Research Roadmap Development

- **INITIAL ASK:** If any members have roadmaps or roadmap development processes that have worked well in the past, please share as we’d like to leverage your collective experience and see no need to re-create the wheel.

- **Today’s Focus:**
  - Discuss Initial Technology Focus Areas
  - Consortium Partners Existing Efforts
    - Identify core areas where existing research can be extended to address Navy-specific concerns
    - Identify commercial tech that could be adapted to Navy use
    - Identify gaps in R&D efforts that need to be pursued

- Develop white papers for high priority efforts for potential FY23 ONR Funding

Contact:
Bill Muras
william.j.muras.ctr@us.navy.mil
703-261-5059
Platform Decarbonization Focus Areas

• Across multiple existing studies, there seems to be general agreement on technology “focus areas”
  • OECD/International Transport Forum – “Decarbonising Maritime Transport” – 2018
  • IATA Fly Net Zero

• Broad Focus Areas
  • Technology – *this is primary focus for this Consortium*
  • Operations
  • Fuels
MARAD META Glosten Report

Part 2 – Technology Evaluation

2.1 Efficiency Technologies (ET)

- DIRECT DRAG REDUCTION
  - Advanced Hull Coatings
  - Anti-Fouling Coatings
  - Nanocoatings
  - Hull Cleaning and Maintenance
  - Hull Form Optimization
  - Air Lubrication

- PROPULSIVE LOSS REDUCTION
  - Propellers
  - Pre-Swirl Devices
  - Post-Swirl Devices

- PROPULSION AND POWER GENERATION
  - Diesel-Electric propulsion (DEP)
  - Variable Speed Generator (VSG)
  - Power Take-Off/Power Take-In (PTO/PTI)
  - Magnetic Gearing
  - Printed Circuit Board (PCB) Stator Motor

- ELECTRICAL ENERGY STORAGE
  - Hybrid Mechanical/Electrical
  - Battery (All-Electric)
  - Shore Power
  - Supercapacitor Energy Storage (ScES)
  - Superconducting Magnetic Energy Storage (SMES)

- WASTE HEAT RECOVERY
  - Waste Heat Recovery Systems
  - HVAC Optimization

- RENEWABLE ENERGY
  - Kite Sails
  - Rotor Sails
  - Rigid Wingsails
  - Flexible Sails
  - Inflatable Sails
  - Wave-Assisted Propulsion
  - Solar Power

2.2 Fuel Technologies (FT)

- Fuel Colors
- Transitional Fuels
- Hydrogen
- Ammonia
- Biofuels
- Fischer Tropsch Diesel (FTD)
- Methanol
- ICE Technology
- Fuel Cell Technology
- Fuel-Ready Vessel Design
- Onboard Carbon Capture and Storage (oCCS)
- Marine Nuclear Power

2.3 Operational Measures (OM)
Navy Specific Constraints/Considerations

Some aspects of the Navy unique mission(s) to keep in mind
• Navy platforms operate:
  • Forward presence
  • Contested logistics
  • Replenishment at sea
• Navy platforms are:
  • Space constrained
  • Often/Sometimes power constrained
  • Operated by 18-19 year old sailors
  • Long-lived $1B+ assets

Some other Consortium considerations
• Short-, Mid- and Long-Term Horizons
• Retro-fit versus new build
• Not just an economic decision
• Potential future force structure – UxVs
• “Collaborate with the past”
## OECD / International Transport Forum

### Table 1. Overview of measures to reduce shipping’s carbon emissions

<table>
<thead>
<tr>
<th>Type of measures</th>
<th>Main measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technological</td>
<td>Light materials, slender design, less friction, waste heat recovery</td>
</tr>
<tr>
<td>Operational</td>
<td>Lower speeds, ship size, ship-port interface</td>
</tr>
<tr>
<td>Alternative fuels/energy</td>
<td>Sustainable biofuels, hydrogen, ammonia, electric ships, wind assistance</td>
</tr>
</tbody>
</table>

### Table 2. Main technological measures

<table>
<thead>
<tr>
<th>Measures</th>
<th>Potential fuel savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light materials</td>
<td>0-10%</td>
</tr>
<tr>
<td>Slender design</td>
<td>10-15%</td>
</tr>
<tr>
<td>Propulsion improvement devices</td>
<td>1-25%</td>
</tr>
<tr>
<td>Bulbous bow</td>
<td>2-7%</td>
</tr>
<tr>
<td>Air lubrication and hull surface</td>
<td>2-9%</td>
</tr>
<tr>
<td>Heat recovery</td>
<td>0-4%</td>
</tr>
</tbody>
</table>

### Table 3. Main operational measures

<table>
<thead>
<tr>
<th>Measures</th>
<th>CO₂ emissions reduction potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed</td>
<td>0-60%</td>
</tr>
<tr>
<td>Ship size</td>
<td>0-30%</td>
</tr>
<tr>
<td>Ship-port interface</td>
<td>1%</td>
</tr>
<tr>
<td>Onshore power</td>
<td>0-3%</td>
</tr>
</tbody>
</table>

### Table 4. Main measures related to alternative fuels and energy

<table>
<thead>
<tr>
<th>Measures</th>
<th>CO₂ emission reductions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced biofuels</td>
<td>25-100%</td>
</tr>
<tr>
<td>LNG</td>
<td>0-20%</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>0-100%</td>
</tr>
<tr>
<td>Ammonia</td>
<td>0-100%</td>
</tr>
<tr>
<td>Fuel cells</td>
<td>2-20%</td>
</tr>
<tr>
<td>Electricity</td>
<td>0-100%</td>
</tr>
<tr>
<td>Wind</td>
<td>1-32%</td>
</tr>
<tr>
<td>Solar</td>
<td>0-12%</td>
</tr>
<tr>
<td>Nuclear</td>
<td>0-100%</td>
</tr>
</tbody>
</table>

Note: Emission reduction potential measured individually. Percentage indicates possible reduction compared to baseline.
IATA Fly Net Zero

The plan

Contribution to achieving Net Zero Carbon in 2050

- 65%
- 19%
- 13%
- 3%

Net Zero 2050 is achievable through:

Combination of measures
- Sustainable Aviation Fuel, new technologies, operational and infrastructure improvements, and offsetting/carbon capture

Collective effort
- of the entire industry together with governments, oil producers and investors