SMART MARITIME

SHIP DATA PROCESSING & PERFORMANCE MONITORING

Prateek Gupta, NTNU

June 20, 2023 – Trondheim

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Outline

- Data Processing:
  - The Framework!
  - Quasi-Steady-State Filter
- Ship Performance Monitoring:
  - Data-driven
  - Physics-based
- Fouling Growth Model
  - Fouling Growth Factor
  - Generalized Admiralty Coefficient

PART 1: DATA PROCESSING

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Data Processing Framework

- Developed a framework to process the operational data for ships
- Presented solutions to problems associated with in-service data, AIS data as well as noon reports
- Code for weather data interpolation (wind, waves, & current) is available in IMT@Github!
- Currently working on preparing AIS data + noon reports for ship performance monitoring

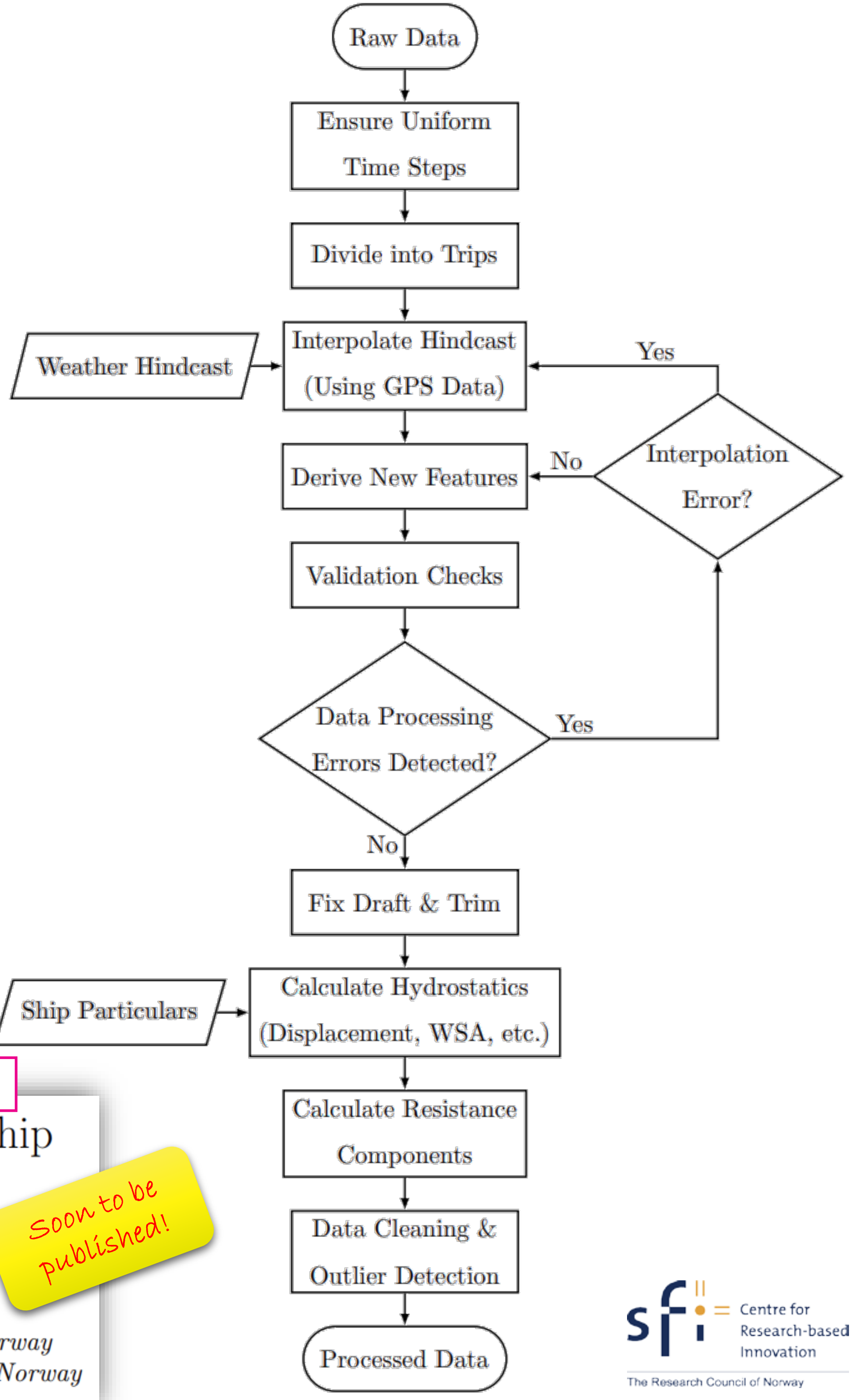
Preprint available on request!

Streamlined Semi-automatic Data Processing Framework for Ship Performance Analysis

Prateek Gupta[a,*], Young-Rong Kim[a], Sverre Steen[a], Adil Rasheed[b]

[a]*Department of Marine Technology, Norwegian University of Science and Technology (NTNU), Norway*
[b]*Department of Engineering Cybernetics, Norwegian University of Science and Technology (NTNU), Norway*

Soon to be published!

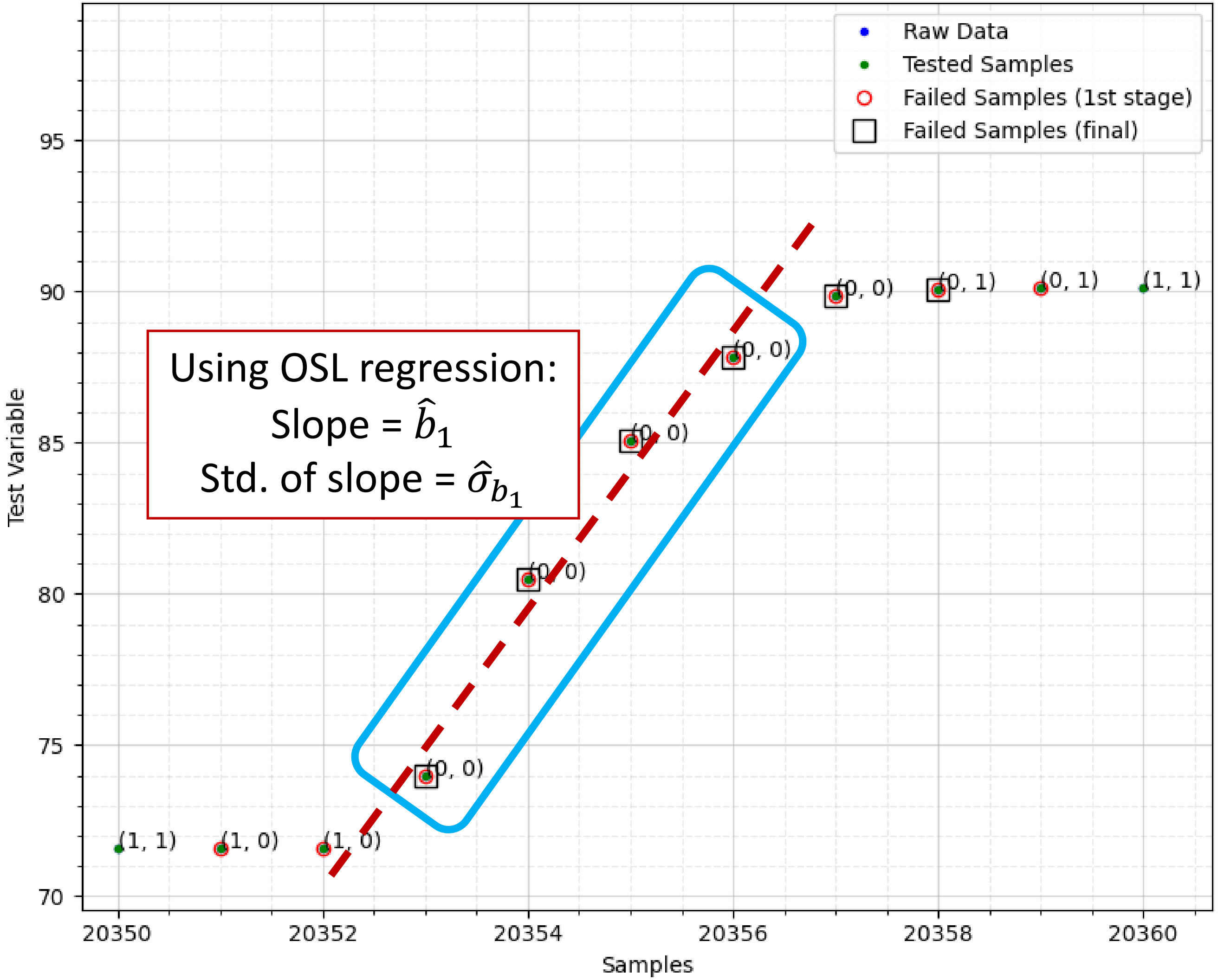


Quasi-Steady-State Filter

- Originally developed by *Dalheim & Steen (2020)*
- Improvements to be published soon:
  - Correction to t-value equation

$$t_1 = \frac{\hat{b}_1}{1 + \hat{\sigma}_{b_1}}$$

  - Fixed time-length sliding window instead of fixed number of samples
- Code available in IMT@Github!

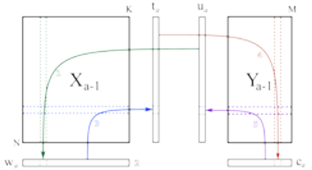


Dalheim, Ø. Ø., & Steen, S. (2020), *A computationally efficient method for identification of steady state in time series data from ship monitoring,* Journal of Ocean Engineering and Science, 5(4), 333-345

PART 2: PERFORMANCE MONITORING

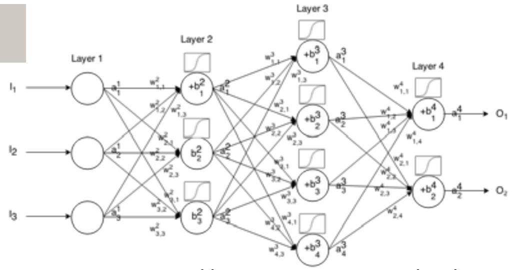
Data-driven Models

PLSR



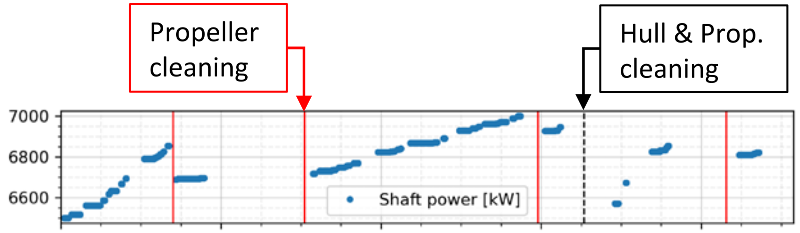
Source: https://learnche.org/pid/latent-variable-modelling/projection-to-latent-structures/how-the-pls-model-is-calculated

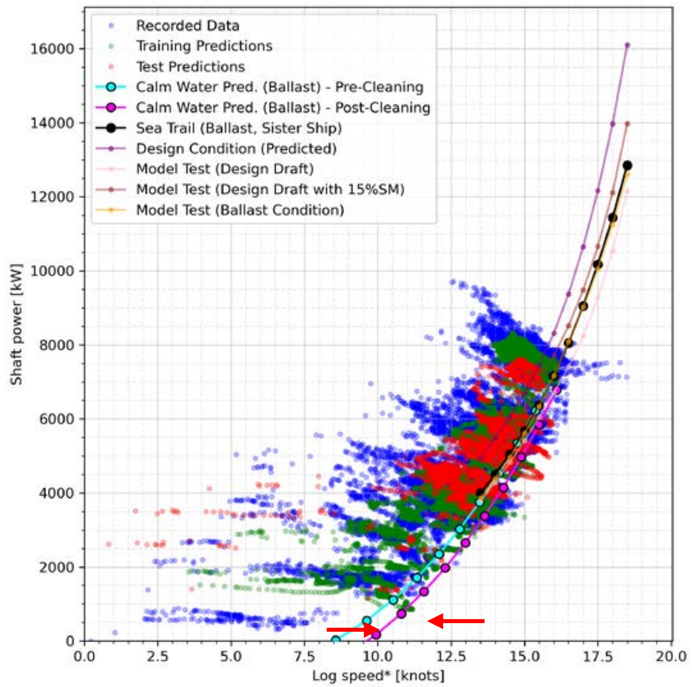
ANN



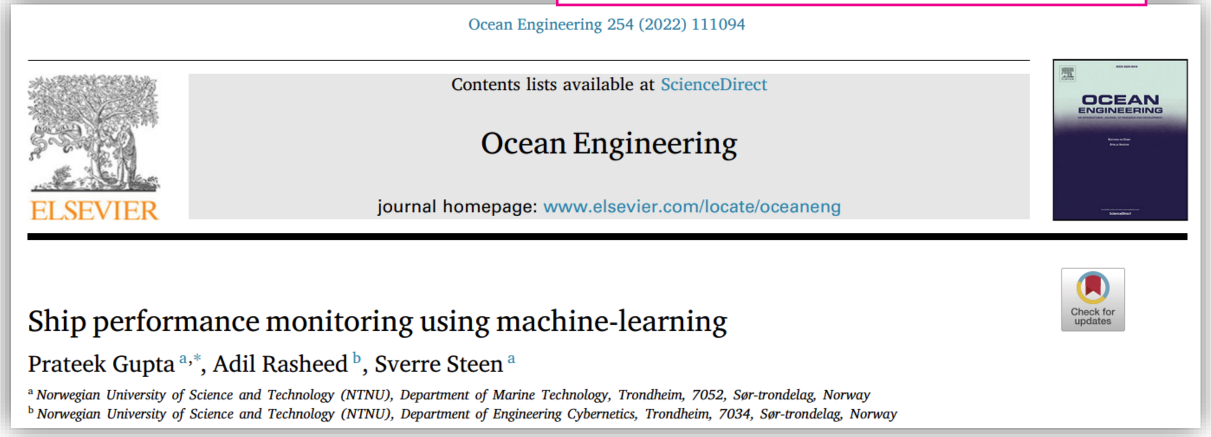
Source: https://www.pngegg.com/en/png-nuvrh

- Presented machine-learning (ML) models for ship performance monitoring
- Linear models like PCR and PLSR were proven to be effective using non-linear transformations
- Used ML to predict the trend in ship's calm-water power demand or speed-loss and the evolution of calm-water speed-power curve





https://doi.org/10.1016/j.oceaneng.2022.111094



Ocean Engineering 254 (2022) 111094

Contents lists available at ScienceDirect

Ocean Engineering

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Ship performance monitoring using machine-learning

Prateek Gupta [a,*], Adil Rasheed [b], Sverre Steen [a]

[a] Norwegian University of Science and Technology (NTNU), Department of Marine Technology, Trondheim, 7052, Sør-trondelag, Norway
[b] Norwegian University of Science and Technology (NTNU), Department of Engineering Cybernetics, Trondheim, 7034, Sør-trondelag, Norway

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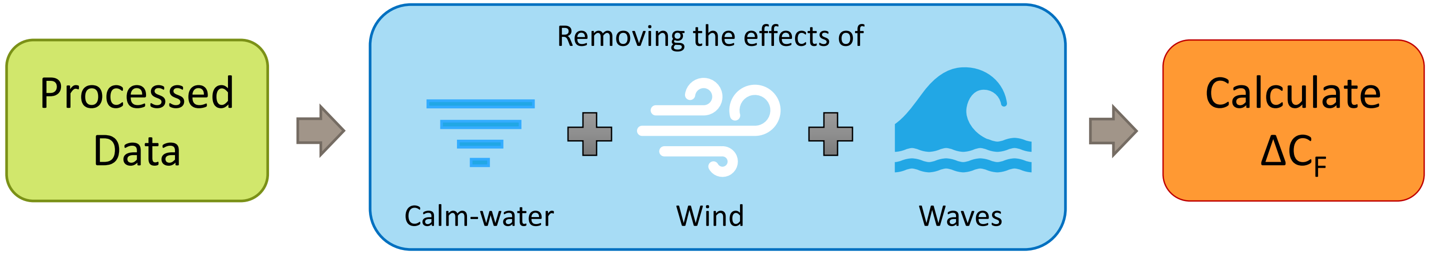
Physics-based Model

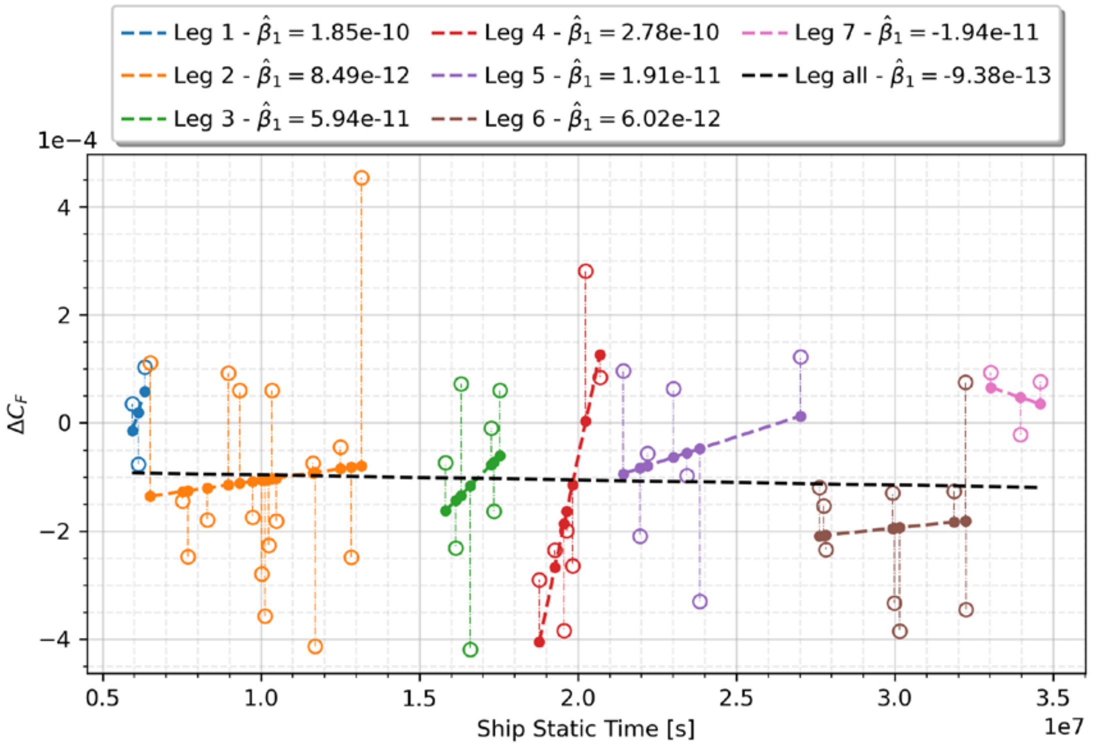


- Calculated fouling friction coefficient as:

$$\Delta C_F = \frac{R_T - (R_{Calm} + R_{wind} + R_{wave})}{0.5 \rho S V^2}$$

- Estimated calm-water resistance from empirical methods like Hollenbach, Guldhammer & Harvald
- Physics-based corrections for wind and wave loads on the measured shaft power
  - Wind correction: Fujiwara's method
  - Wave correction: DTU's & SNNM method

Fouling Friction Coefficient (ΔC_F)



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PART 3: FOULING GROWTH MODEL

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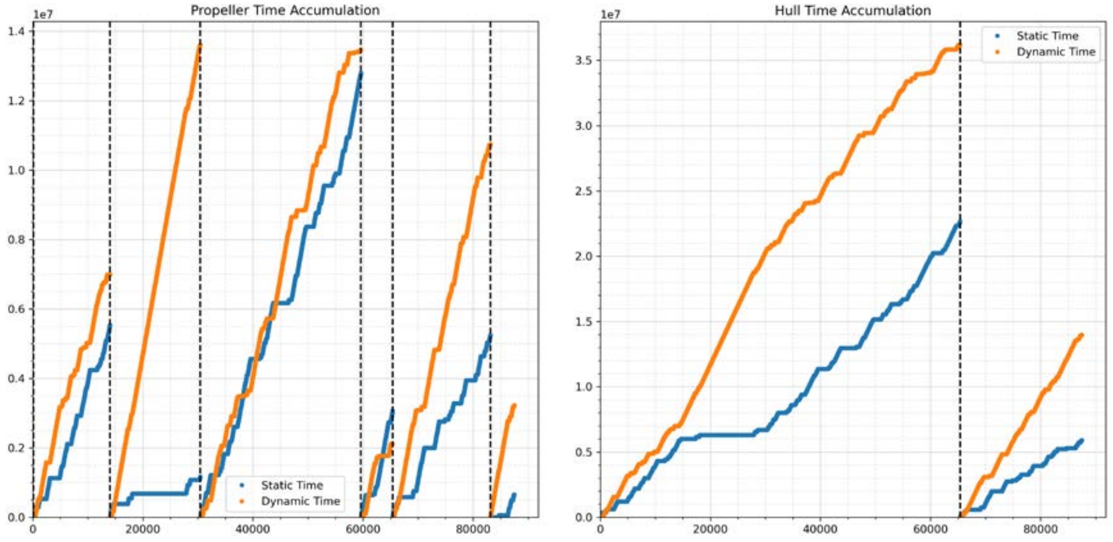
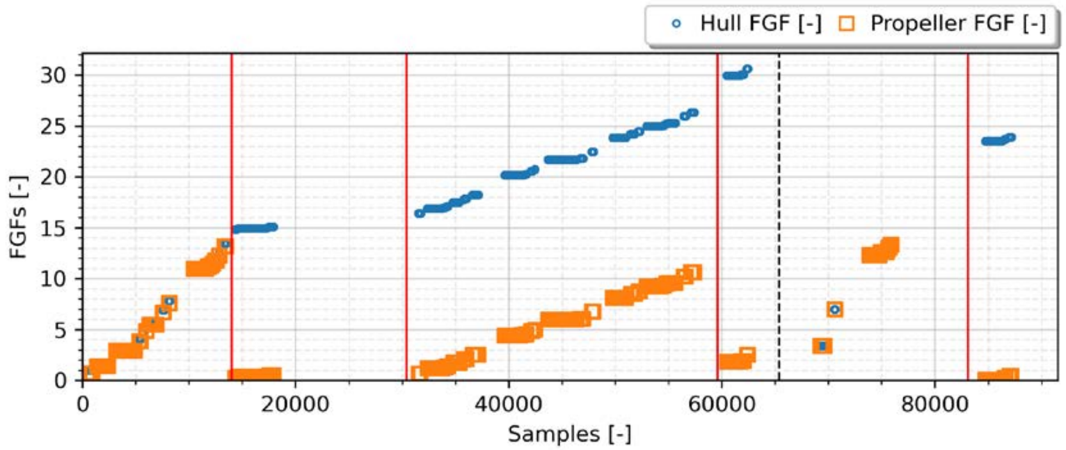
Fouling Growth Factor (FGF)



- Fouling growth is simply assumed proportional to ship's cumulative static time and its growth rate (*Malone & Little, 1980*) :

$$FGF = \sum_i t_{static,\,i}.\,FGR_i$$



- Fouling Growth Rate (FGR) can be modeled as a function of biological factors like temperature, salinity, etc.

- A proper FGR is work in progress!

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Malone, J. A., & Little, D. E. (1980), *Effects of hull foulants and cleaning/coating practices on ship performance and economics* (No. 2)

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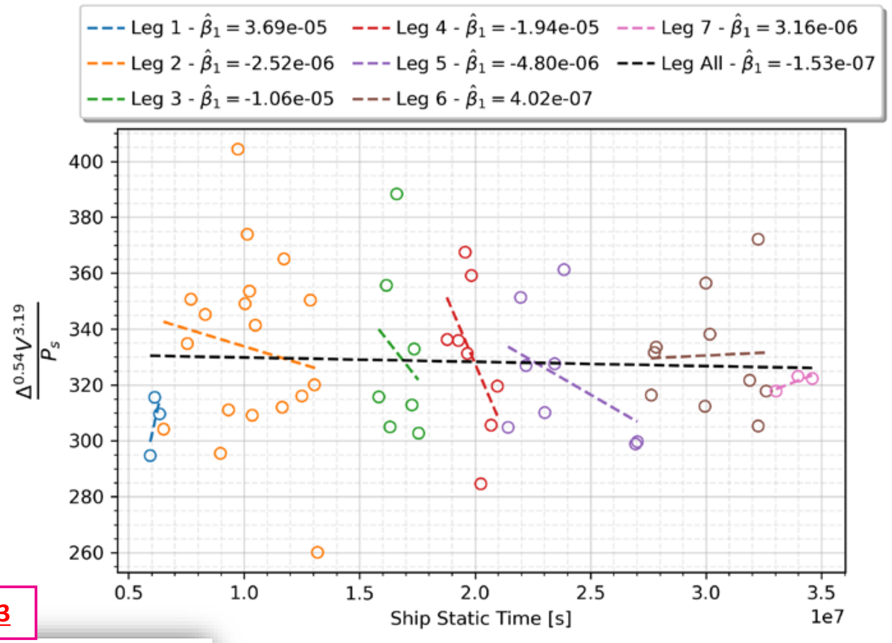
Generalized Admiralty Coefficient

- Ship's hydrodynamic performance indicator
- Used to approximate FGR for data-driven models
- Advantages:
  - Intuitive & easy to remember
  - Can be used for the life-time of a ship
  - Plug & play!!
- Disadvantages:
  - Log-linear

Generalized Admiralty Coefficient (C)



https://doi.org/10.1016/j.apor.2021.102623

Applied Ocean Research 111 (2021) 102623

Contents lists available at ScienceDirect

Applied Ocean Research

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Statistical modeling of Ship's hydrodynamic performance indicator

Prateek Gupta [*,a], Bhushan Taskar [c], Sverre Steen [a], Adil Rasheed [b]

[a] Department of Marine Technology, Norwegian University of Science and Technology (NTNU), Norway
[b] Department of Engineering Cybernetics, Norwegian University of Science and Technology (NTNU), Norway
[c] Technical University of Denmark (DTU), Denmark