Protection Technologies--Challenges and Opportunities

2012 Science, Technology & Requirements Forum
17-18 October 2012

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Wendy A. Winner
Associate Director for Protection & Lethality Technology Focus Teams
Weapons & Materials Research Directorate
Army Research Laboratory, RDECOM
wendy.a.winner.civ@mail.mil, 410-306-0696 (DSN 458)
# Protection Technologies -- Challenges and Opportunities

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**Performing Organization:**

U.S. Army Research, Development and Engineering Command, U.S. Army Research Laboratory, 2800 Powder Mill Road, Adelphi, MD, 20783-1197

**Sponsoring/Monitoring Agency:**

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**Abstract:**

Presented at the 2012 Science, Technology & Requirements Forum held 17-18 October in Fort Leonard Wood, MO.
Purpose: Discuss challenges and opportunities in science, technology & manufacturing science for protection

Approach:
- Define protection from the RDECOM frame of reference
- Provide context for the roles of missions and threats
- Identify science & technology challenges & opportunities
  - Materials for protection
  - Ballistic mechanisms
  - Manufacturing sciences
- Discuss one of many success stories & its future directions
- Summary

How do we break through the paradigm of incremental advances to yield inventions & innovations?
Provide integrated research, development and engineering solutions to empower, unburden, protect and sustain the Warfighter.
RDECOM is the Army’s go-to organization for the superior scientific and engineering expertise that defines the space between the state of the art and the art of the possible and delivers innovative technology solutions that ensure the United States maintains global battlefield dominance.
Technologies that enable the preservation of the effectiveness and survivability of individual soldier systems; manned and unmanned air and ground platforms; command posts and other high valued assets against a spectrum of threats.

Technologies principally focus on preventing, through physical means, acquisition and observation; avoiding contact; preventing penetration; and enabling Soldier/crew/vehicle survivability from threats.
## Protection TFT Taxonomy

<table>
<thead>
<tr>
<th>Level 1</th>
<th>Ground Protection</th>
<th>Air Protection</th>
<th>Soldier Protection</th>
<th>Base/Area Protection</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Active Protection</td>
<td>Aircraft Hardening</td>
<td>Head-borne</td>
<td>Active Base Protection</td>
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<td></td>
<td>Hit Avoidance</td>
<td>Aircrew Protection</td>
<td>Small Arms</td>
<td>Passive Base Protection</td>
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<td></td>
<td>Non-Armor Protection for Vehicles</td>
<td>Threat Avoidance</td>
<td>Soft Armor (&amp; Extremities)</td>
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<tr>
<td>Level 2</td>
<td>Underbody Blast/Occupant Protection</td>
<td>Environmental Protection for Soldiers</td>
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<td></td>
<td>Vehicle Armor</td>
<td>M&amp;MS for Vehicles</td>
<td>M&amp;MS for Aircraft</td>
<td>M&amp;MS for Soldier</td>
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</table>

### Human-Machine/Material Systems (M&MS) for Protection

- **L2 Basic Materials & Manufacturing Science**
- **L1 Materials & Manufacturing Science (M&MS) for Protection**
  - Ballistics for Vehicles
  - Ballistics for Aircraft
  - Ballistics for Soldier
  - Ballistics for Base/Area

### Human-Machine/Material Systems (M&MS) for Protection
- Ballistics Research
- Humans in Extreme Environments
- Current and Emerging Threats
- Core Competencies

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Diversity of Mission

- Within a Current Operation
- Other Operations in Other Regions
- Envisioning Future Operations

Current

Future

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Current and Emerging Threats

- Direct Fire
- Indirect Fire
- IEDs/mines
- Fragments
- Blast & debris
- Flame/thermal
- Non-lethal
- Chemical/Biological
- Obscurants
- Weather
- etc.
Materials breakthroughs offer opportunities for technical advances

- Lighter weight
- Advanced functionality & performance through nanoscience
- Thermal management
- Better adhesives/interfaces

Materials are fundamental building blocks for protection systems
Understanding terminal ballistics helps makes materials into protective systems

- High rate behavior and failure
- Computational methods
- Shock physics and wave mechanics
- Material interfaces and damage propagation
Manufacturing science provides opportunities to achieve desired material properties and system architecture

- Virtual manufacturing
- Process modeling & improvement
- Novel manufacturing methods
- Processing of hybridized materials systems

Equal Channel Angular Extrusion

Hot pressing furnaces with multiple heating and cooling chambers, and a central hot pressing chamber
PROVIDE INNOVATIVE PROTECTION TECHNOLOGIES

• **Lightweight Ballistic Protection**
  – Ultra-lightweight and multifunctional materials
  – Next generation armor materials
  – Modeling and simulation tools for advanced threats, materials and mechanisms
  – Maturation and system engineering integration of technologies
  – Optimized multi-threat protection
  – Analytical tools to evaluate ballistic and high energy events

• **Active protection technologies**
  – Smart armors
  – Active protection systems
  – Extended area protection

• **Soldier / Crew Protection Technologies**
  – Vision protection
  – Advanced automatic energy attenuators, smart landing gear, advanced inflatable restraint system components, crashworthiness design criteria, & active energy attenuation control
  – Advanced structural survivability for ground platforms
  – Integrated Soldier protection technologies
Innovative materials and architectures are leading to improved performance.

**Development of Improved Ceramic Compositions for Reduced Impact Damage**

- Torso Armor Plate (baseline ceramic)
- Plate with modified material composition and processing to reduce cracking

**Influence of Backing Architecture on Ceramic/Composite Performance**

- A hybrid exhibits better s-curve performance than [0/90] over entire probability range
- Oriented backings lead to a lower maximum in back face deformation

Armor package after two-shot impact
Army & Industry Manufacturing Collaborations to advance Soldier Protection Technologies

Development of Helmet Process Technologies

Special Ops FAST and Navy SEAL Maritime Helmet (fielded)

Development of Body Armor Process Technologies

Marines/Army Enhanced Combat Helmet (pending)

FY15 Goal: 10% lighter ESAPI System

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Partnership Methods & Opportunities

With the current pace of technology advancement, insular research and development (R&D) organizations will rapidly lose relevance and value. ARL has adopted business practices that have created a truly collaborative research environment between it and the private sector in select technology areas. ARL has also provided the Army access to private sector sources of research with the requisite diversity and quality. Currently, ARL outsources 80 percent of its research program to academia with over 250 academic partners in all 50 states and to industry through a mix of grants, cooperative agreements, other transactions authority, or contracts.

Click the links below to find out more on any of the following partnerships:

- ARL’s Single Investigator Program
- University Centers
- ARL’s Collaborative Technology Alliances (CTAs)
- DoD Multi-Disciplinary University Research Initiative (MURI)
- Historically Black Colleges and Universities/Minority Institutions Program (HBCU/MI)
- Educational Partnership Agreements (EPAs)
- Cooperative Research and Development Agreements (CRDA)
- Patent License Agreements
- Small Business Innovation Research (SBIR) Program
- International Collaborative Activities
- Economic Development Organizations
FY14 Call for Army ManTech Proposals

- **Official Call for Proposals (FY14 New Starts)**
  - Late October 2012 – early January 2013
  - Program executed through Army Science & Technology Organizations (RDECOM, ERDC, MRMC and SMDC)

- **Topics**
  - Materials and Components for the Soldier
  - Missile and Munitions Components
  - Communications and Electronics
  - Propulsion
  - Manufacturing Process Data Capture & Utilization
  - Power and Energy
  - Structures and Survivability

- **More information can be found at:**
  - www.armymantech.com
# FY14 Call for Army ManTech Proposals

## Advanced Mfg Technology Initiatives

<table>
<thead>
<tr>
<th>Ground Systems</th>
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<tbody>
<tr>
<td>• Affordable Armor Processes</td>
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<td>• Sintered Spinel for Transparent Armor</td>
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<td>• Advanced and Multi-Purpose Warhead</td>
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<td>• IMX 104 Munitions Manufacturing</td>
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<td>• Cannon Life Extension</td>
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<td>• Guided Missile Antennas</td>
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<th>Soldier Systems</th>
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<tr>
<td>• Lightweight Body Armor</td>
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<td>• Chemical/Biological Resistant Fabric</td>
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<td>• Energy Efficient Tent Liners</td>
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<th>C3 Systems</th>
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<tr>
<td>• Large Affordable Substrates</td>
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<tr>
<td>• Chip Scale Atomic Clocks</td>
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<td>• High Operating Temp FPAs</td>
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<td>• High Definition FPAs</td>
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<tr>
<td>• Active Pixel Sensor</td>
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<td>• Flexible Display</td>
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<tr>
<td>• Net-Centric Model Based Engineering</td>
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<tr>
<td>• Accelerated Adaptive Fabrication Enterprise (A3FABE)</td>
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<td>• Additive Manufacturing for Quick Tooling</td>
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<td>• Advanced Ceramic Matrix Composite Machining</td>
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<td>• Rotorcraft Blade Erosion Coating Application</td>
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<td>• Reliable and Affordable UAV Propulsion</td>
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<tr>
<td>• Nano-composite Coatings</td>
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<td>• Composite Structures for Aviation Systems</td>
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Synergies for the Future

• Rate of technical progress will continue to slow with conventional approaches alone

• Multidisciplinary opportunities offer avenues for disruptive innovations

• Future challenge is linking disparate scientific disciplines & communities

• Collaboration is the process of bringing the contributions of all the partners together, to integrate them into a single coherent whole that is greater than the sum of our parts.
RDECOM operates between the state of the art and the art of the possible.