Electromagnetic Railgun

NDIA Joint Armaments
Forum, Exhibition & Technology Demonstration
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Program Structure

Program Sponsors:
OSD, OPNAV (N96), Office of Naval Research

Program Management

Safety

Systems Engineering

- Power and Energy
- Mount
- Projectile
- Combat System

Test and Evaluation

- Pulsed Power
- Launcher
- Fire Control
- Land/Sea Platforms

Test Infrastructure

- Test Ranges
- Test Facilities
- Laboratories
Railgun System Integration

RAILGUN SYSTEM

TARGETING INFORMATION

GUIDED PROJECTILE
ARMATURE
SABOT

MULTIMISSIONS
AAW
ASuW
NSFS

SENSOR

LAUNCHER

COMBAT SYSTEM

LOADER/MOUNT

PFN

BATTERIES/CHARGERS

COOLING

SHIP POWER

CONTROL SYSTEM

MANUFACTURABILITY – OPERABILITY – RELIABILITY – MAINTAINABILITY – SUSTAINABILITY

LETHALITY AND MISSION EFFECTIVENESS

\[ P_k = P_h * P_{d/h} * P_{k/d} \]
Railgun and Hyper Velocity Projectile

An Affordable Multi-Mission Asymmetric Capability

DISTRIBUTION STATEMENT A. Approved for public release.
Multi-Mission Railgun

32 Mega Joule Laboratory Launcher

Railgun Development Focus
- Technology Proven at 32MJ Muzzle Energy
  - Focus shifting to rep rate operations
  - Tactical Barrel & Mount Compatibility
- Rep Rate 32MJ Launcher & Test Stand
  - Establish Manufacturing with BAE Systems
  - Validate Bore Life during Rep Rate Ops
- Rep Rate 32MJ Gun Mount (100NM capable)
  - Leverage Navy Gun Mount Experience
  - Integrate HVP Handling & Initialization
  - Design for Pulsed Power Transfer & Cabling

Warfighting Payoff
- Responsive, Wide Area Coverage
- Precision fires via guided munitions
- Deep magazines – cost effective
- Enhanced safety with Low Collateral Damage
- Multi-mission, Multi-Barrel Hyper Velocity Projectile (HVP)

HVP & Gun Systems equates to Distance
- 20 MJ Railgun → 50 nautical miles
- 32 MJ Railgun → 110 nautical miles

Transition to Tactical Mount
- Rep Rate 32MJ Test Stand
- 32MJ Mount with Train & Elevate
- 32MJ Muzzle Energy Barrel
• High speed launch enables effectiveness
• High density electronics enables packaging & survivability
• High computational power enables advanced tracking & guidance algorithms
Real Progress

**Significant Barrel Life**

**Modular Approach – multiple ship types**

**Power & energy for multi-mission**

**Projectile component risk reduction**
Naval Railgun – Focus of Effort

**Launcher**
- Multi-shot barrel life
- Barrel construction to contain rail repulsive forces
- Scaling from 8MJ (state of the art) to 32MJ
- Thermal management techniques
- M&S – Represent interaction between bore and projectile

**Projectile**
- Dispensing and Unitary Rounds
- Gun launch survivability
  - 20 to 45 kG acceleration
  - Aero Thermal Risk Management
- Hypersonic guided flight for accuracy
- Lethality mechanics

**Power & Energy**
- Pulsed Power Capacitors
  - Energy Density
  - Rep rate operation & thermal management
  - Switching

**Ship Integration**
- Dynamic Power Sharing
- Space and Weight
- Cooling
- EM Field Management
Joint High Speed Vessel

Near Term Demonstration
- 50NM Manually Loaded Railgun Launcher
- NSFS Demonstration
Long Term Demonstration (Configuration Pictured)
- 50-110NM Multi-Shot Capable Railgun Mount
- Ready for At-Sea Demonstration

Ideal Platform for Near and Long Term Demonstrations
Path Forward

- Naval EM Railgun is a Game Changer
- Opportunities
  - Barrel Life Development
  - Critical Projectile Components
  - Compact Power & Energy Power Conversion
  - High Energy Density Pulsed Power
  - Understanding Ship and Weapons System Integration Requirements
  - Execution of Demos to validate Simulation/Designs

Transition to Land & Sea Demonstrations
Navy Railgun Contacts

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Lorentz Force = 1/2 Inductance Gradient (L’) * Current (I)^2

or

Lorentz Force = Current (J) X Magnetic Field (B)

How Railgun Works

Operating Principle

1. Electrical energy stored in capacitor bank

2. Switch closes, current flows through cables, rails & armature

3. Force from magnetic field and armature current pushes projectile down barrel

4. Sabot and armature discards

Cross-Section

Insulator

Composite Wrap

Rail
**Railgun Operational Impact**

- **Wide Area Coverage**
  - Increased speed to target
  - 100+ NM

- **Accelerates operational tempo**
  - Faster attrition of enemy personnel and equipment
  - Operation timeline shifts left

- **Reduces Cost per Kill**
  - Lower Unit Cost
  - Lower handling Cost

- **Enhances Safety**
  - Reduced collateral damage
  - Simplified storage, transportation and replenishment
  - No unexploded ordnance on battlefield

- **Reduces Logistics**
  - Eliminates gun powder trail
  - Deep magazines

- **Multi-Mission Capability**
  - Naval Surface Fire Support
  - Surface Warfare
  - Missile Defense
  - Long Range Fires

**Multi-Mission Capable for Offense and Defense**
### Commonality Approach

<table>
<thead>
<tr>
<th>GUN SYSTEM</th>
<th>PROJECTILE (SABOTED &amp; SUB-CALIBER)</th>
<th>MISSION &amp; WARHEAD TYPE</th>
<th>TRANSITION OPPORTUNITES</th>
<th>GAME CHANGING CAPABILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>5&quot; MK 45 MOD 2/4</td>
<td>![5&quot; MK 45 MOD 2/4 Image]</td>
<td>NSFS – HE</td>
<td>113 Barrels (PEO IWS)</td>
<td>GUIDED 26 – 41 NM NSFS/ASCM/ASuW</td>
</tr>
<tr>
<td></td>
<td>![5&quot; MK 45 MOD 2/4 Image]</td>
<td>NSFS – HE</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>![5&quot; MK 45 MOD 2/4 Image]</td>
<td>NSFS - KE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 – 32 MJ Railgun</td>
<td>![20 – 32 MJ Railgun Image]</td>
<td>NSFS – HE</td>
<td>FUTURE (PMS405/PEO IWS)</td>
<td>GUIDED 50 - 100 NM NSFS/ASCM/ASuW/Future Threats</td>
</tr>
<tr>
<td>155 mm – AGS</td>
<td>![155 mm – AGS Image]</td>
<td>NSFS – HE</td>
<td>6 Barrels (PEO IWS)</td>
<td>GUIDED 40 NM NSFS/ASCM/ASuW</td>
</tr>
<tr>
<td>155 mm</td>
<td>![155 mm Image]</td>
<td>Ground Fires – HE</td>
<td>800 ARMY 300 MARINE ASSETS</td>
<td>GUIDED 17 NM Fires/CMD</td>
</tr>
</tbody>
</table>

**Multi- Barrel, Multi- Mission, & Multi-Service Applications**
Pulsed Power at the Electromagnetic Launch Facility, Dahlgren, VA
Advanced Energy Systems

High Density Power Electronics

- Charging Power Supplies for Advanced Energy Systems
- Converting Ship’s Power to High Voltage for Electric Weapons
- Supports Electric Drive, Railguns, Lasers & Radars

Battery Energy Storage

- Energy Storage to buffer Prime Generators
- Ready Reserve Energy for response to “quick” threats
- Requires close Ship Safety Design, Test & Monitoring

Pulsed Forming Network

- Capacitor based PFN
- Higher Energy Density lowers shipboard volume/footprint
- Rep rate operation & thermal management

System / Ship Integration

- Dynamic power sharing across platform
- Designing with Space and Weight Constraints
- Assessing Thermal and EM Field management

Battery Energy Storage in ISO Container for Mobility & Demo Platform Flexibility

- Actively Cooled Rep-Rate Pulsed Power Module

Lithium Ion Battery Packet

- Ready Reserve Energy for response to “quick” threats
- Requires close Ship Safety Design, Test & Monitoring