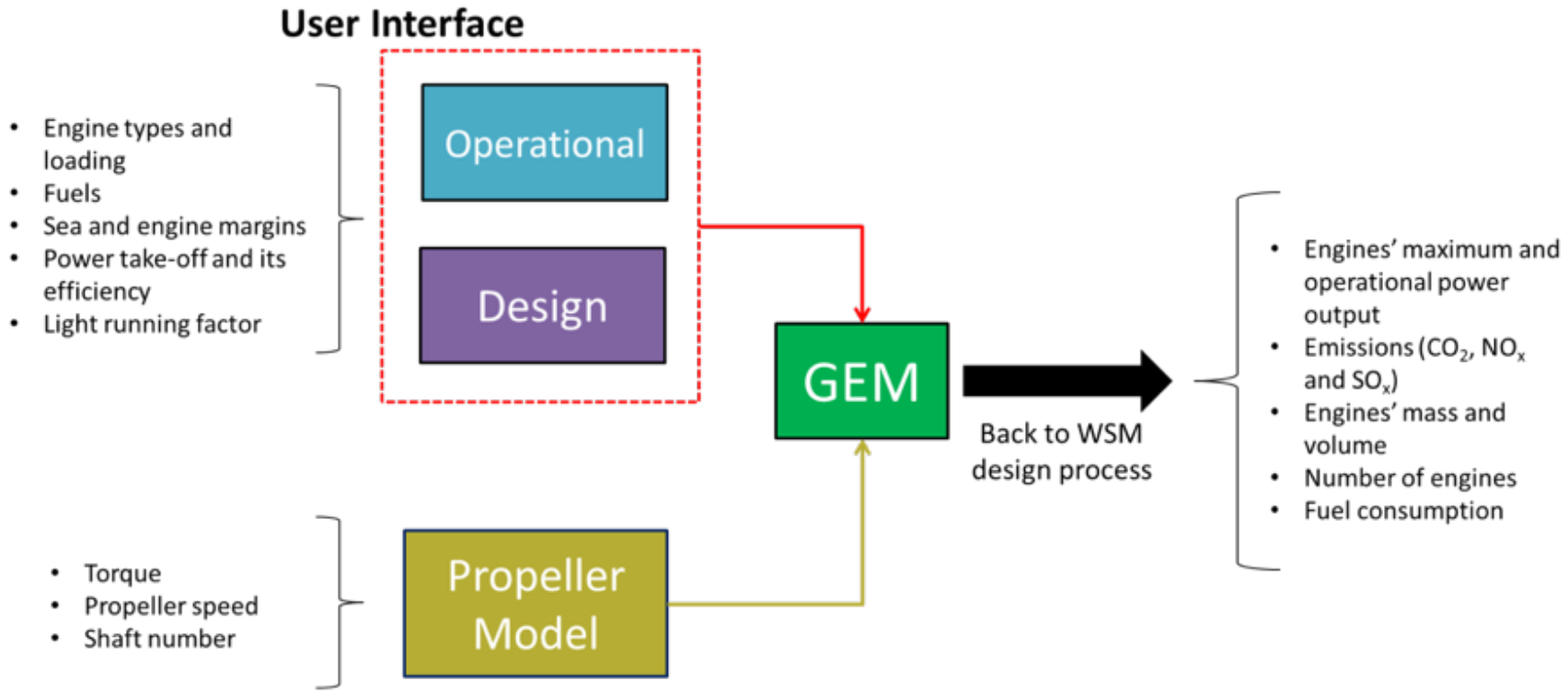
- Wageningen B-series is in the model, a constant number or override can also be used.
- Allows “off-design” to be evaluated.



Whole Ship Model



Engine and Marine System Model



Engine and Marine System Model

- 12 Fuels can be selected for main and auxiliary engine use.
- Initial GEM model by David Trodden (Newcastle) was:
  - A MAN engine database by David Trodden, based on MAN Project Guides.
  - Engine and service points selected for lowest SFOC in demanded condition

- When WSM looks for engines that do not exist at the moment
  - The model had to be modified to make it more robust.

- The final model is a combination of assumptions between two models:
  - Accurate enough whilst being robust, fast and predictable.

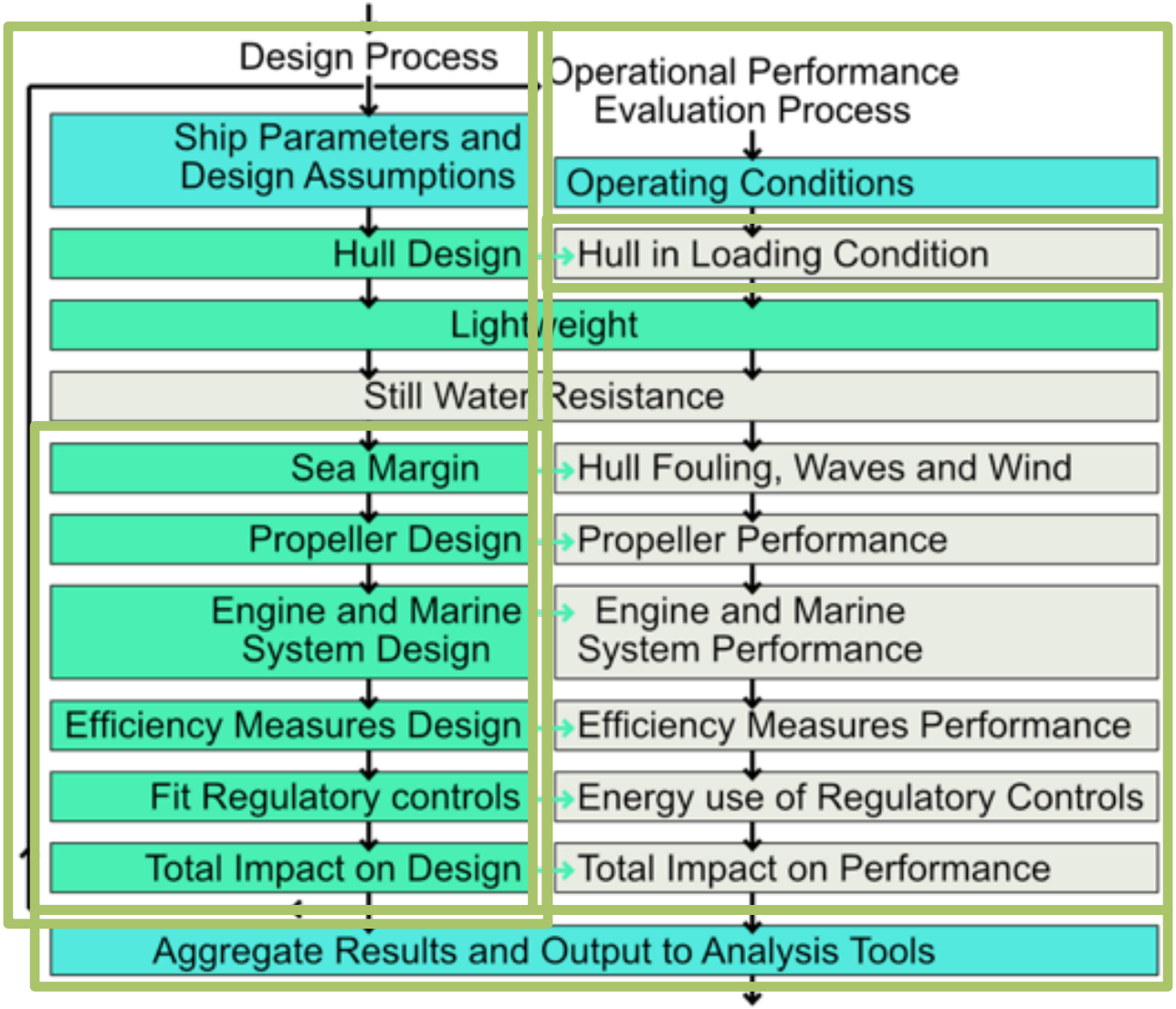
Efficiency Measures Design

- Efficiency Measures are modelled on a “first principles” level.

Technology	Sails	Air Lubrication (Air Cavity)	Twisted Rudder (or Pre-Swirl)
Viscous Resistance	-	Decrease	-
Wetted Surface Area	-	-	-
Propulsion Coefficient	Decrease	-	Increase
Thrust Requirement	Decrease	-	-
Alternative Fuel Use	-	-	-
Auxiliary Power	-	Increase	-
Cargo Capacity	Decrease	Decrease	-

- Performance can be scaled to different ships types sizes and speeds.

Whole Ship Model



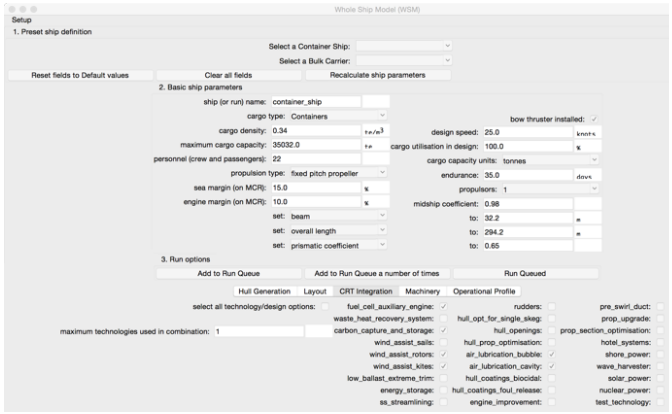
Aggregate Results and Output to Analysis Tools

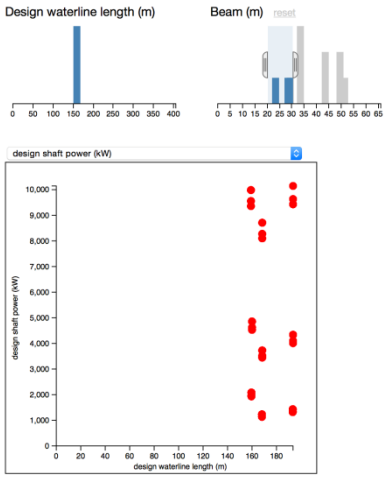
Outputs are used:

- to refine the design of efficiency measures and ship designs.
- to provide design variants for economic model, GloTraM.

Currently some outputs consist of over 30000 designs so methods are needed to better search and filter this data.

Whole ship model and D3



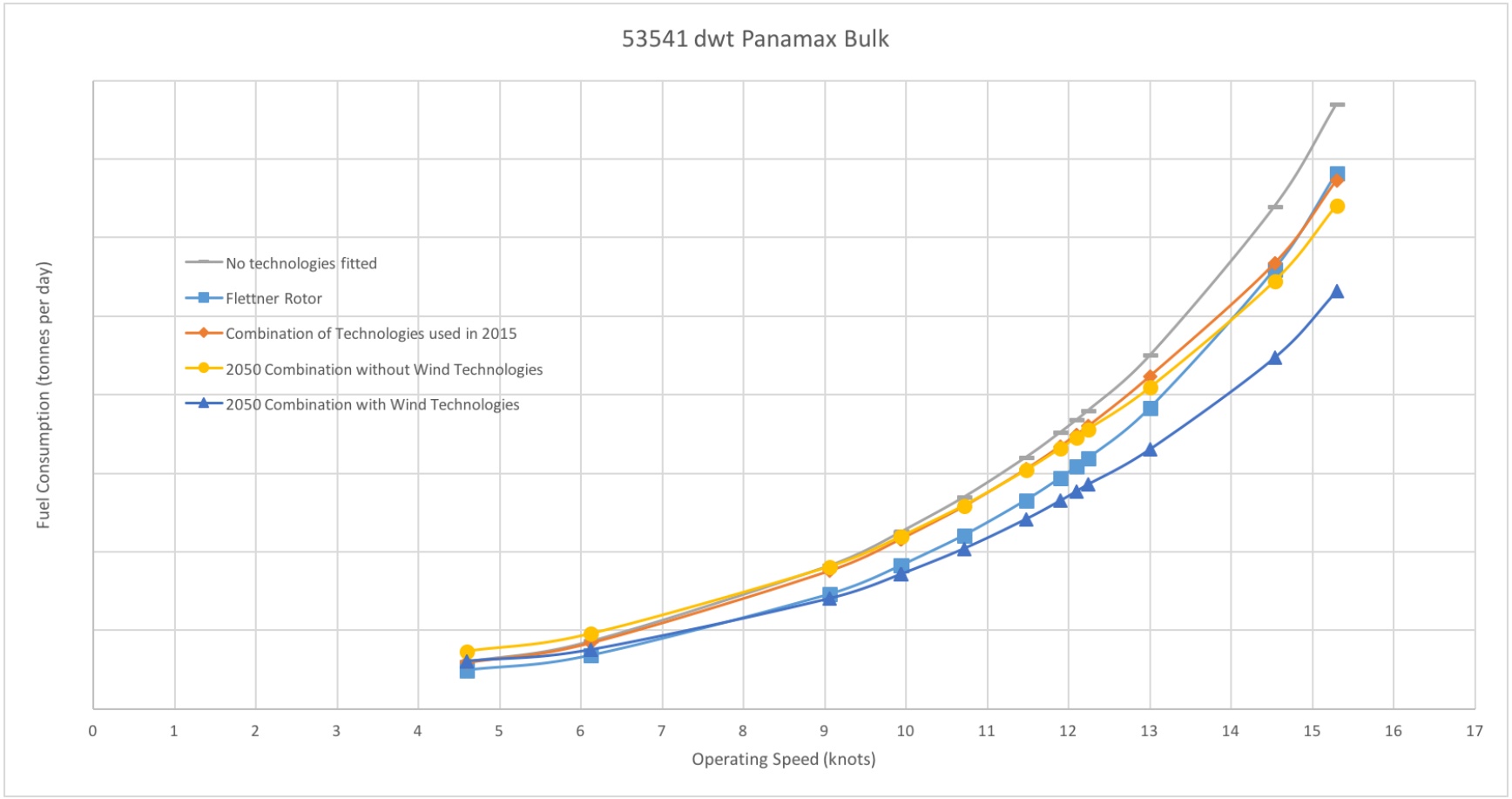


- Started as a joint paper between NTNU/Ulstein and UCL.
- Interface can run with pre-calculated results from python WSM.

Lessons from Modelling Process

- For the integrated ship model, WSM, there has been a balance between accuracy and robustness.
- It is necessary to understand underlying physics to model ships better, a combination of regression and mathematical modelling has been used.

Reduction in Fuel Consumption from Combination of Efficiency Measures



The future of Efficiency Measures and Fuels

- Combinations of efficiency measures alone have emissions reduction of approximately between 10% and 20%...
- …but we may need to be looking at 75% to 90%.
- Speed flexibility and switching to fuels are important.
- As alternative fuels may be more expensive the role of energy efficiency measures may increase in the future.

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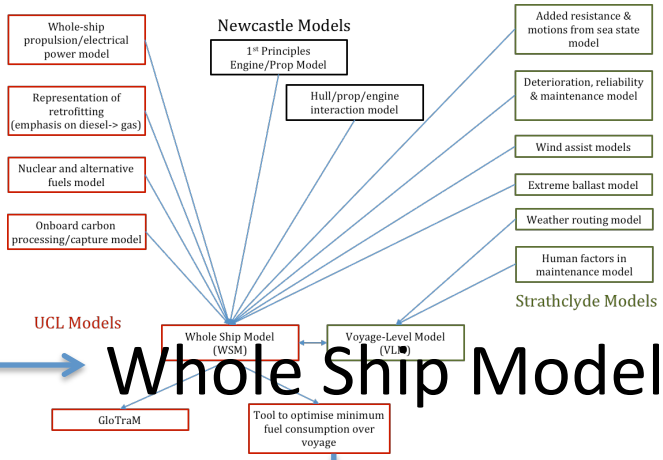
www.lowcarbonshipping.co.uk

Pease e-mail for sources/data/ references.

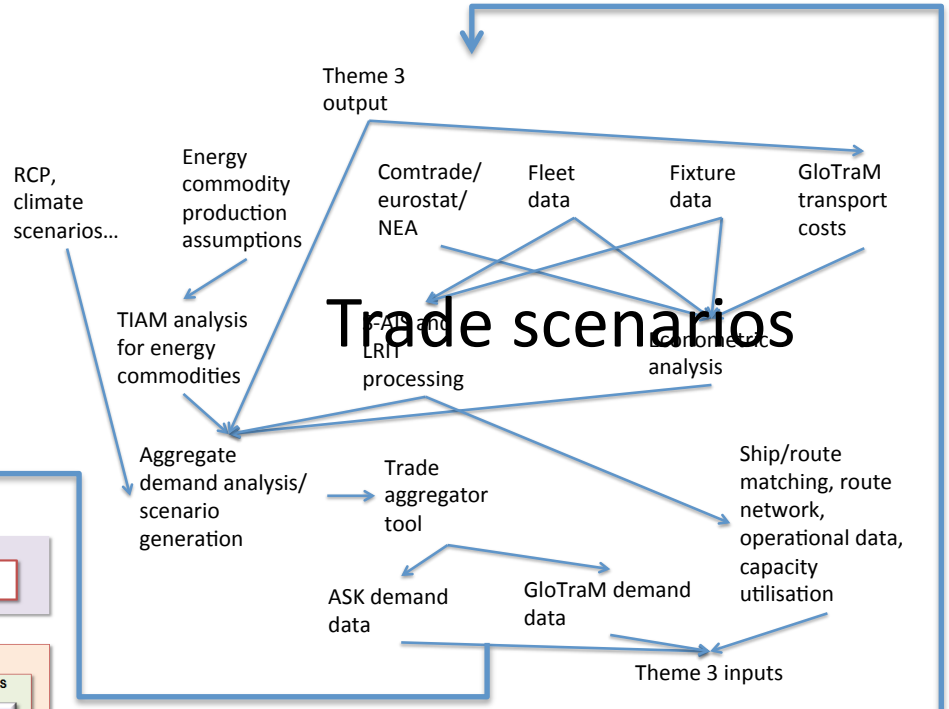
source: adapted from www.he-alert.org

Future Work on Technology Combinations

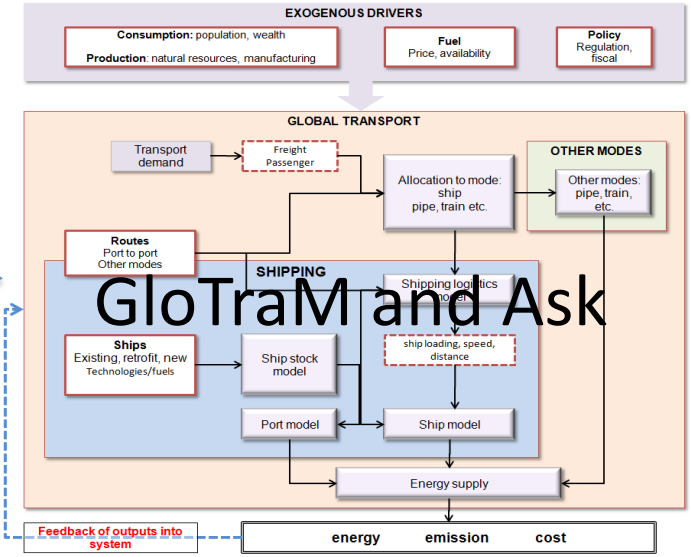
- Combinations of technologies can be designed to work better over a speed range:
  - e.g. WHRS can be optimised to perform at lower engine powers
  - e.g. Flettner rotors and kites were also modelled in a generically
- Development of a web-based approach to make the massive dataset from WSM more useful.
- This work also has important implications for the ongoing discussion at the IMO assessing the potential energy saving from technologies which allows for a path for future technologies and fuels to be developed.



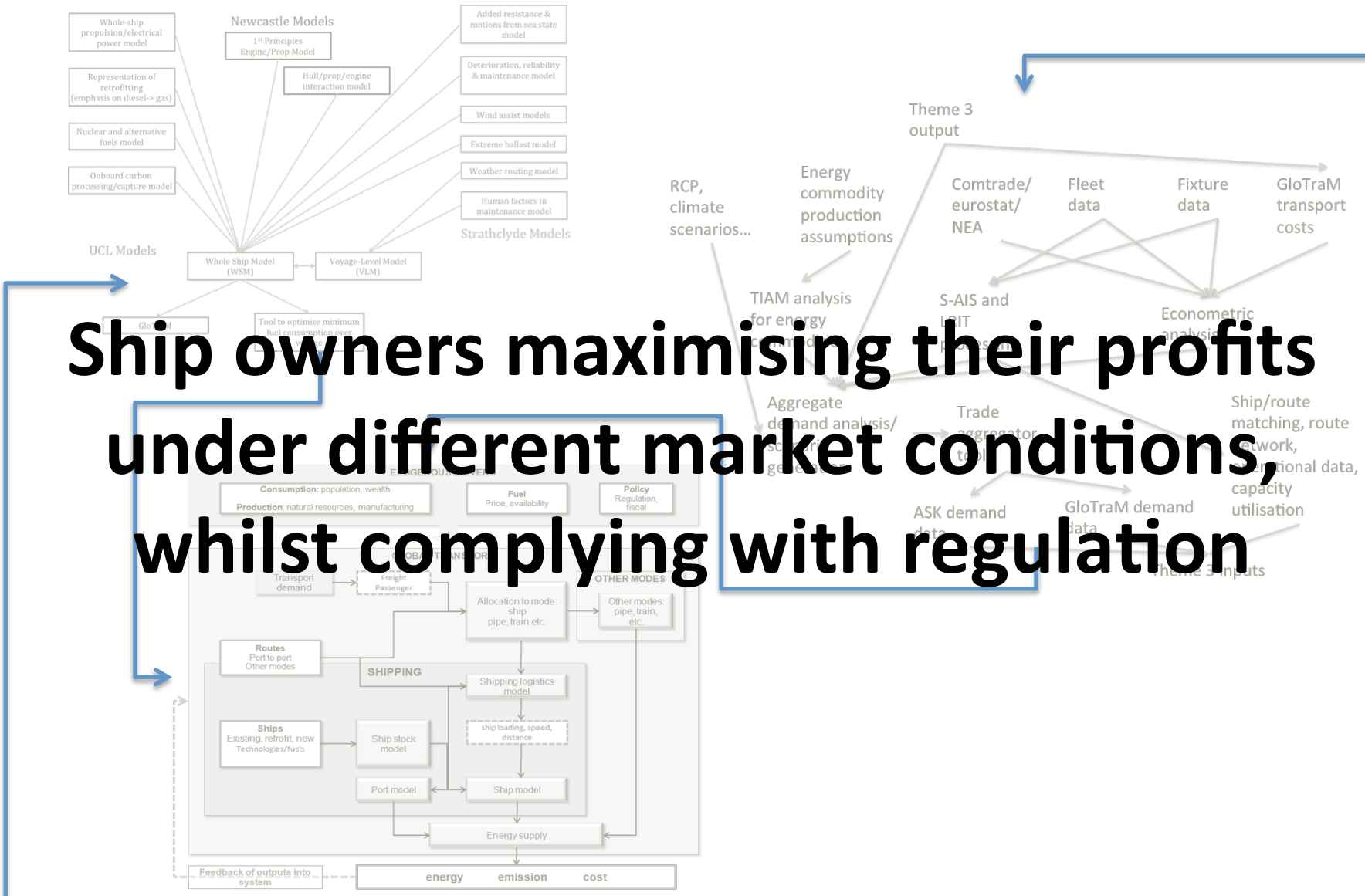
Whole Ship Model



Trade scenarios

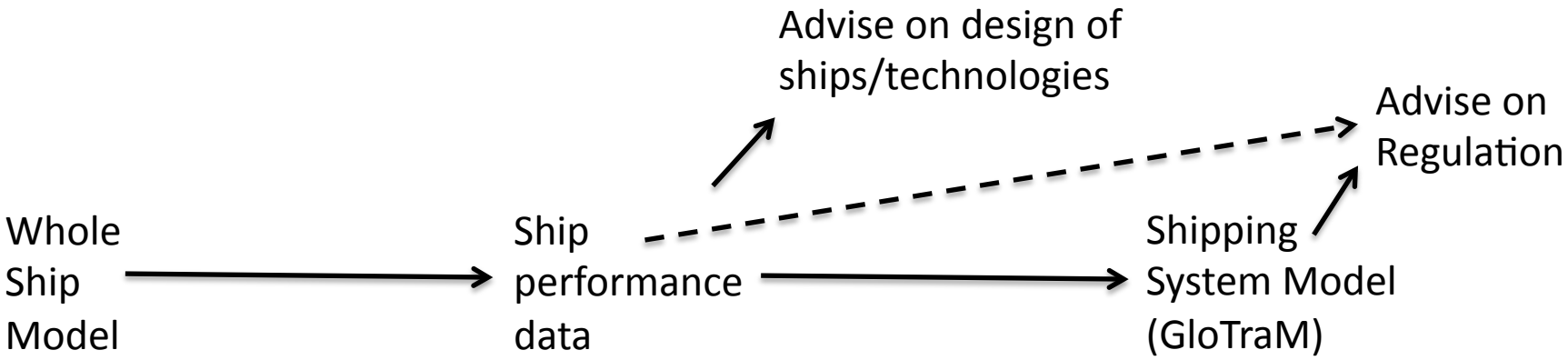


GloTraM and Ask



Ship owners maximising their profits under different market conditions, whilst complying with regulation

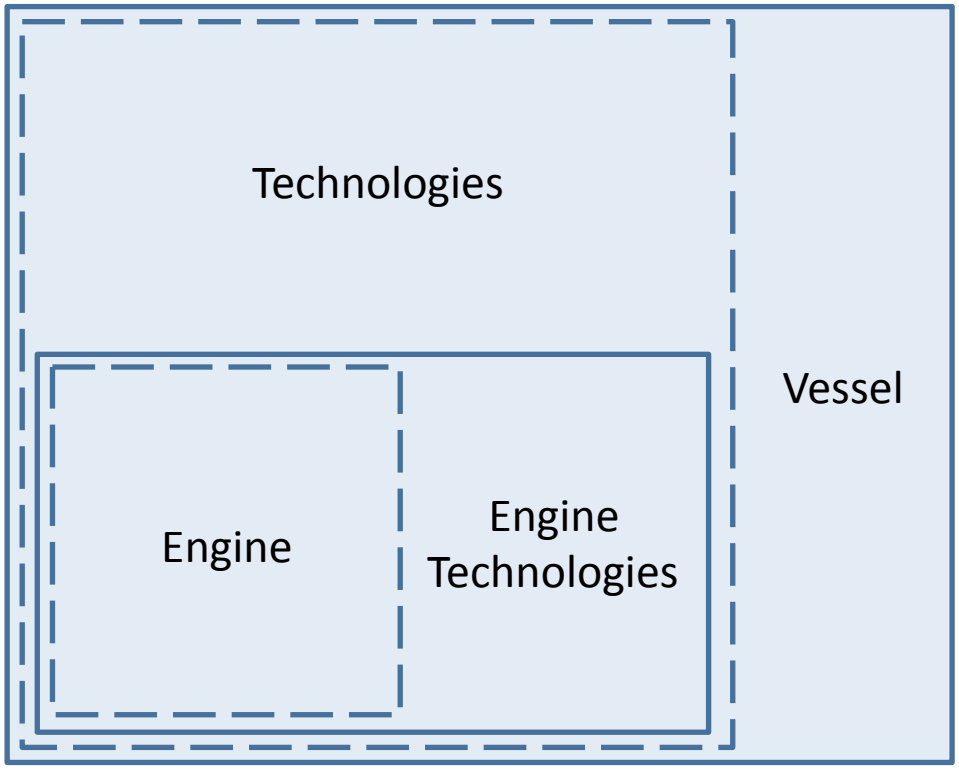
Modelling Process - Whole Ship Model



Note on large quoted savings

- Large quoted savings often mean:
  - Performance calculated at design speed.
  - Scaling issues (e.g. surface tension or Re scaling issues).
  - Physics not fully understood or missing from the modelling process.

A Note on Multiple Technologies



- Compatibility matrices have been used
- The ship / technology interface can be used to describe a system of technologies and their architecture

Future Fuels