30mm x 113mm (LW30)
Target Practice Tracer (TP-T) Ammunition

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Outline

• Applications
• Performance Objectives
• Initial Development Phase
• Final Development Phase
• Summary
Applications

M230 Gun

- Currently on Apache helicopter

M230LF (Link Fed) Gun

- Based on proven M230 gun
- Low-recoil design makes gun adaptable to many systems
- Being implemented for ground applications

ATK System Application Examples for M230LF

- Modular Advanced Weapon System (MAWS)
- Palletized Autonomous Weapon System (PAWS)
- Nobles Engineering Viper Gun System

Ground & shipboard applications require traced ammo
Performance Objectives

Flight Characteristics

• Ballistic match to M789 HEDP

Desire direct drop-in addition to current LW30 ammo family

Tracer

• Trace distance to 2000 meters
• Daylight & infrared visible
Initial Design – Option 1

Common Igniter & Tracer
Steel Body
Aluminum Nose
Boom Tail
Common Cavity Shape

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Initial Design – Option 2

Common Igniter & Tracer

Steel Body

Aluminum Nose

Boat Tail

Non-Standard Cavity
Initial Design – Option 3

- Common Igniter & Tracer
- One-Piece Nose & Forward Body
- Boat Tail
- Non-Standard Cavity
Initial FEA Analysis – Setback

ANSYS Finite Element Analysis at Setback / Max Base Pressure at 71ºC (390 MPa)

• Option 1: Localized projectile body deformation – **Fracture not anticipated**

- Projectile Body Plastic Strain

• Option 2: No projectile body deformation – **Robust**

- Projectile Body Plastic Strain

• Option 3: Localized nose and projectile body deformation – **Fracture not anticipated**

- Projectile Body Plastic Strain
  - Nose Plastic Strain
Initial FEA Analysis – Tracer

ANSYS FEA for tracer consolidation in Opt 1

- Outcome: Tracer boom will support consolidation

ANSYS FEA for pressure leak for Opt 2 and 3

- Outcome: Tracer will fail mechanically if gun pressure leakage occurs (red arrows)
  - Led to development of more robust assembly process to prevent leakage
PRODAS ballistics analysis of match to M789 out to 2000 meters

**Outcome:** Option 1, 2, & 3 **ballistic match (drop) is within objective requirements**
### PRODAS Ballistics Analysis

<table>
<thead>
<tr>
<th>Projectile</th>
<th>Gyro Stab Factor (2-3)</th>
<th>Muzzle Jump Factor</th>
<th>Predicted Yaw (deg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M789</td>
<td>2.94</td>
<td>.025</td>
<td>3.5</td>
</tr>
<tr>
<td>M788</td>
<td>2.86</td>
<td>.028</td>
<td>3.5</td>
</tr>
<tr>
<td>Option 1</td>
<td>2.28</td>
<td>.023</td>
<td>2.5</td>
</tr>
<tr>
<td>Option 2</td>
<td>2.75</td>
<td>.021</td>
<td>4.5</td>
</tr>
<tr>
<td>Option 3</td>
<td>1.93</td>
<td>.026</td>
<td>4.5</td>
</tr>
</tbody>
</table>

- Outcomes: **Stability, dispersion, and yaw all predicted to be acceptable**
Initial Fabrication & Assembly

Option 1

Option 2

Option 2 & 3 Tracer Assembly

Option 3
Initial Test Results – Radar, Drag to Max Range

• Radar and drag profile data collected and analyzed
  – Outcome: ‘Tracer effect’ less significant than estimated, resulting in slightly higher drag and longer flight times to 2000 meters than predicted

• PRODAS model updated based on empirical data
  – Outcome: Ballistic match and required muzzle velocity predictions updated

<table>
<thead>
<tr>
<th>Projectile</th>
<th>Original QE Match (Drop in mils) @ Req’d Muzzle Velocity</th>
<th>Updated QE Match (Drop in mils) @ Req’d Muzzle Velocity</th>
</tr>
</thead>
<tbody>
<tr>
<td>M788</td>
<td>0.69 @ 805 m/s</td>
<td>same</td>
</tr>
<tr>
<td>Option 1</td>
<td>0.30 @ 783 m/s</td>
<td>0.47 @ 817 m/s</td>
</tr>
<tr>
<td>Option 2</td>
<td>0.29 @ 801 m/s</td>
<td>0.28 @ 850 m/s</td>
</tr>
<tr>
<td>Option 3</td>
<td>0.14 @ 816 m/s</td>
<td>0.79 @ 856 m/s</td>
</tr>
</tbody>
</table>
Initial Test Results – Tracer – Option 1

- Ambient: **18/20** successful
  - Both failures ignited but were short burns (failures averaged 9 meters short)
- Cold: **20/20** successful
- Hot: **11/20** successful
  - All failures ignited but were short burns (failures averaged 152 meters short)
  - **High burn time variation**

<table>
<thead>
<tr>
<th>Shot No.</th>
<th>Ambient</th>
<th>Cold</th>
<th>Hot</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6.41</td>
<td>6.60</td>
<td>6.15</td>
</tr>
</tbody>
</table>

**2km Flight Time (sec)≈**

```
Opt 1: TraceAvg vs Temp
```

```
Trace Time (sec)
```

```
Shot No.
```

```
0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00
T1 T3 T5 T7 T9 T11 T13 T15 T17 T19
```
Initial Test Results – Tracer – Option 2

- Ambient: **17/20** successful
  - All failures ignited but were short burns (failures averaged 10 meters short)
- Cold: **15/20** successful
  - 4 failures ignited but were short burns (failures averaged 15 meters short)
  - 1 failure did not ignite
- Hot: **19/21** successful
  - 1 failure ignited but was a short burn (42 meters short)
  - 1 failure did not ignite
- All had **consistent burn time variation**

<table>
<thead>
<tr>
<th>2km Flight Time (sec)</th>
<th>Ambient</th>
<th>Cold</th>
<th>Hot</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6.12</td>
<td>6.50</td>
<td>6.04</td>
</tr>
</tbody>
</table>

**Opt 2: TraceAvg vs Temp**

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Initial Test Results – Tracer – Option 3

• Ambient: 7/20 successful
  – All failures ignited but were short burns (failures averaged 33 meters short)

• Cold: 4/20 successful
  – 14 failures ignited but were short burns (failures averaged 41 meters short)
  – 2 failures did not ignite

• Hot: 2/21 successful
  – All failures ignited but were short burns (failures averaged 62 meters short)

• All had consistent burn time variation

<table>
<thead>
<tr>
<th>2km Flight Time (sec)</th>
<th>Ambient</th>
<th>Cold</th>
<th>Hot</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6.55</td>
<td>6.83</td>
<td>6.43</td>
</tr>
</tbody>
</table>

Opt 3: TraceAvg vs Temp

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Initial Conclusions – Options 1, 2, & 3

Structural Integrity
• All designs survived gun launch at all temperatures
• Risk areas identified during FEA

Aeroballistic Performance
• All designs met threshold ballistic match objectives

Tracer Performance
• All designs must have longer tracer burn times to reliably meet objective trace distance of 2000 meters

Producibility
• Many improvement opportunities identified

An updated design was required to meet performance objectives
Threshold (Primary) Requirements:

• Continue to meet ballistic match and dispersion objectives

• **Reliably meet tracer burn distance requirements**

• Added requirement for *compatibility in alternate barrel design*
  – 42” with 6.5° rifling exit angle (most common barrel for M230 on Apache)
    - This is design used for all previous PRODAS simulations
  – 60” barrel with 6.2° rifling exit angles (most common barrel for M230LF)

Objective (Secondary) Requirements:

• Method to improve tracer ignition reliability

• Improve producibility & affordability
Final Design Summary

Common Igniter & Tracer

1018 Steel Body

Formed Aluminum Nose

Metering Ring

Enlarged Cavity
ANSYS Analysis Input Summary

• Body & Nose Materials:
  – Minimum allowable material properties

• Base Pressure:
  – 350 MPa pressure (greater than predicted pressure at hot) applied to aft exterior
Final FEA Analysis (cont’d) – Robust Design

ANSYS Analysis

- Outcome: Localized projectile body deformation
  - Fracture not anticipated

Colors represent plastic deformation
Initial FEA Analysis – Tracer

ANSYS FEA for tracer consolidation

- Outcome: Projectile body will support tracer consolidation
PRODAS ballistics analysis of match to M789 out to 2000 meters

- Simulations completed for both 42” and 60” barrel designs, and updated to account for radial match (a function of both drop and drift)

<table>
<thead>
<tr>
<th>Projectile</th>
<th>42” Barrel, 6.5º Exit Angle</th>
<th>60” Barrel, 6.2º Exit Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>M788</td>
<td>QE Match (Radial in mils) @ Req’d Muzzle Velocity</td>
<td>QE Match (Radial in mils) @ Req’d Muzzle Velocity</td>
</tr>
<tr>
<td>Final</td>
<td>0.64 @ 769 m/s</td>
<td>0.60 @ 804 m/s</td>
</tr>
</tbody>
</table>

- Outcome: Final design within objective requirements
PRODAS ballistics analysis

<table>
<thead>
<tr>
<th>Projectile</th>
<th>42” Barrel, 6.5° Twist</th>
<th>60” Barrel, 6.2° Twist</th>
<th>Either Barrel</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gyro Stab Factor (2-3)</td>
<td>Gyro Stab Factor (2-3)</td>
<td>Muzzle Jump Factor</td>
</tr>
<tr>
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<td>2.74</td>
<td>.012</td>
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</table>

- Outcomes: Stability, dispersion, and yaw all predicted to be acceptable
Final Fabrication & Assembly

Completed:
• Nose caps
• Projectile Bodies (Figure 1), through banding (Figure 2), band trim, and plate/paint
• Tracer & igniter pellets
• Metering Discs

On-Going:
• Final Assembly to be completed in near future
Final Test Plan

- Charge Establishment
- Charge Verification
- PVAT, Dispersion, Yaw, Mann Barrel Function & Casualty
- Max Range Tracer & Radar
- Autogun Function & Casualty
- Environmental then PVAT

Testing to be conducted in near future
Summary

Initial 3 Designs

• Met ballistic match and flight objectives

• **Could not reliably meet tracer objectives**

• Had producibility and assembly concerns

Final Design

• Simulations indicate this **will meet ballistic and flight requirements**

• Additional tracer mix capacity and metering ring expected to provide **reliable tracing to 2km**

• **Structurally robust** design

• **Improved producibility** and cost savings
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