Laser Ignition Technology
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Briefer: Anthony Tartarilla
AMSRD-AAR-AEW-F(D)
Indirect Fire Team
Why Laser Ignition?

- Supports continuous, remote, fully automated firing and high rates of fire

- Improved system safety - Safety interlocks will not allow the LIS to fire unless the gun is laid on target

- Eliminates the burdens of conventional primers:
  - Fewer items to resupply (logistics benefit)
  - Eliminates the need for a primer autofeed mechanism
  - Potential for significant life cycle cost savings versus primer ignition
  - Green System - No need to dispose of old primers
Laser Ignition System Performance

Pressure vs. Time

Pressure curve identical to primer with 30msec offset

Ignition Profiles are essentially the same e.g., Rise Time & Peak Pressure

Only difference is in the ignition delay (30 ms)
## Laser Ignition Vs. Primer

<table>
<thead>
<tr>
<th>Laser</th>
<th>Primer</th>
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<tr>
<td><strong>Supports Continuous, Remote, Automated High-Rate Fires</strong></td>
<td><strong>Diminished Rates of fire</strong></td>
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<tr>
<td>- No moving parts; no firing timeline impact</td>
<td>- Difficult to automate, must eject spent primer</td>
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<tr>
<td>- &gt; 12 Rounds per minute</td>
<td>- Moving parts, Prone to jamming</td>
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<td><strong>Significant Life Cycle Cost Savings:</strong></td>
<td>- Rearm impacts Time Line</td>
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<td>- Reduced Logistics – No primer logistics supply tail to the battlefield</td>
<td>- Limited number of primers before resupply</td>
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<tr>
<td>- Improved Reliability – &gt; 99%</td>
<td><strong>Additional Life Cycle Costs</strong></td>
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<tr>
<td>- Green Technology – Eliminates manufacture, storage, disposal of energetic materials</td>
<td>- Logistics Burden: Resupply</td>
</tr>
<tr>
<td>- Decreased costs of logistics tail, storage and disposal associated with Primers</td>
<td>- Lower reliability- Primer Jams and Misfires</td>
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<tr>
<td><strong>Implements Safety</strong></td>
<td>- Environmentally Unfriendly: Lead based therefore manufacture, storage and disposal concerns</td>
</tr>
<tr>
<td>- Electronic Interlocks will not allow the weapon to fire unless the gun is layed on target</td>
<td>- Costs associated with Transport and storage of energetic material</td>
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<tr>
<td>- Provide Capability for remote “Check Fire”</td>
<td><strong>Safety Issues</strong></td>
</tr>
<tr>
<td>- No Hang fires</td>
<td>- Transport and storage of energetic material</td>
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<tr>
<td><strong>Misfire</strong></td>
<td>- Disposal of duds</td>
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<tr>
<td>- Automated Misfire Procedure</td>
<td>- Potential Hang Fires</td>
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<tr>
<td>• Automatically triggered to fire higher energy pulse in the event of a misfire for multiple pulses</td>
<td><strong>Misfire</strong></td>
</tr>
<tr>
<td></td>
<td>- Complicated Misfire Procedure</td>
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<tr>
<td></td>
<td>• Manually fire primer multiple times</td>
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<td>• Swap primer</td>
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Paladin Laser Accomplishments

- February 1995 - Demonstrated a Paladin mounted LRS-200 Laser Ignition System to the U.S. Army Field Artillery School (15 rounds fired)

- July 1996 - Demonstrated a Paladin mounted LRS-200 Laser Ignition System in Kuwait (43 rounds fired)
Crusader Laser Accomplishments

- Maximum Rate of Fire of 10 – 12 rounds per minute
- Electrical make-break breech connector
- Multiple Round Simultaneous Impact (MRSI) Capability
- Durable Chamber Window – over 1000 Effective Full Charge Firings
- Durable Laser Igniter Design – over 3000 Rounds on One Igniter
- Over 14,000 rounds fired
NLOS-C Laser Accomplishments

- Successfully Adapted Crusader Laser Ignition Technology to NLOS-Cannon in less than 10 months
- Performed M&S, and finite element analysis of system components to increase robustness
- Successfully fired over 240 rounds
NLOS- C Breech Mounted Laser

- Breech Ring
- Carrier
- Breech Mounted Laser
- Breech Block
Variable Volume Chamber Cannon (V²C²) Laser Accomplishments

P.O.P. Cannon Design

- Quick response laser implementation
- Uses laser compatible 155mm MACS w/ 105mm cannon
- Successfully fired over 140 rounds
Future Objectives

• Evaluate and develop emerging laser technologies for use in weapon systems.
• Develop lower power robust lasers for implementation in towed artillery systems.
• Work With leading edge technology specialist to develop more versatile systems.
• Two Small Business Innovative Research (SBIR) Programs in progress
  • PC Photonics
    • Multi-Core Fiber laser
  • Coherent Technologies
    • Wave Guide Laser
- The output is a high brightness
- Output is highly stable and extremely robust
- Power can be scaled up to thousands of watts good beam characteristics
- Array size – output power increases with the array size or the core number, while maintaining a good beam quality.
- Fiber length – uniform gain is established over any fiber length through multiple launching ports. The output power scales linearly with the length of the fiber.

MULTICORE FIBER LASER ARRAYS

One Ring
(7 CORES)

Two Rings
(19 CORES)

Three Rings
(37 CORES)
19 Core Fiber and Side Pump Device

DESIGN OF A 19-CORE FIBER

CROSS-SECTION OF A 19-CORE D-SHAPED FIBER

SIDE-PUMPING OF MULTICORE FIBER LASER

OUTPUT IN A HIGH-BRIGHTNESS BEAM
Coherent Technologies Approach

Innovative beam-combining architecture, capable of dramatically enhancing the combined brightness (>300x) of multiple diode bars to generate near diffraction-limited output at multi-kW levels.

- The beam-combiner uses the diode bars to drive an active laser MOPA implementing CTI’s proprietary wave guide technology that offers:
  - Enhanced brightness by dramatic beam quality improvement over diode lasers, with minimal reduction in electrical-optical efficiency
  - The high efficiency and beam quality of a fiber laser, but at much higher peak/average powers
  - Simple and efficient (>90%) diode-coupling
  - Modular architecture scalable to kW levels
  - Excellent thermal handling
  - Compact ruggedizable architecture with a clear path to a fieldable prototype
  - Leverage off other in-house programs
Phase II breadboard deliverable, and output beam profile
ARDEC Research Programs

Ultimate goal to establish cross platform ignition system

• 2000 Tech base program
  – Teamed with leading scientists, Industry and Academia
  – Results technical report entitled “Estimation of Laser Ignition Parameters for MACS”
  – Thorough evaluation of available laser technologies and application to laser ignition

• In-house Laboratory Independent Research (ILIR) Laser Program
  – 2003 program designed to fully evaluate the emerging laser technologies and evaluate nano-materials compatibility with laser ignition
  – Results:
    • Emerging technologies excellent laser characteristics for ignition.
    • Patent application for a Pre-igniter to enhance laser ignition and reduce laser requirements
Summary

• Laser Ignition has the potential to greatly improve existing and future artillery systems
  • Safer
  • Environmentally Friendly
  • Cheaper
  • Reliable
  • Automated Operation
  • Technology Driven System Improvements
  • Versatile and Flexible