Vessel Technical Index and RP on Technical Ship Performance

SFI SmartMaritime

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Background and Motivation

Key drivers influencing ship decarbonization

- Regulation will be increasingly putting pressure on shipping to decarbonize, but environmental performance will have a business impact beyond regulatory compliance
  - Access to cargo and capital (asset value and commercial attractiveness)
  - FuelEX i) keeping the energy demand low will be more important with more expensive fuels ii) the business case for energy efficiency measures will be improved with the introduction of more expensive low carbon fuels iii) direct cost of emissions
  - New business models could emerge (compliance by the hour)

Environmental data will be monetized which demands for transparency and trust!
The Frameworks Must be Targeted and Empower the Stakeholders that has the Opportunity to have an Impact

- CII can be a good measure to calculate the carbon efficiency (CO2/ton-miles) for the world fleet
- Improving the CII takes collaborative efforts between i) owner (technical condition) ii) charterer (operations) and iii) customer (needs).
- When business critical decisions will be made - stakeholders need to be measured on what they can influence! Transparency and trust is key!

Set the standard on how to measure, evaluate and verify technical condition of ships

CII

AER

EEOI

Yards
Charterers
Operators
Ship Owners
Ports

Weather Impact
Speed Instructed
Cargo Carried
Ports to Call
+++
Use Cases

Setting requirements on how to measure and evaluate the technical condition of ships, rests heavily upon the intended use.

1. A consistent way to work with ship performance data and a way to set a baseline
2. Comparing the technical condition of different ships – creating performance/sustainability adjusted CP’s
3. Identify the need for maintenance and evaluate effect of maintenance
4. Evaluate and verify the effects of energy efficiency devices and other technical measures
The Vessel Technical Index
- VTI
VTI definition

\[ VTI = \frac{p_m - p_{env}}{p_0} \]

where

• \( p_m \) is the measured shaft power
• \( p_{env} \) is the power due to environment
• \( p_0 \) is power in ideal condition (reference power)

Performance degradation

\( p_m \)
\( p_{env} \)
\( p_0 \)
Data used for calculation

- All the data will be synchronized to every 1 min
- It requires that all different parameters are steady at the same time.

\[ VTI = \frac{P_m - P_{env}}{P_0(\Delta V)} \]

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Shaft Revolutions*</td>
<td>rpm</td>
</tr>
<tr>
<td>2 Vessel Heading*</td>
<td>Deg.</td>
</tr>
<tr>
<td>3 Water Temperature*</td>
<td>°C</td>
</tr>
<tr>
<td>4 Relative Wind Speed*</td>
<td>m/s</td>
</tr>
<tr>
<td>5 Relative Wind Direction*</td>
<td>Deg.</td>
</tr>
<tr>
<td>6 Significant Wave Height</td>
<td>m</td>
</tr>
<tr>
<td>7 Primary Relative Wave Direction</td>
<td>Deg.</td>
</tr>
<tr>
<td>8 Primary Wave Period</td>
<td>s</td>
</tr>
<tr>
<td>9 Speed Over Ground*</td>
<td>m/s</td>
</tr>
<tr>
<td>10 Speed Through Water_abb</td>
<td>m/s</td>
</tr>
<tr>
<td>11 Shaft Power_abb</td>
<td>kW</td>
</tr>
<tr>
<td>12 Water Depth_abb</td>
<td>M</td>
</tr>
<tr>
<td>13 Displacement-DRAFT*</td>
<td>m³</td>
</tr>
</tbody>
</table>
Data used for calculation

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Process variability</th>
<th>time period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vessel heading (deg)</td>
<td>2 deg</td>
<td>30</td>
</tr>
<tr>
<td>Primary wave direction relative (deg)</td>
<td>10 deg</td>
<td>60</td>
</tr>
<tr>
<td>Wind direction relative (deg)</td>
<td>10 deg</td>
<td>60</td>
</tr>
<tr>
<td>Significant wave height (m)</td>
<td>0.15m</td>
<td>30</td>
</tr>
<tr>
<td>Primary wave period (s)</td>
<td>0.5 s</td>
<td>60</td>
</tr>
<tr>
<td>STW Wavex (m/s)</td>
<td>0.1 m/s</td>
<td>30</td>
</tr>
<tr>
<td>Speed over ground (m/s)</td>
<td>0.1 m/s</td>
<td>30</td>
</tr>
<tr>
<td>Water temperature (C)</td>
<td>0.5 (C)</td>
<td>60</td>
</tr>
<tr>
<td>Wind magnitude relative (m/s)</td>
<td>15% [-]</td>
<td>30</td>
</tr>
<tr>
<td>Shaft speed (rpm)</td>
<td>t-student</td>
<td>10</td>
</tr>
</tbody>
</table>
Correcting weather effects

\[ VTI = \frac{P_m - P_{env}}{P_0} \]

\[ P_{env} = P_{wave} + P_{wind} + P_{temp} \]

\[ P_{env} = (R_{wave} + R_{wind} + R_{temp}) \cdot V_{STW} \]

- Added resistance induced by waves from arbitrary directions
  *Liu and Papanikolaou (2020)*


Use Case 1 – VTI used in CP contracts

Standard CP terms:

<table>
<thead>
<tr>
<th>Service speed</th>
<th>Eco speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>LADEN</td>
<td>BALLAST</td>
</tr>
<tr>
<td>Speed (kts)</td>
<td>14</td>
</tr>
<tr>
<td>Consumption (mt/day)</td>
<td>36</td>
</tr>
</tbody>
</table>

TC hire: 20000 USD/day < Beaufort force 5

Adjusted CP terms based upon VTI:

<table>
<thead>
<tr>
<th>Q1 2023</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service speed</td>
</tr>
<tr>
<td>LADEN</td>
</tr>
<tr>
<td>Speed (kts)</td>
</tr>
<tr>
<td>GHG emissions (MT CO2_eq/day)</td>
</tr>
<tr>
<td>VTI (·)</td>
</tr>
<tr>
<td>TC hire (USD/day)</td>
</tr>
</tbody>
</table>

Dynamic CP terms based upon VTI:

<table>
<thead>
<tr>
<th>Q2 2023</th>
<th>Q3 2023</th>
<th>Q4 2023</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service speed</td>
<td>Eco speed</td>
<td>Service speed</td>
</tr>
<tr>
<td>LADEN</td>
<td>BALLAST</td>
<td>LADEN</td>
</tr>
<tr>
<td>Speed (kts)</td>
<td>115</td>
<td>81</td>
</tr>
<tr>
<td>GHG emissions (MT CO2_eq/day)</td>
<td>19000</td>
<td>19000</td>
</tr>
<tr>
<td>VTI (·)</td>
<td>1,3</td>
<td>1,3</td>
</tr>
<tr>
<td>TC hire (USD/day)</td>
<td>20000</td>
<td>20000</td>
</tr>
</tbody>
</table>

- Enable informed contracting decisions between charterer and owner
- Incentivise the technically good ships
- There will be a need for one source of truth
- Making the CP’s VTI adjusted allows for sharing of risk/reward
- Improving VTI is incentivised
- VTI is a better index than CII for this purpose
VTI with uncertainty

*informed decisions*

**Use Case**

Compare the technical condition of two sister ships travelling at the same speed and with the same loading condition.
VTI with uncertainty
informed decisions

**Use Case**
Compare the technical condition of different ships

Prob. VTI of Ship A < Ship B = 0.99
VTI with uncertainty
informed decisions

Use Case
Compare the technical condition of different ships

Prob. VTI of Ship A < Ship B = 0.65
VTI with uncertainty
informed decisions

Use Case
Compare the technical condition of different ships

Prob. VTI of Ship A < Ship B = 0.7
Use case 2  – Maintenance

WORLD VIRTUE (Ultramax Bulk Carrier)
San Vincente (29-07-2021) – Callao (01-08-2021)

Average VTI of 1.20 indicate hull and/or propeller fouling
Diver’s inspection in Callao 03-08-2021

- Light hull fouling (slime)
- Propeller heavy fouled (slime, barnacles, sea grass)

It was decided only to clean and polish the propeller
VTI – Propeller cleaning

Propeller cleaning resulted in:

**VTI reduction ~8% point**

Fuel Saving of ~1.5 t/day on the following 4 days voyage.

Fuel saving 4 x 1.5 x 600 USD/t, ie 3,600 USD

Cost for propeller cleaning 3,200 USD in Callao

- Hull and/or propeller fouling identified by real-time VTI measurements
- Cost-benefit of propeller cleaning verified
- Pay-back time for propeller cleaning was less than 4 days!
RP – documentation and verification
Recommended Practice

Aim: Make a standard with transparent procedure to facilitate scaling
- What to measure
- How to handle data
- How to calculate VTI

The RP is on public hearing now. We welcome your feedback!

Hearing Document
Collaboration with SFI Smart Maritime

Projects

• Co-Cii: Collaborative strategies for GHG emission reduction through the Cii
  • VTI as the technical index

• Ship Technical Performance evaluation System (STEPS)
  • Working together with NTNU

• 3F- TRIPLE FUEL SHIPS WITH COST AND RISK REDUCTIONS
  • Piloting VTI on new Skarv ships

Papers

Reliable Hull Performance Analysis using Vessel Technical Index

Piloting VTI on new Skarv ships

Evaluating Vessel Technical Performance Index using Physics-based and Data-driven Approach

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Thanks for your kind attention!

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