Total Ship Systems Engineering
2016 Design Project

Minutemen Class
“Answering the Call by Sea”
Objectives

- Team Members
- AOR Backgrounds
- Problem Statement/Operational Requirements
- Deployment CONOPS/Employment
- Missile/Gun Selection Process
- Hull Development
- Prime Mover Selection
- Arrangements
- Components:
  - Navigation
  - RADAR
  - Communication
  - Data Management
  - Fire Suppression
  - Manning
- Cost Analysis
- References
### Team Members

<table>
<thead>
<tr>
<th>Name</th>
<th>Nationality</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prof. Jarema M. Didoszak</td>
<td></td>
<td>Mechanical &amp; Aero Engineering Dept.</td>
</tr>
<tr>
<td>Prof. Fotis A. Papoulias</td>
<td></td>
<td>Systems Engineering Dept.</td>
</tr>
<tr>
<td>LTJG Hayden</td>
<td>Peruvian Navy</td>
<td>Physics</td>
</tr>
</tbody>
</table>

* Systems Engineering Lead  
** HM&E Design Team Lead
Background

- Western Pacific Area of Interest (7th Fleet)
  - West Sea (Yellow Sea)
    - DPRK Aggression
  - East China Sea
    - JMSDF Assistance
  - South China Sea
    - Taiwan Strait Defense
  - Spratly Islands
    - PRC Military Outposts
  - Strait of Malacca
    - Main shipping between Indian and Pacific Oceans
    - Approx. 15 million barrels of oil per day
Background

- South West Asia Area of Concern (5th Fleet)
  - Persian Gulf
    - Strait of Hormuz
    - 20% of world’s petroleum
  - Red Sea
    - Bab el Mandeb Strait
    - Access to Suez Canal
  - Gulf of Aden
    - Access to Suez Canal
  - Mediterranean Sea
    - Strait of Gibraltar
    - Over 110,000 vessels pass through per year for passage to the Middle East
Problem Statement

• Sea control traditionally provided by capital ships is increasingly difficult as advanced sea-denial strategies reduce global maritime security.

• Distributed lethality has the ability to overcome these challenges by forcing adversaries to disperse their defenses into a countering position.

• In order to accomplish this mission, a conceptual design of an affordable surface vessel capable of offensive surface operations for sea control is required.
Operational Requirements

- Primary Weapons: 8 canisterized anti-ship cruise missiles.
- Endurance: 1000 nm insertion with 5 days on station at 5 knot loiter and 1000 nm exfiltration.
- Speed: 30 knots or greater.
- Crew: 12 with additional ability to embark 15 operators.
- Cost: Ship construction less than $100 million (GFE included).
- Combat System: No requirement. Self-defense against enemy combatant vessels and aircraft.
- Sensors: Commercial navigation and 360° EO/IR system.
- Networks: C2 system capable of generating firing solution. Network with additional swarm combatants.
- Signature: Emphasize reduced radar and IR signatures.

**STAKEHOLDER INPUT**
Deployment Concepts

• Forward Operating Base:
  • Traditional deployment model
  • Utilize existing USN forward operating bases

• Supplemental Re-supply Methods
  • Friendly islands vendors
  • Island drop-off points
  • Air-dropped w/ buoy
Mothership/Tender

- Tender
  - Utilize existing tender ships
  - Tenders transit w/ vessels
  - Provide crew swap-out

- Mothership
  - Utilize Amphibious Ship
  - Hold vessels in well deck
  - Transport vessels to the fight

<table>
<thead>
<tr>
<th>Ship Class</th>
<th>Welldeck Length (ft)</th>
<th>Welldeck Beam (ft)</th>
<th># Minutemen Vessels</th>
<th># Ships in service (active/reserve)</th>
</tr>
</thead>
<tbody>
<tr>
<td>San Antonio</td>
<td>170</td>
<td>50</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>Whidbey Island</td>
<td>440</td>
<td>50</td>
<td>2</td>
<td>8</td>
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<tr>
<td>Harpers Ferry</td>
<td>220</td>
<td>50</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Austin</td>
<td>168</td>
<td>50</td>
<td>1</td>
<td>1/5</td>
</tr>
<tr>
<td>Wasp</td>
<td>267</td>
<td>50</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>Tarawa</td>
<td>268</td>
<td>78</td>
<td>2</td>
<td>0/2</td>
</tr>
</tbody>
</table>
Afloat Forward Staging Base

- Mobile Landing Platform (MLP) / Expeditionary Transfer Dock (ESD)
  - 154m x 50m mission deck
  - Provide refueling & resupply
  - Provide crew swap-outs
## CONOPS Comparison

<table>
<thead>
<tr>
<th>Mothership / Tender</th>
<th>AFSB (MLP/ESD)</th>
<th>Forward Operating Base</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Advantages:</strong></td>
<td><strong>Advantages:</strong></td>
<td><strong>Advantages:</strong></td>
</tr>
<tr>
<td>• Keeps vessels close to fight with quick turnaround</td>
<td>• Greatest payload capacity</td>
<td>• Infrastructure currently in place</td>
</tr>
<tr>
<td>• Minimizes seakeeping/habitability requirements (mothership)</td>
<td>• Greatest payload flexibility</td>
<td><strong>Disadvantages:</strong></td>
</tr>
<tr>
<td><strong>Disadvantages:</strong></td>
<td>• Reduces design constraints for seakeeping &amp; endurance</td>
<td>• Transit time reduces vessel on-station time</td>
</tr>
<tr>
<td>• Well-deck use precludes amphibious operation use</td>
<td>• Requires dedicated mothership</td>
<td>• Increased design constraints</td>
</tr>
<tr>
<td>• Current iteration limits # of vessels in well deck</td>
<td></td>
<td>• Increased op-time for crew</td>
</tr>
</tbody>
</table>
Employment Concepts

- Operating Forward:
  - In pairs, four or eights vessels
  - Implement various tactics
    - Deception
    - Swarm
- Advantages:
  - Distributes adversary forces
  - Flexibility in deploying units
  - Cover larger footprint
  - Reduced cost per unit
- Disadvantages:
  - Unable to conduct sustained engagements
  - Limited defense capabilities
  - Local area operator
<table>
<thead>
<tr>
<th></th>
<th>Exocet MM40 Blk III</th>
<th>Harpoon II</th>
<th>Harpoon II+</th>
<th>Harpoon II+ ER</th>
<th>NSM</th>
<th>LRASAM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Operational Range</strong></td>
<td>200+ km</td>
<td>130+ km</td>
<td>180+ km</td>
<td>248+ km</td>
<td>200+ km</td>
<td>950+ km</td>
</tr>
<tr>
<td><strong>Targets</strong></td>
<td>Littoral and coastal attacks</td>
<td>Littoral and coastal attacks</td>
<td>Littoral and coastal attacks</td>
<td>Littoral and coastal attacks</td>
<td>Littoral and coastal attacks</td>
<td>Littoral and coastal attacks</td>
</tr>
<tr>
<td><strong>Speed</strong></td>
<td>0.9 Mach</td>
<td>0.85 Mach</td>
<td>0.9 Mach</td>
<td>0.9 Mach</td>
<td>0.7-0.95 Mach</td>
<td>High subsonic</td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>777 kg</td>
<td>691 kg</td>
<td>&lt; 691 kg</td>
<td>&lt; 691 kg</td>
<td>407 kg</td>
<td>~1134 kg</td>
</tr>
<tr>
<td><strong>Length</strong></td>
<td>5.86 m</td>
<td>4.6 m</td>
<td>&lt; 5 m</td>
<td>&lt; 5 m</td>
<td>3.96 m</td>
<td>4.3 m</td>
</tr>
<tr>
<td><strong>Lethality</strong></td>
<td>153 kg warhead</td>
<td>136 kg warhead</td>
<td>136 kg warhead</td>
<td>136 kg warhead</td>
<td>227 kg titanium warhead</td>
<td>450 kg fragmentation warhead (Based on JASSM-ER)</td>
</tr>
<tr>
<td><strong>Features</strong></td>
<td>IN/GPS, radio altimeter, active RF terminal homing, mission planning, software 3D waypoints, high G terminal maneuvers, adaptive search patterns</td>
<td>IN/GPS radio altimeter, active RF terminal homing, mission computer, coastal target suppression</td>
<td>In addition to Harpoon II: 10x improved selectivity with data link, AJGPS reduces susceptibility</td>
<td>In addition to Harpoon II+: Increased standoff distance</td>
<td>Passive sensor, super sea skimming, ship class identification, selectable flight profiles, INS, GPS, TERCOM</td>
<td>Multimodal sensor, weapon datalink, digital anti-jam GPS, reduces the dependence of ISR platform</td>
</tr>
<tr>
<td><strong>Launcher</strong></td>
<td>Canister: 6.3 m, 413 kg per missile</td>
<td>Canister: grade B, 1181 kg for 4 missiles</td>
<td>Canister: grade B, 1181 kg for 4 missiles</td>
<td>Canister: grade B, 1181 kg for 4 missiles</td>
<td>Not Available</td>
<td>MK 41 VLS strike, tactical and self-defense module</td>
</tr>
<tr>
<td><strong>System Weight (kg)</strong></td>
<td>6000 kg</td>
<td>6130 kg</td>
<td>6130 kg</td>
<td>6130 kg</td>
<td>Not Available</td>
<td>Not available</td>
</tr>
<tr>
<td><strong>Contractor</strong></td>
<td>MBDA</td>
<td>Boeing</td>
<td>Boeing</td>
<td>Boeing</td>
<td>Kongsberg Norway and Raytheon USA</td>
<td>Lockheed Martin</td>
</tr>
<tr>
<td><strong>Status</strong></td>
<td>First development in 1967, combat proven</td>
<td>First flight: 1972, first deployed: 1977, combat proven</td>
<td>Form and fit use existing inventory and infrastructure, affordable path of $185k per missile</td>
<td>Form and fit use existing inventory and infrastructure, affordable path of $670k per missile</td>
<td>Test on USS Coronado (LCS 4): 2014, intercepted a mobile ship target</td>
<td>Based on JASSM-ER. 2 - Mk 41 LRASM tests at the White Sands Missile Range: 2013/2014. Works on deck mounted launcher for no-VLS platforms.</td>
</tr>
<tr>
<td><strong>Used By</strong></td>
<td>Fast patrol boats, destroyers, frigates</td>
<td>Fast patrol boats, destroyers, frigates</td>
<td>Fast patrol boats, destroyers, frigates</td>
<td>Fast patrol boats, destroyers, frigates</td>
<td>Nansen class frigates, Skjold class missile torpedo boats</td>
<td>USAF</td>
</tr>
</tbody>
</table>
Missile Comparison

- **LRASM**: 900+ km
- **NSSM**: 248+ km, 200+ km, 130 km
- **RGM-84**:
- **EXOCET**:

Ranges Not to Scale
RGM-84 Harpoon

• Exclusively Anti-Ship Cruise Missile (ASCM).
• Foreign missiles were excluded due to limited data and initial directive to use LRASM.
• Proven track record; installed on most capital ships in the fleet.
• Best meets the requirements of weight, lethality, and cost.
• Upgradable from the Harpoon Blk II to the Harpoon Blk II+
  • $185,000 per missile:
  • Range increase up to 180 km
  • Data link capabilities
• Further capable of upgrade to Harpoon Block II+ER:
  • $670,000 per missile
  • Range increase up to 248 km
<table>
<thead>
<tr>
<th>Gun Weapon System Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CIWS Blk 1B</strong></td>
</tr>
<tr>
<td>Cartridge (mm)</td>
</tr>
<tr>
<td>Muzzle Velocity V₀ (m/s)</td>
</tr>
<tr>
<td>Dispersion Δ (rad)</td>
</tr>
<tr>
<td>Rate of Fire (Hz)</td>
</tr>
<tr>
<td>Burst(s)</td>
</tr>
<tr>
<td>Mass of Projectile (g)</td>
</tr>
<tr>
<td>Number of Projectiles in a 5 second Engagement</td>
</tr>
<tr>
<td>Weight of the mount (kg)</td>
</tr>
<tr>
<td>Working radius (m)</td>
</tr>
<tr>
<td>KE on target per shot (KJ)</td>
</tr>
<tr>
<td>Total Mass of HE in a 5 second Engagement (g)</td>
</tr>
<tr>
<td>Contractor</td>
</tr>
<tr>
<td>Range (m)</td>
</tr>
<tr>
<td>Sensors</td>
</tr>
<tr>
<td>Elevation</td>
</tr>
<tr>
<td>Stealth Enclosure</td>
</tr>
</tbody>
</table>
Gun Defense Comparison

MK 38 Mod 2

MK 38 Mod 3

MK 15 PHALANX CIWS
## Weapon Selection

<table>
<thead>
<tr>
<th></th>
<th>Design Alternative A</th>
<th>Design Alternative B</th>
<th>Design Alternative C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Missile (8x)</td>
<td>Harpoon Legacy</td>
<td>Harpoon Blk 2+ ER</td>
<td>LRASM</td>
</tr>
<tr>
<td>Cost</td>
<td>$7,100,000</td>
<td>$14,500,000</td>
<td>$29,600,000</td>
</tr>
<tr>
<td>GWS</td>
<td>Mk 38 Mod 2</td>
<td>Typhoon 30 mm (Mk38 Mod 3)</td>
<td>CIWS Blk 1B</td>
</tr>
<tr>
<td>Cost</td>
<td>$1,100,000</td>
<td>$2,500,000</td>
<td>$5,600,000</td>
</tr>
</tbody>
</table>

*Costs are in USD.*
Proposed Weapon System

MK 38 Mod 3

RGM-84 Harpoon Block II+ ER

Ranges Not to Scale
Design Process

Mission Analysis

Weapon Selection

Hull Form

Prime Mover Selection

Arrangements

Outfitting

Survivability

Final Design
• Hull Type Considerations:
  • Catamaran
  • Surface Effect Ship (SES)
  • Monohull

• Initial Hull Specifications
  • Length (LOA): 50 m (164 ft)
  • Beam: 8.48 m (27.8 ft)
  • Draft: 1.4 m (4.6 ft)
  • Displacement: 300 MT (295 LT)
  • Shaft Power: 13,000 kW
  • Max Speed: 42 knots

\[ y = 207.18x + 439543 \]
Preliminary Design

- Preliminary hull form design:
  - Inspired by SwiftShip’s
    - YDT 17/18
    - 45M fast missile boat

[Images of YDT 17/18 and 45m Fast Missile Boat]
Hull Model

- Hull offsets modified to suit requirements using POSSE
Primary Tank Arrangement

Legend

<table>
<thead>
<tr>
<th>Fuel Oil</th>
<th>Lube Oil</th>
<th>Fresh Water</th>
<th>Grey Water</th>
</tr>
</thead>
</table>

Diagram showing the arrangement of primary tanks with different colored sections for fuel, lube oil, fresh water, and grey water.
Hydrostatic Characteristics

Weight Distribution

Draft vs. Displacement
Hydrostatic Characteristics

LCB vs Displacement

KM vs Displacement
Displacement, Trim, & Heel

Stability

<table>
<thead>
<tr>
<th>Stability</th>
<th>Length</th>
<th>Specific Gravity</th>
</tr>
</thead>
<tbody>
<tr>
<td>KM</td>
<td>5.524 m</td>
<td>1.0250</td>
</tr>
<tr>
<td>VCG (Upright)</td>
<td>2.589 m</td>
<td>LCF Draft 1.566 m</td>
</tr>
<tr>
<td>GMT (Solid)</td>
<td>2.906 m</td>
<td>LCF 20.795F m-AP</td>
</tr>
<tr>
<td>FS Correction</td>
<td>0.006 m</td>
<td>LCB 20.348F m-AP</td>
</tr>
<tr>
<td>GMT (Corrected)</td>
<td>2.929 m</td>
<td>LCG 20.448F m-AP</td>
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Trim

<table>
<thead>
<tr>
<th>Trim</th>
<th>Drafts - Perps</th>
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</thead>
<tbody>
<tr>
<td>Specific Gravity</td>
<td>1.0250</td>
</tr>
<tr>
<td>LCF Draft</td>
<td>1.566 m</td>
</tr>
<tr>
<td>LCF</td>
<td>20.795F m-AP</td>
</tr>
<tr>
<td>LCB</td>
<td>20.348F m-AP</td>
</tr>
<tr>
<td>LCG</td>
<td>20.448F m-AP</td>
</tr>
<tr>
<td>TP1cm</td>
<td>3 MT/cm</td>
</tr>
<tr>
<td>MT1cm</td>
<td>11 m-MT/cm</td>
</tr>
<tr>
<td>Trim at Perps</td>
<td>0.030F m</td>
</tr>
<tr>
<td>Heel Angle</td>
<td>0.07S deg</td>
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</table>

Drafts - Perps

<table>
<thead>
<tr>
<th>AP</th>
<th>MS</th>
<th>FP</th>
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<tbody>
<tr>
<td>1.553 m</td>
<td>1.568 m</td>
<td>1.583 m</td>
</tr>
<tr>
<td>F0</td>
<td>Trans</td>
<td>1.584 m</td>
</tr>
</tbody>
</table>

Strength

<table>
<thead>
<tr>
<th>Shear (Min)</th>
<th>Shear (Max)</th>
<th>Moment (Max Hog)</th>
<th>Moment (Max Sag)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-8 MT</td>
<td>15 MT</td>
<td>144H m-MT</td>
<td>735 m-MT</td>
</tr>
<tr>
<td>37.800F m-AP</td>
<td>25.800F m-AP</td>
<td>35.442F m-AP</td>
<td>13.400F m-AP</td>
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</tbody>
</table>

Group

<table>
<thead>
<tr>
<th>Group</th>
<th>Weight</th>
<th>VCG</th>
<th>LCG</th>
<th>TCG</th>
<th>FSt</th>
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</thead>
<tbody>
<tr>
<td>Lightship</td>
<td>218</td>
<td>2.761</td>
<td>20.704F</td>
<td>0.028S</td>
<td>0</td>
</tr>
<tr>
<td>Fuel Tanks</td>
<td>87</td>
<td>2.206</td>
<td>18.887F</td>
<td>0.502P</td>
<td>2</td>
</tr>
<tr>
<td>Oil Tanks</td>
<td>3</td>
<td>2.298</td>
<td>21.398F</td>
<td>3.46S</td>
<td>0</td>
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<tr>
<td>Sewage Tanks</td>
<td>0</td>
<td>2.542</td>
<td>36.465F</td>
<td>3.126S</td>
<td>0</td>
</tr>
<tr>
<td>Water Tanks</td>
<td>8</td>
<td>2.183</td>
<td>29.340F</td>
<td>3.329S</td>
<td>0</td>
</tr>
<tr>
<td>Displacement</td>
<td>316</td>
<td>2.589</td>
<td>20.448F</td>
<td>0.003S</td>
<td>2</td>
</tr>
<tr>
<td>Deadweight</td>
<td>99</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avail Deadweight</td>
<td>77 --Init--</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

WWW.NPS.EDU
• Maximum righting arm is 1.2 meters at 36 degrees
• Preliminary strength analysis conducted for
  • Bending moment
  • Shear stress
 Resistance and Powering Data

- Van Oosanen, P. “Resistance Prediction”

- Fujisawa, Nobuyuki. “Measurements of Basic Performances”

NPL Model Series Resistance Data
Shaft Power Requirements

Required Shaft Power vs Speed (Varying Cp)

- NPL Series
- Savitsky
- Parametrics

Required Shaft Power (kW) vs Speed (kts)
Design Process

Mission Analysis

Weapon Selection

Hull Form

Prime Mover Selection

Arrangements

Outfitting

Survivability

Final Design
### Prime Mover Selection

<table>
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<tr>
<th>Engine Type</th>
<th>Initial Design</th>
<th>First Iteration</th>
<th>Final Design</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Qty</td>
<td>Model</td>
<td>Qty</td>
</tr>
<tr>
<td>Diesels</td>
<td>2</td>
<td>Wartsila 31</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Wartsila 26</td>
<td>2</td>
</tr>
<tr>
<td>Gas Turbine</td>
<td>3</td>
<td>LM500</td>
<td>3</td>
</tr>
</tbody>
</table>

- Several design combinations were investigated in terms of:
  - Speed
  - Fuel consumption
  - Weight
  - Plant dimensions (size)
  - Cost
  - Survivability
Prime Mover Comparisons

Examples of engine selection results based on design iterations

Total Fuel Consumption Comparison

Total Cost

Achieved Speed

Dimensions

Total weight
Prime Mover Survivability

Kill Tree for the Gas Turbine propulsion plant

Kill Tree for the Diesel Engines propulsion plant
Prime Mover

Final Design

<table>
<thead>
<tr>
<th>VS</th>
<th>Speed</th>
<th>√</th>
<th>Fuel Consumption</th>
<th>√</th>
<th>Dimensions</th>
<th>√</th>
<th>Weight</th>
<th>√</th>
<th>Survivability</th>
<th>=</th>
<th>Cost</th>
<th>√</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2 Diesel Engines:</td>
<td></td>
<td>2 Diesel Engines:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>•</td>
<td>2 x Wartsila 31</td>
<td></td>
<td>•</td>
<td>MTU 1163 TB73</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Fuel Requirement Analysis

• The proposed design offers a total fuel capacity of 93m³

• For the proposed design, the most economical speed or transient speed is found to be 18 knots.

• The maximum ship speed is 40 knots.
Fuel Efficiency Analysis

- For the proposed design, the most economical speed is found to be 18 knots.
- At 18 knots, a total distance of 2000 nautical miles could be transited in 111 hours, and would only require 71 m³ of fuel oil.
- At a constant speed of 30 knots, a volume of 120 m³ of fuel oil is required.
- The time to travel 2000 nautical miles would be 67 hours.
• Rolls-Royce
  • Type: S3-90
  • Outboard Length (B): 2.57 m
  • Inboard Length (D): 3.18 m
  • Power Range: 2000-8500 Kw
  • Weight: 4.8 T
  • Highest pump performance on the market.
  • One of the lighter in its category.
  • Stainless steel for maximum corrosion and wear resistance.
Design Process

Mission Analysis

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Final Design
Ship Design Views
Port and Starboard Profile View
Design Process

Mission Analysis

Weapon Selection

Hull Form

Prime Mover Selection

Arrangements

Outfitting

Survivability

Final Design
Radar / Weapons Arrangement

- Typhoon (MK 38 Mod 3)
- Furuno NAVNET 3D TRS 6A
- Harpoon Block II +ER
- Furuno Nav Radar
RADAR (Bridge Master-E)

- Bridge Master-E is capable of supporting high speed tracking of fast moving and maneuvering targets up to 150 knots.
- Simultaneously able to track 60 targets.
- Offers unparalleled choice of configurations and options to meet the lightweight constraint of 538 lbs.
- Extended range of 120 nm.

### Pugh Evaluation Matrix

<table>
<thead>
<tr>
<th>CRITERIA</th>
<th>UNIT</th>
<th>BASELINE: (AN/SPS-73 (V-12))</th>
<th>AN/SPS-75</th>
<th>AN/SPS-77</th>
<th>Bridge Master-E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>$</td>
<td>$421,000</td>
<td>$5.2M</td>
<td>$4.8M</td>
<td>&lt;$100K</td>
</tr>
<tr>
<td>Weight</td>
<td>lbs.</td>
<td>8000lbs</td>
<td>6154lbs</td>
<td>3693lbs</td>
<td>538lbs</td>
</tr>
<tr>
<td>Range</td>
<td>nm</td>
<td>68nm</td>
<td>107nm</td>
<td>98nm</td>
<td>120nm</td>
</tr>
<tr>
<td>Attributes</td>
<td>MEDIUM</td>
<td>LOW</td>
<td>LOWER</td>
<td>HIGH</td>
<td></td>
</tr>
</tbody>
</table>
Navigation Systems

- Minutemen will be able to independently execute navigation to accomplish mission.
- WECDIS-E employed as its primary navigation system.
- Minutemen will make use of GPS satellites to maintain accurate positional fix.
- Incorporated with FURUNO (NAVNET 3D).
- AIS provides maritime patrol & SAR A/C with ability to track and identify AIS equipped vessels over a dedicated VHF data link.
- Crew to maintain proficiency with paper charting technique and relay visual fixes when operating close to land and nautical marker.
Minutemen will be have secure/non-secure voice/data communications via SATCOM, VHF, UHF, HF, and IFF.

Capable of communicating with ships in company, supporting A/C, units ashore and allied military units.

Mark VI Patrol Boat communications suite used as a reference.

Communication systems were selected for optimal support of missions as shown in table.

IBM Data Management System
- Incorporated with ship’s network.
- Reduces storage costs through data compression and advanced storage management techniques.
- Improve database administrator productivity through autonomies and data management tools.
- Able to move data from ship to shore via satellite connection to shore side server.

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Designation</th>
<th>Rational</th>
</tr>
</thead>
<tbody>
<tr>
<td>VHF/UHF Dual Radio System</td>
<td>AN/PRC-152</td>
<td>Provides simultaneous voice, video, and high-speed data in a highly portable form factor. Compliant without waivers to the Joint Tactical Radio System (JTRS).</td>
</tr>
<tr>
<td>VHF</td>
<td>Bridge to Bridge</td>
<td>GX5500S</td>
</tr>
<tr>
<td>HF</td>
<td>AN/PRC-150 (C)</td>
<td>Provides reliable tactical communications through enhanced secure voice and data performance, networking, and extended battery life.</td>
</tr>
<tr>
<td>SATCOM System</td>
<td>AN/PRC-117G</td>
<td>Covers the 30 MHz to 2 GHz frequency range, this single-channel radio is 30% smaller and 35% lighter than currently fielded multiband man pack radios and operates off a single standard battery.</td>
</tr>
<tr>
<td>IFF System</td>
<td>AN/APX-117/118</td>
<td>The APX-117/118(V) airborne CXP supports both interrogating and responding operations in a single unit. It supports all IFF modes in use today and is upgradeable to next-generation IFF signals.</td>
</tr>
<tr>
<td>EO/IR System</td>
<td>Sea FLIR III Electro-Optical Imaging</td>
<td>Provides up to four payloads: thermal imager, daylight/lowlight TV, laser rangefinder, and laser pointer, plus an IMU interface for accurate target location.</td>
</tr>
<tr>
<td>PA System</td>
<td>Zenitel ETB-10</td>
<td>The system will be installed to all essential areas and compartments. ETB-10 consists of a combined central and operator unit.</td>
</tr>
<tr>
<td>Air Horn</td>
<td></td>
<td>The new Kahlenberg KB-15 is a type approved Electronic Horn and Hailing system for marine use that produces a powerful horn signal for all types of vessels up to 20 meters in length as well as voice amplification.</td>
</tr>
<tr>
<td>IR Strobe Light</td>
<td></td>
<td>To be mounted on the radar tower and clearly visible when looking down at the boat.</td>
</tr>
</tbody>
</table>
Electrical Distribution System

- Total installed electrical power 1,150KW
  - 2 MTU 12 V 2000 M41A- 575kw/450V/3 phase/1500 rpm (each)
  - One Generator is used during normal operation while the other is on standby. Each is able to auto recover when on standby

- Electrical Distribution
  - 2 distribution panels, 2 inverters, 2 frequency converters, and two 400 Hz converters

- Total Power Load (Navigation, Combat, Auxiliaries, and Communications)
  - 573.6KW
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Final Design
Damage Control Ethos

• No space for traditional repair locker
• Not enough personnel to man hose teams
• Implementation similar to submarine force
• Damage control repair stations
  • 2 sets of firefighting coveralls, flash hoods, helmets, gloves, boots
  • 2 – 45 min. SCBAs
  • Will act as investigators and fire team
• Installed system for engine enclosure
• Portable bottles for all other spaces
• Multiple Survitec liferafts:
  • 8 person capacity
• Control damage to enable crew retreat and rescue
- Squadron will employ traditional CO and XO construct
- Individual unit’s will have junior officer OIC
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Costs are estimated based on existing designs such as the MK VI and historical data primarily coming from SWBS.
Final Design Parameters

• **Ship Characteristics**
  - Hull Type: Planing monohull
  - Material: Aluminum
  - Length (LOA): 51.2 m (168 ft)
  - Beam: 8.48 m (27.8 ft)
  - Draft: 1.57 m (5.2 ft)
  - Freeboard: 2.1 m (6.9 ft)
  - Displacement: 316 MT (311LT)
  - Shaft Power: 12,000 kW (16,100 HP)
  - Service Speed: 18 knots
  - Max Speed: 40 knots
  - Manning: 12 crew members, 17 additional personnel
  - 8 RGM-84 Harpoon, Block 2+ ER
  - 1 MK 38 Mod 3
  - Cost: $53 million (Vessel only)
  - Total Cost: $88 million (Approx.)

• **Deployment Concepts:**
  - Forward Operating Base
  - Tender / Mothership
  - Afloat Forward Staging Base

• **Employment Concepts:**
  - Large Squadron Swarm Tactic:
    - Variable size (2-8) task units
    - Overwhelm adversary
  - Element Deception
    - 1-2 vessel elements
    - Utilize geography for deception/cover
    - Engage and redeploy
## Requirements Evaluation

<table>
<thead>
<tr>
<th>Stakeholder Requirement</th>
<th>TSSE Final Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Weapon</td>
<td>8 Harpoon AGM 84 Blk II+</td>
</tr>
<tr>
<td>Endurance</td>
<td>1000nm</td>
</tr>
<tr>
<td>Speed</td>
<td>40 kts</td>
</tr>
<tr>
<td>Crew</td>
<td>12 +17</td>
</tr>
<tr>
<td>Combat System</td>
<td>1 MK 38 Mod 3</td>
</tr>
<tr>
<td>Sensors</td>
<td>Bridge Master-E, Furuno NAVNET3D</td>
</tr>
<tr>
<td>Networks</td>
<td>Basic SATCOM, VHF, UHF, HF, and IFF communications</td>
</tr>
<tr>
<td>Signature</td>
<td>Low profile hull, enclosures</td>
</tr>
<tr>
<td>Cost</td>
<td>$88M ($53M w/o GFE)</td>
</tr>
</tbody>
</table>

Requirements Continuum: No

Yes
Minutemen – answering the call by sea

Jarema M. Didoszak
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Aft Engine Room
Auxiliary Room

![Auxiliary Room Diagram](image-url)