Heartland Waterway Vessel: River Tender Replacement Project

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Brian Cuneo (Not Present)
Problem Statement (History)

• Current vessels are aging rapidly and are badly in need of replacement
• Maximum speed of the current River Tenders is too low - barely able to make way in the strong current on the Mississippi River and St. Lawrence Seaway
• Shoaling and changing mission environment have altered the conditions of the inland waterways requiring shallow draft vessels to set the aids to navigation
Design Objectives

• Complete a feasibility assessment for a replacement to the existing River Tender fleet
• Do a preliminary design analysis of the ship – hull form, propulsion system, general arrangements, etc.
• Select a propulsion system and determine what emission mitigation systems will be needed to meet current and expected EPA requirements
Resources

• Existing Inland River Tenders and associated crews
• Coast Guard Engineering Logistics Center (ELC-Baltimore)
• Coast Guard Naval Engineering Support Units (NESU-New Orleans, NESU-Cleveland)
• University of Michigan Staff
The Heartland Waterway Vessel
Hull Design

- LOA – 61.4 m (201.4 ft)
- Beam – 11 m (36 ft)
- Draft (max) – 1.52 m (5ft)
- Displacement – 660 metric tons
- Deck Capacity – 150 short tons
- Speed – 19 kts (max)/14 kts (transit)
- Endurance – 3000 NM
Superstructure Arrangements

Main Deck Plan View

01 Deck Plan View

02 Deck Plan View
Deck Arrangement

96 Sinkers
24 Class 4 Buoys
36 Class 6 Buoys
24 Wood Piles
12 m Crane Reach

Max deck load
TEU capabilities
Boat deck
Davits
Work area
Staterooms

- Crew comforts
  - 7 Two Man Staterooms
  - 4 Single Staterooms
Galley/Messdeck

- 20 m² attached Dry Storage
- Seating for 18
Pilot House

• 360° View with full walk around bridge wings
Resistance

- Resistance was calculated using Von Oortmeersen method
- Based on regression of Tugs and Trawlers

<table>
<thead>
<tr>
<th>Speed (kts)</th>
<th>Resistance (kN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 (transit)</td>
<td>55.7</td>
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<tr>
<td>19 (max)</td>
<td>134</td>
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</table>
Propeller Selection

• Propeller:
  – Ka 4-70 1.08 m Diameter
  – Pitch to Diameter Ratio 1.25 Provides necessary thrust at 19 kts and higher efficiencies at 14 kts

• Nozzle:
  – MARIN Type 37
  – High performance for both forward and reverse thrust
Propulsion Plant

• Two Wärtsilä 4L20 Diesel Engines – MCR 800 kW @ 1,000 RPM each (1,073 hp)

<table>
<thead>
<tr>
<th>Propulsion Selection</th>
<th>Speed (Vk)</th>
<th>Propeller Speed</th>
<th>Engine Speed</th>
<th>Required Thrust (Rt)</th>
<th>Effective Power (PE)</th>
<th>Delivered Power (PD)</th>
<th>Brake Power (PB)</th>
<th>Total Installed MCR</th>
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</thead>
<tbody>
<tr>
<td>Speed (Vk)</td>
<td>19</td>
<td>530</td>
<td>1,000</td>
<td>134</td>
<td>1,453</td>
<td>1,471</td>
<td>1,516</td>
<td>1,600</td>
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<tr>
<td>Propeller Speed</td>
<td></td>
<td>350</td>
<td>660</td>
<td>55.7</td>
<td>434</td>
<td>447</td>
<td>461</td>
<td>1,600</td>
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<tr>
<td>Engine Speed</td>
<td></td>
<td></td>
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<td>Required Thrust (Rt)</td>
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<td>Effective Power (PE)</td>
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<td>Delivered Power (PD)</td>
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<tr>
<td>Brake Power (PB)</td>
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<tr>
<td>Total Installed MCR</td>
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<td></td>
<td></td>
<td></td>
<td>1,600</td>
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</table>
Selective Catalytic Reduction
Maneuvering and Rudder Selection

- Maneuvering criteria based on IMO standards
- Main rudders sized to 1.8 m² per rudder giving a tactical diameter of 4 times the vessel length
- Flanking rudders are included to aid in maneuvering while reversing
Electrical Generation

• Completed regression analysis of Buoy Tender fleet world wide to obtain average generator capacity

<table>
<thead>
<tr>
<th>Vessel</th>
<th>Propulsion MCR (kW)</th>
<th>Total Generator Capacity (kW)</th>
<th>Percentage of Generator to Propulsion Power</th>
<th>Normal Load - 75% of Capacity (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>1678</td>
<td>371</td>
<td>22%</td>
<td>279</td>
</tr>
<tr>
<td>HWV</td>
<td>1600</td>
<td>326</td>
<td>20%</td>
<td>245</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Model</th>
<th>Rated Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Generator</td>
<td>Caterpillar C9</td>
</tr>
<tr>
<td>Emergency Generator</td>
<td>Caterpillar C4.4</td>
</tr>
</tbody>
</table>
## Tank Arrangements

<table>
<thead>
<tr>
<th>Tank</th>
<th>Volume (m³)</th>
<th>95 % load (gal)</th>
<th>Weight (Tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ballast</td>
<td>218</td>
<td>54,711</td>
<td>207</td>
</tr>
<tr>
<td>Fuel</td>
<td>159</td>
<td>39,822</td>
<td>24</td>
</tr>
<tr>
<td>Potable Water</td>
<td>51</td>
<td>12,725</td>
<td>48</td>
</tr>
<tr>
<td>CHT</td>
<td>51</td>
<td>12,725</td>
<td>34</td>
</tr>
<tr>
<td>Urea</td>
<td>16</td>
<td>4,099</td>
<td>21</td>
</tr>
<tr>
<td>Lube Oil</td>
<td>5</td>
<td>1,242</td>
<td>4</td>
</tr>
</tbody>
</table>
Stability Criterion - Metacentric Height ($GM_T$)

• The stability of the Heartland Waterway Vessel at fully loaded and unloaded conditions was evaluated against the $GM_T$ requirements in 46 CFR 170.170.

• The resulting required $GM_T$ is 0.412 meters.
  – $GM_T$ at full load departure - 7.02 meters.
  – $GM_T$ at no load arrival - 8.73 meters.
Weight Distribution
# Midship Structure

All dimensions above are in meters.  
Plate thickness = 3/8”  
Stiffener thickness = 1/4”

<table>
<thead>
<tr>
<th></th>
<th>Heartland Waterway Vessel</th>
<th>ABS Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deck Section Modulus [cm-m²]</td>
<td>5,470</td>
<td>&gt;3,485</td>
</tr>
<tr>
<td>Bottom Section Modulus [cm-m²]</td>
<td>6,088</td>
<td>&gt;3,485</td>
</tr>
<tr>
<td>Moment of Inertia [cm²-m²]</td>
<td>8,644</td>
<td>&gt;6,279</td>
</tr>
</tbody>
</table>
Floodable Length

• The HWV has been designed to meet two compartment flooding standards.
Damaged Stability

• The HWV has been designed to meet the damage stability requirements of 46 CFR 42.20-6.
## Damaged Stability

### Summarization of Damage Stability Modeling Results

<table>
<thead>
<tr>
<th>Compartment(s)</th>
<th>Intact Trim</th>
<th>Damaged Trim</th>
<th>Max GZ in 20 deg range</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Aft</td>
<td>Forward</td>
<td>Aft</td>
</tr>
<tr>
<td>Flooded</td>
<td>(m)</td>
<td>(m)</td>
<td>(m)</td>
</tr>
<tr>
<td>Hold 1/Hold 2</td>
<td>1.52</td>
<td>1.52</td>
<td>1.11</td>
</tr>
<tr>
<td>Hold 2/Hold 3</td>
<td>1.52</td>
<td>1.52</td>
<td>1.3</td>
</tr>
<tr>
<td>Hold 3/Hold 4</td>
<td>1.52</td>
<td>1.52</td>
<td>1.44</td>
</tr>
<tr>
<td>Hold 4/Hold 5</td>
<td>1.52</td>
<td>1.52</td>
<td>1.79</td>
</tr>
<tr>
<td>Engine Room/Machinery Room</td>
<td>1.52</td>
<td>1.52</td>
<td>2.38</td>
</tr>
</tbody>
</table>
Maintenance

• Large open machinery Spaces
• Easy Access to all machinery
• Large Hatches/Doors for easy movement of replacement parts
• Large flat hull plate to ease hull repairs
• Expanded overheads for access to pipe/wire runs
• Tank Tops located to ease inspections
• Use of cathodic hull protection suited for the fresh water environment i.e. Navalloy™ (aluminum/zinc/indium alloy)
Dry Docking

- C&C Marine Maintenance – Clairton, PA
- Newt Marine (overhang) – Dubuque, IA
- Wepfer Marine – Memphis, TN
- National Maintenance – Hartford, IL; Paducah, KY
- Mississippi Marine – Greenville, MS
- Bollinger Shipyard – Lockport, LA
Conclusions

• The HWV was designed to meet all safety criterion, and improve on current designs by including:
  – Single Hull vessel vs. tug and barge
  – Optimized Hull Form
  – Kort Nozzles
  – Flanking Rudders
  – Ease of Maintenance
Recommendations

• Conduct model testing to refine resistance calculations
• Detailed electrical load analysis for correct generator sizing
• In depth cost analysis
Discussion