Joint Armaments Conference

Mr. George Solhan
Deputy Chief of Naval Research,
Expeditionary Maneuver Warfare and
Combating Terrorism (ONR 30)
18 May 2010
Naval Research: A Statutory Mission

Naval Research Laboratory (Appropriations Act, 1916):
“[Conduct] exploratory and research work...necessary... for the benefit of Government service, including the construction, equipment, and operation of a laboratory....”

Office of Naval Research (Public Law 588, 1946):
“...plan, foster, and encourage scientific research in recognition of its paramount importance as related to the maintenance of future naval power, and the reservation of national security.... ”

“...manage the Navy's basic, applied, and advanced research to foster transition from science and technology to higher levels of research, development, test, and evaluation.”
ONR S&T Departments

Code 30

Expeditionary Maneuver Warfare & Combating Terrorism

Code 31

C4ISR

Code 32

Ocean Battlespace Sensing

Sea Warfare and Weapons

Warfighter Performance

Air Warfare and Weapons

Code 33

Code 34

Code 35
FY10 DON S&T Funding = $1,824M

**S&T Focused on Naval Needs**

- **Discovery & Invention** (Basic Science, Early Applied Research)
  - ~40%
- **Leap Ahead Innovations** (INPs)
  - ~10%
- **Acquisition Enablers** (FNCs)
  - ~30%
- **Quick Reaction & Other S&T**
  - ~10%

**Time Frame**

- **Near**
  - Quick Reaction & Other S&T
    - PE: 6.3
  - Acquisition Enablers (FNCs)
    - PE: 6.3
- **Mid**
  - Leap Ahead Innovations (INPs)
    - PE: 6.3 / 6.2
- **Far**
  - Discovery & Invention
    - PE: 6.2 / 6.1

**Focus**

- **Broad**
- **Narrow**

**Quick Reaction** (10%)
- Tech Solutions
- Experimentation
- MC S&T (MCWL, JNLW, etc.)

**Acquisition Enablers** (36%)
- Future Naval Capabilities
- Warfighter Protection
- Capable Manpower
- LO/CLO

**Leap-Ahead Innovations** (12%)
- Innovative Naval Prototypes
- NSPs
- Swampworks

**Discovery & Invention** (42%)
- Basic & Early Applied Research
- National Naval Responsibilities
- Education Outreach HBCU/MI
FY10 Marine Corps Funding Allocation

ONR30 FNC (USMC Funded) $26,861K
ONR30 FNC (Navy Funded) $47,823K
ONR30 Core Expeditionary (6.1) $18,199K
ONR30 Core Expeditionary (6.2) $29,558K
ONR30 Core Expeditionary (6.3) $53,632K
JNLWD $6,008K
JNLWD $10,998K
JNLWD $3,049K
JNLWD $6,091K

MCWL $36,620K
C4 $16,113K
Intel $6,958K
Force Pro $733K
Fires $4,394K
Logistics $6,225K
T&E $2,197K

HPT&E $13,214K
C4 $9,358K
ISR $5,369K
Force Protection $11,303K
Fires $9,598K
Logistics $16,335K

Counter Material $1,057K
Counter Personnel $6,091K
Human Effects $3,049K

FY10 Marine Corps Funding Allocation

ONR30 Breakout Funding Allocation (FY10)
ONR

Half full...No! Wait! Half empty! No, half... What was the question?

SYSCOM

Hey!
I ordered a cheeseburger!

MCCDC/OPNAV

Fleet/MARFOR

The glass is half full!

The glass is half empty.
Distributed Operations Defined

“Distributed operations describe an operational approach that creates an advantage over an adversary through the deliberate use of separate, coordinated and interdependent actions. Distributed operations are enabled by improved access to functional support, as well as by enhanced combat capabilities at tactical levels. Distributed operations are essentially a form of maneuver warfare in all domains and dimensions.” -- Major Combat Operations Joint Operating Concept

“Distributed operations is a technique applied to an appropriate situation wherein units are separated beyond the limits of mutual support. Distributed Operations are practiced by general purpose forces, operating with deliberate dispersion, where necessary and tactically prudent, and decentralized decision-making consistent with the commander’s intent to achieve advantages over an enemy in time and space...” -- Marine Corps Ops in Complex & Distributed Environments (concept paper)

“[The] Navy’s current operating environment drives us to adopt distributed, networked operations as our overarching global Navy concept. [This concept] takes advantage of the Navy’s persistent forward posture to support active, layered defenses while placing the Navy-Marine Corps team in a unique position to conduct the shaping operations needed to assure friends and allies, and dissuade or deter potential regional, transnational, or global competitors.” -- Navy Strategic Plan, 2006
Technology Transforms Operational Art

DO is the next logical step in a historical progression toward increased dispersion.

Evolution of the Operational Art, leveraging technology advances

Area of Influence* (Km²/100 men)

Innovation over Time

Roman Empire (BC) Napoleonic Era (1800s) WW I (1910s) WW II (1940s) Gulf War (1991) OEF (2001+) DO

Organization/discipline Massed direct fires Indirect and continuous fires Blitzkrieg/Maneuver Precision fires/Maneuver Warfare

Information Revolution (1980s – today)

Cold War (1950 – 1990)

RMA/Precision (1980s – 2000s)

Initial DO

Ind Rev 2/Great Powers (1870 – 1940s)

Industrial Revolution (1750 – 1850)

?
"Armies do not win wars by means of a few bodies of super-soldiers but by the quality of their standard units"

Field Marshall Sir William Slim
**Vision**
Enable dispersed small units to dominate an extended battlespace through advanced warfighter training, assured network connectivity, enhanced situational awareness, and guaranteed access to logistics and fire support.

**Objectives**

1. **Warfighter Preparation:**
   1.1 Optimized physical readiness and enhanced cognitive performance
   1.2 Immersive, synthetic systems for training and education

2. **Command & Control:**
   2.1 Robust communications networks
   2.2 Enhanced small-unit situational awareness through intelligence and alert dissemination
   2.3 Small unit blue force tracking systems

3. **Logistics:**
   3.1 Automated logistics planning and monitoring
   3.2 Sustained demand reduction
   3.3 Logistics delivery

4. **Mobility:**
   4.1 Individual mobility & combat load reduction
   4.2 Small-unit mobility

5. **Lethality and Survivability:**
   5.1 Enhanced organic small-unit weapons effects
   5.2 Enhanced small-unit surveillance and reconnaissance

**Key Research Topics**
Training, Education & Human Performance
Expeditionary C4
Communications and Networks
Expeditionary Logistics
Expeditionary Firepower
Precision Strike
Expeditionary ISR
Unmanned Air and Ground Vehicles
Special Warfare / EOD
Land Mine Countermeasures
Expeditionary Maneuver/ Individual Mobility
Fires as a Commodity

Technology Investment Areas (TIA):

- Targeting and Engagement
- Advanced Ammunition
- Advanced Weapons

Netted:
- Shared Situational Awareness throughout sensor-to-shooter chain
- Ability to mass fires

- Reliable
- Accurate
- Lethal (Scalable)
- Responsive
- Flexible
- Inorganic
- Bomb Damage Assessable
- Logistically Supportable

“Lighten the Load”

Technology Investment Areas (TIA):
Targeting and Engagement TIA

Precision Urban Mortar Attack (PUMA)

Fire Support Coordination Center (FSCC)
Targeting and Engagement TIA

Precision Urban Mortar Attack (PUMA)

Fire Support Coordination Center (FSCC)

Fire Direction Center (FDC)
Targeting and Engagement TIA

**Flight Controlled Mortar (FCMortar):**
- Guidance kit for 81mm mortar system, for precision engagement of targets in deep defilade
- Flight trajectory shaping, miniature guidance and control components
Targeting and Engagement TIA

• **Non-magnetic Azimuth Sensing (NMAS):**
  - Handheld azimuth sensor for targeting, to 1 mil accuracy
  - System accuracy in operational environments

• **Eye-safe Laser Designation (ESLD):**
  - Handheld, eye-safe laser designator and seeker for covert targeting and engagement
  - Detector responsivity at eye-safe wavelength
• Integrated Day-Night Sight Technology (IDNST):
  – Integrated Vis-NIR-SWIR-LWIR optics in a single sight package; version for individual weapons, version for crew served weapons
  – Seek, acquire, track, observe, and engage targets to weapons’ maximum effective ranges, under all light levels, through smokes and aerosols
  – Electromagnetic spectrum integration in a lightweight system
  – Lighten the load: reduce size, weight, and power
# Advanced Ammunition TIA

## Lightweight Small Arms Technologies (LSAT)

- **More than 16 pounds of weight savings!**

<table>
<thead>
<tr>
<th></th>
<th>M855</th>
<th>Cased Telescoped</th>
<th>Caseless</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Volume (cu in)</strong></td>
<td>0.247</td>
<td>0.215</td>
<td>0.152</td>
</tr>
<tr>
<td><strong>Percent Volume Reduction</strong></td>
<td>----</td>
<td>13%</td>
<td>38%</td>
</tr>
<tr>
<td><strong>Weight (grains) Including link</strong></td>
<td>220</td>
<td>130.6</td>
<td>105.1</td>
</tr>
<tr>
<td><strong>Percent Weight Reduction</strong></td>
<td>----</td>
<td>41%</td>
<td>51%</td>
</tr>
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</table>

- **Light Machine Gun (Comparable to M249 SAW)**
- **5.56mm Case Telescoped**
- **5.56mm Caseless**
Advanced Ammunition TIA

• Extended Range Mortar Ammunition (ERMA):
  – Increase range of the 81mm mortar by changing propellant formulation and granulation
  – Propellant formulations, interior ballistics, insensitive munitions

• Physics Based Modeling of Novel Warhead Designs:
  – Optimize initiation, explosives, materials, and shapes phenomenologies for warheads designed for specific effects on a variety of material targets
  – Computational/modeling capabilities of National Laboratories

• Micro-electromechanical Systems (MEMS):
  – Mortar Safety and Arming, ignition safety device
  – MEMS energetics
Advanced Weapons TIA

• High Performance Alloys for Weapons Applications (HPAWA):
  - Lighten the Load
  - Durability/Reliability
  - Cost Avoidance
  - Flowformed, lightweight, Cobalt Alloy machine gun barrels able to withstand high firing temperatures
  - Alloy characterization and fabrication
LSAT Cost Comparison

- Cost to Replace Army and Marine Corps M249 SAW, M4, and M16:
  
  $1,300,000,000

- Cost of M1 Main Battle Tank:
  
  $5,000,000 each
  
  Total: $31,400,000,000

- Cost of F-22 Raptor:
  
  $143,000,000 each
  
  Total: $19,600,000,000

All costs are estimated
Advanced Weapons TIA

Autonomous Fires Systems

Functions
- Survey
- Detect
- Recognize
- Identify
- Determine Intent
- Transfer Data
- Engagement Decision
- Track
- Aim
- Fire
- Battle Damage Assess

Autonomous Fires

Semi-Autonomous Fires

Issues

Safety
Fratricide
Ethics
Policy
The Ultimate Customer – The Warfighter!

ONR S&T enables Sailors and Marines!
- S&T in support of Expeditionary Maneuver Warfare
- Distributed Operations (Enhanced MAGTF Operations (EMO)/Enhanced Company Operations (ECO)
- Survive and Win
- Be more lethal
- Expand Small Unit area of influence
- Be flexible in all phases of warfare
- Move between kinetic and non-kinetic tactics
- Generate combat power operationally/tactically
Questions?
Back-Up
### Targeting and Engagement TIA Willful Intent

**Current Capability:**
- Conventional targeting and engagement systems for direct and indirect fire capability

<table>
<thead>
<tr>
<th>FY</th>
<th>Desired Capability</th>
<th>S&amp;T Challenge</th>
<th>S&amp;T Solution</th>
</tr>
</thead>
</table>
| **Near Term FY10-FY15** | - Precision fires for battalions  
- Accurate target location  
- Eye-safe, light weight, low-power target designation  
- Threat detection, recognition, and identification out to effective ranges of small arms and crew served weapons | - Develop a miniature guidance, navigation, and control system for a 81mm mortar  
- Develop miniature azimuth sensors with 1mil accuracy  
- Develop low power eye safe laser designator technologies  
- Develop advanced Focal Plane Arrays (FPA), having miniature displays, applying scene enhancement technologies | - GPS and terminal seeker based guidance kit and tail kit for the M821/M889 81mm mortar munitions  
- Miniature Micro-electromechanical Systems (MEMS) based inertial azimuth sensors  
- Micro pulsed laser range finder and pulse integrating seeker technologies and algorithms  
- Integrated Vis-NIR-SWIR-LWIR optics in a single sight package through the Future Naval Capability (FNC) program |
| **Mid Term FY15-FY18** | - Precision fires for companies  
- Remotely deployed tags to mark hostile vehicles and combatants  
- Day and night wide Field of View (FOV) target acquisition for crew served weapons | - Develop a miniature guidance, navigation, and control system for a 60mm mortar  
- Develop rapidly dispersed aerosols or MEMS to attack to targets  
- Develop Graduated Index of Refraction (GRIN) lenses coupled to curved FPA | - GPS and terminal seeker based guidance kit and tail kit for the M720/M888 60 mm Mortar  
- Flight controlled mortar delivering aerosol/MEMS tags on designated standoff site  
- Combine GRIN lens, curved FPA, and advanced signal processing on Crew served weapons to provide day/night target acquisition |
| **Far Term FY18-FY22** | - Precision fires for the individual warfighter  
- Day and night wide FOV target acquisition for individual dismounted warfighters | - Develop guidance, navigation, and control technologies to flight correct small caliber projectiles  
- Develop nano- and doping-technologies for small sights, for individual weapons | - Micro-thrusters and MEMS based GNC for minor caliber and small arms ammunition  
- Miniaturized GRIN lens, curved focal plane array to provide small sight |

**Endstate:** Advanced targeting and engagement capabilities, enabling responsive and flexible Fires as a Commodity to individual warfighters, netted for shared situational awareness throughout the sensor-to-shooter chain, providing precision fires and massed fires ability, against unconventional and hybrid threats across the full range of military operations and environments.
## Advanced Ammunition TIA Willful Intent

### Current Capability:
- Conventional munitions for direct and indirect fire capability

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<tbody>
<tr>
<td><strong>Near Term</strong></td>
<td>- Extended range fires for battalions</td>
<td>- Develop advanced propellant technologies for the 81mm mortar</td>
<td>- High nitrogen propellants and new propellant formulations</td>
</tr>
<tr>
<td>FY10-FY15</td>
<td>- Enable defeat of all targets in urban terrain and other complex types of terrain</td>
<td>- Develop novel warhead technologies that combine kill mechanisms for various target sets</td>
<td></td>
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<tr>
<td></td>
<td>- Improve munitions reliability and first round Probability of Kill ( (P_X) )</td>
<td>- Improve the reliability and output of safe-arm and ignition devices</td>
<td>- Combine conventional kill mechanisms including linear explosively formed penetrators, a shaped charge, a unitary penetrator, high explosive, and fragments in a single warhead</td>
</tr>
<tr>
<td></td>
<td>- Reduce weight and logistics burden of ammunition</td>
<td>- Reduce small caliber ammunition weight by 50% and volume by 40%</td>
<td>- Miniature MEMS based low-energy reactive bridges and safe-arm technologies</td>
</tr>
<tr>
<td><strong>Mid Term</strong></td>
<td>- Extended range fires for companies</td>
<td>- Develop advanced propellant technologies for the 60 mm mortar</td>
<td>- High ignition temperature propellant, PNP binder replacement, and improved primer technologies for advanced caseless small caliber ammunition</td>
</tr>
<tr>
<td>FY15-FY18</td>
<td>- Defeat of targets behind walls (both combatants and doubly protected items)</td>
<td>- Develop advanced warheads and fuzes that delay detonation until the penetrator enters the protected space</td>
<td>- Physics based modeling and optimization of advanced penetrating warheads, combining multiple effects (i.e. Munroe, Misznay-Schardin, spall, etc)</td>
</tr>
<tr>
<td></td>
<td>- Insensitive primary explosives and fuzes for advanced warheads</td>
<td>- Develop high output explosives with low sensitivity</td>
<td>- Porous chromium oxide matrices that control the ignition and detonation of high output explosives combined with advanced nano-circuits for reduced explosive sensitivity</td>
</tr>
<tr>
<td><strong>Far Term</strong></td>
<td>- Extended range fires for individual warfighters</td>
<td>- Develop propulsion technologies for extending range for guided projectiles</td>
<td>- Nano-materials for propellant with significant advantages in propulsion output</td>
</tr>
<tr>
<td>FY18-FY22</td>
<td>- Scalable warhead effects for shoulder launched missiles and mortars</td>
<td>- Develop warhead configurations enabling scalable lethality</td>
<td>- Unique configurations of MEMS based fuzing, variable output explosives, and advanced kill mechanism combinations</td>
</tr>
</tbody>
</table>

### Endstate:
Improved lethality (scalable) and dominance of the individual Warfighter within his area of influence through advanced warhead, propulsion, and ammunition technologies, supporting Fires as a Commodity.
## Advanced Weapons TIA Willful Intent

### Current Capability:
- Conventional weaponry for direct and indirect fire capability

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</table>
| Near Term FY10-FY15 | - Reduce the weight of weapon systems and components  
- Extend the service life of weapon systems  
- Coordinated threat response with remote weapons stations | - Develop new manufacturing processes that improve characteristics of materials used in weapon systems  
- Develop an integrated tactical network of threat detection sensors and remote weapons systems on moving vehicles  
- Demonstrate the utility of reducing combat load by increasing warfighter “kills-per-kilogram” | - High performance alloys and novel manufacturing methods  
- Acoustic sensors, advanced radios, and stabilized remotely operated weapon stations  
- Caseless ammunition small caliber weapons technologies |

| Mid Term FY15-FY18 | - Improved life cycle performance for small arms (reduced barrel erosion, improved operational performance)  
- Affordable fires accuracy and lethality against small tactical platforms from small manned tactical platforms  
- Covert tagging of enemy vehicles and combatants | - Develop new materials and materials production techniques to provide consistent high weapon performance  
- Develop a remotely operated, stabilized weapon station mount of less than 200 lbs  
- Develop tag dispersion techniques that provide more than 95% coverage of all targets within 25m diameter from 2 km standoff range | - Flow-form processing, super alloys, and advanced composite materials  
- Integration of micro-pulsed laser designator, integrated day-night optics, lightweight minor caliber weapons, and low cost missiles  
- Airburst warhead for 81mm mortar with infrared reflective and other unique signature tagging technologies |

| Far Term FY18-FY22 | - High velocity launch for kinetic kill projectiles to defeat future armor systems  
- Non-lethal fires  
- Precision engagement and escalation of force from unmanned ground, air, and surface platforms | - Increase projectile velocities beyond chemical property limits of current propellants to velocities in excess of 4 km/s  
- Develop inexpensive non-lethal weapons effects and munitions, in coordination with Joint Non-lethal Weapons Directorate (JNLWD)  
- Develop wireless lethal effectors for safe and legally permissible employment from unmanned platforms | - Combustion light gas gun using hydrogen and oxygen for propulsion  
- Directed energy, electromagnetic pulse generators, variable density projectiles, and phaser technologies  
- Null latency targeting and C2 technologies, autonomous on-board target recognition algorithms |

### Endstate:
Lightweight, reliable, accurate weapons systems, enabling organic and inorganic scalable lethality Fires as a Commodity, against diverse unconventional and hybrid threats, with the ability to escalate from non-lethal to lethal force from ground, air, and naval platforms, across the full range of military operations.
Discovers and develops technologies to provide decisive, unrivaled new capabilities for, or to improve the performance of Navy and Marine Corps warfighters in the areas of Fires; with particular focus on Distributed Operations and Asymmetric/Irregular Warfare; to include Naval Expeditionary and other weapons, munitions, fuzes, ballistics, propulsion, weapons systems control and guidance, enhanced accuracy, tailored lethality including non-lethal alternatives, enhanced targeting (to include detection, locating, identification, designation, and tracking), directed energy, and lightweight components; and to avoid technological surprise.

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KEY: Other FNC D&E E&D Plus-Up

RECENT TRANSITIONS

IMPROVED FIRE CONTROL SYSTEM (FNC)
TRANSITIONED TO PM INFANTRY WEAPONS SYSTEMS

LIGHTWEIGHT MORTAR SYSTEM (FNC)
TRANSITIONED TO PM MORTARS & PM INFANTRY WEAPONS SYSTEMS

ADVANCED FIRES COORDINATION TECHNOLOGY
TRANSITIONED TO PM MAGTF C2

ADVANCED GUN BARREL TECHNOLOGY
TRANSITIONED TO PEO-IWS3c

MEMS SAFE & ARM
TRANSITIONED TO PM AMMO

TARGETING & ENGAGEMENT

USMC Fires STO-1: Targeting technologies for faster, more precise engagements, while simplifying fire control tasks
USMC Fires STO-2: Integrated lightweight day-night optics
USMC Fires STO-3: Engagement damage assessments
USMC Fires STO-4: More capable, lighter weight ammunition across the spectrum of lethality, with increased reliability, range, precision, and safety
USMC Fires STO-6: Increased capabilities and reduced weight of all ground combat weapons systems
USMC Fires STO-7: Technologies that utilize the electromagnetic spectrum to detect, exploit and target adversary systems, equipment, or individuals
NECE Fires STO-6: Lightweight day-night optics
NSW Fires 09-7: Lightweight, All Weather, Precision Targeting Technologies
NSW Fires 09-9: Lightweight Day-Night Weapons Optics
NSW Fires 09-13: Munitions Terminal Guidance for NSW Applications
NSW Fires 09-16: Highly Responsive Loitering Munitions/Weaponized UAS
NSW Fires 09-18: Advanced Weapons and Propellant Technologies

TECHNOLOGY INVESTMENT AREAS

IMPROVED FIRE CONTROL SYSTEM (IFCS)

NON-MAGNETIC AZIMUTH SENSING (NMAS)

INTEGRATED DAY/NIGHT SIGHT TECHNOLOGY (IDNST)

MEMS INERTIAL SENSORS (UC IRVINE)

FLIGHT CONTROLLED MORTAR

PRECISION ENGAGEMENT TECHNOLOGIES (PET)
Discovers and develops technologies to provide decisive, unrivaled new capabilities for, or to improve the performance of Navy and Marine Corps warfighters in the areas of Fires; with particular focus on Distributed Operations and Asymmetric/Irregular Warfare; to include Naval Expeditionary and other weapons, munitions, fuzes, ballistics, propulsion, weapons systems control and guidance, enhanced accuracy, tailored lethality including non-lethal alternatives, enhanced targeting (to include detection, locating, identification, designation, and tracking), directed energy, and lightweight components; and to avoid technological surprise.

**TECHNOLOGY INVESTMENT AREAS**

<table>
<thead>
<tr>
<th>ADVANCED AMMUNITION</th>
<th>TACTICAL URBAN STRIKE WARHEAD (TUSW)</th>
<th>81mm EXTENDED RANGE MORTAR AMMUNITION (ERMA)</th>
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<tbody>
<tr>
<td>USMC Fires STO-4: More capable, lighter weight ammunition across the spectrum of lethality, with increased reliability, range, precision, and safety</td>
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<tr>
<td>USMC Fires STO-5: Improved propellants and energetic materials</td>
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<tr>
<td>USMC Fires STO-6: Increased capabilities and reduced weight of all ground combat weapons systems</td>
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<thead>
<tr>
<th>CASELESS AMMUNITION</th>
<th>1901 A IGNITION SAFETY DEVICE</th>
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</thead>
<tbody>
<tr>
<td>NSW Fires 09-11: Measured-Effect Munitions</td>
<td></td>
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<tr>
<td>NSW Fires 09-12: Clandestine Structure Penetration</td>
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<tr>
<td>NSW Fires 09-18: Advanced Weapons and Propellant Technologies</td>
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<tr>
<th>REVOLUTIONARY TARGET EFFECTS</th>
<th>MEMS MORTAR S&amp;A</th>
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<th>HIGH PERFORMANCE ALLOYS FOR WEAPONS APPLICATIONS</th>
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