Lightweight 81mm Mortar

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Lightweight 81mm Mortar

The Team

ARDEC

ONR Littoral Combat FNC

Ft. Benning

MARCORSYSCOM

PM Mortars
Lightweight 81mm Mortar

What are the WARFIGHTER needs?

• Lighter weight system
  (Eases burden for man transportability)
• Reduced Life Cycle Cost
• Operational commonality among 60, 81 and 120mm mortar weapons
• FCS Dismounted Mortar Requirements
Lightweight 81mm Mortar

What are the barriers to meeting the needs?

- High operating temperatures due to ROF.
  - Durability of lightweight materials.
  - Unprecedented new material applications.
- Bore tube erosion.
- Unpredictable soil conditions.
- Manufacturing techniques and costs.
How will the barriers be overcome?

- Development and validation of thermal, dynamic, and structural models for accurate analysis.
- Correlation of structural and thermal analysis with live fire data.
- Evaluation/applicability of Nickel-based super alloy (Inconel 718) for mortar tubes.
- Applying the flowform manufacturing process to mortar tube fabrication.
- Evaluation/applicability of carbon fiber reinforced composites for mortar baseplates.
- Application of lightweight materials to new A-frame bipod design.
## Requirements

<table>
<thead>
<tr>
<th>Capability</th>
<th>Current Capability (Baseline)</th>
<th>Threshold</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Operational Metrics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Weight</td>
<td>93.25 lb</td>
<td>63.91 lb</td>
<td>54.78 lb</td>
</tr>
<tr>
<td>- Portability</td>
<td>Baseline to be established in portability test.</td>
<td>5% Improvement</td>
<td>10% Improvement</td>
</tr>
<tr>
<td>• Affordability Metric</td>
<td>$70,500 unit price</td>
<td>Material Dependant</td>
<td>≤ $70,500 unit price</td>
</tr>
<tr>
<td>• TRL</td>
<td>TRL 4</td>
<td>TRL 6</td>
<td>TRL 6</td>
</tr>
<tr>
<td>- Tube Life</td>
<td>10,000 rounds</td>
<td>10,000 rounds</td>
<td>≥10,000 rounds</td>
</tr>
<tr>
<td>- Rate of Fire</td>
<td>30 r/m max, 16 r/m sust</td>
<td>25 r/m max, 16 r/m sust</td>
<td>30 r/m max, 16 r/m sust</td>
</tr>
<tr>
<td>- Range</td>
<td>83-5935 m</td>
<td>83-5935 m</td>
<td>83-5935 m</td>
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</tbody>
</table>
### Lightweight 81mm Mortar

#### Total Program Milestone Schedule

<table>
<thead>
<tr>
<th>FY04</th>
<th>FY05</th>
<th>FY06</th>
</tr>
</thead>
<tbody>
<tr>
<td>1Q</td>
<td>2Q</td>
<td>3Q</td>
</tr>
<tr>
<td>ESTABLISH BASELINES</td>
<td>SELECT MATERIALS</td>
<td>MORTAR BARREL PROTOTYPE DEVELOPMENT/FABRICATION</td>
</tr>
</tbody>
</table>

**Legend:**
- ▲ Actual Start
- ▼ Actual End
- ◇ Milestone
- △ Planned Start
- ◊ Planned End
- □ Planned Milestone
• Thermal Analysis shows that the tube reaches temperatures above 1000°F.

• Inconel 718 is a Nickel super-alloy that retains high strength at high temperatures.
  • IN718 Yield Strength is 149ksi at 1200°F compared to current mortar steel YS of 105ksi.
  • An IN718 mortar tube can meet the rate of fire requirements without cooling fins.

• IN718 has never been used as a gun tube material.

• Flowforming process will be used to fabricate the tubes at a dramatically reduced cost.

<table>
<thead>
<tr>
<th>Test Temperature (°F)</th>
<th>°C</th>
<th>0.2% Yield Strength (ksi)</th>
<th>MPa</th>
<th>Tensile Strength (ksi)</th>
<th>MPa</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>93</td>
<td>170</td>
<td>1172</td>
<td>204</td>
<td>1407</td>
</tr>
<tr>
<td>400</td>
<td>204</td>
<td>163</td>
<td>1124</td>
<td>198</td>
<td>1365</td>
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<tr>
<td>600</td>
<td>316</td>
<td>159</td>
<td>1096</td>
<td>195</td>
<td>1344</td>
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<tr>
<td>800</td>
<td>427</td>
<td>156</td>
<td>1076</td>
<td>191</td>
<td>1317</td>
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<tr>
<td>1000</td>
<td>538</td>
<td>155</td>
<td>1069</td>
<td>185</td>
<td>1276</td>
</tr>
<tr>
<td>1200</td>
<td>649</td>
<td>149</td>
<td>1027</td>
<td>168</td>
<td>1158</td>
</tr>
<tr>
<td>1400</td>
<td>760</td>
<td>110</td>
<td>738</td>
<td>110</td>
<td>738</td>
</tr>
</tbody>
</table>
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CANNON – Flowformed Inconel 718 Cannon Live Fire Testing

Inconel 718 Tube Test Results, Conclusions and Follow-up

141 rounds were fired from 4 IN 718 mortar tubes.

Prototype mortar tubes were heated to maximum operating temperature.

No apparent degradation (erosion/corrosion) of any of the IN 718 tubes was observed. (video bore scope and destructive inspection) Extended wear tests still need to be conducted.

"Nothing was noted to preclude the use of IN718 in future mortar designs."
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CANNON - High Strain Rate Optimized Cannon

Risk Mitigation (Back-up to IN718)
• High strain rate properties yield strength of current Nb-C steel 163 ksi vs 105 ksi @ 1025°F
• Given this new data, the cannon has been re-optimized and designed.
• 1040°F limitation of current steel necessitates cooling scheme.
• Initial Design weighs 24.9 lbs. (~29% reduction)

FY05 Progress and Plans
• Mid-May expected completion.
• Testing Planned at APG in June.
• Eventual design will be “flow-formable” with final machining of the spines.

<table>
<thead>
<tr>
<th>MILESTONES</th>
<th>1QTR</th>
<th>2QTR</th>
<th>3QTR</th>
<th>4QTR</th>
<th>1QTR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fabrication</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Live Fire Testing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analyze Results &amp; Model Verification</td>
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</tbody>
</table>
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Baseplate Structural Analysis

- Developed finite element model of M3A1.
- Correlated model with test data.
- Developed two concepts
  - Composite Baseplate Concept
  - Metal Baseplate Concept
- Initial Prototype fabrication to be completed at the end of July.
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BASEPLATE – Concepts/Materials

Two Baseline Concepts

- **Concept tailored for composite fabrication**
  - **Carbon Fiber Reinforced Thermoset Composite Baseplate**
    - 40% weight reduction
    - Initial Prototype July 05
    - Likely production unit cost $4K

- **Concept tailored for metal fabrication**
  - **High Strength Forged Aluminum Baseplate**
    - 25% weight reduction
    - Initial Prototype Sept 05
    - Likely production unit cost under $3K
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BIPOD – Potential Concepts/Materials

Design Drivers
• Analysis of current bipod completed.
• Results indicate tube clamp is the only highly loaded area of bipod.
• Rough handling will be primary design driver of bipod structure (with the exception of clamp.)
• Current K-mount bipod design will be replaced with a A-mount design.
• Commonality with 60mm and 120mm will be stressed.
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BIPOD – Initial Prototype Material Selection

- Buffers, Clamp, Latch – Titanium
- Sight Mount – Aluminum
- Cant, Traverse Mechanisms – Anodized Aluminum
- Feet and Leg Joints – Anodized Aluminum
- Graphite Legs
- Elevation Shaft – Aluminum
- Elevation Housing – Composite
- Elevation Bevel Gears – Titanium
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Portability Test

• STO exit criteria requires a 5% to 10% improvement in portability.
• Defining a metric that constitutes such an improvement is nebulous.
• Obstacle course at ARL provides a means to establish a portability metric.
• Time as well as qualitative responses will be used to evaluate improvement.
• Two tests will be conducted, the initial was conducted in April 05, and the final is planned for FY06.
• Results from initial test will establish the portability baseline as well as an initial assessment of representative hardware.
• Final test will compare the portability of system demonstration hardware to the M252 and evaluate whether the exit criteria has been met.

Initial test was conducted from Apr 18th to Apr 29th

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