NDIA
Lethality Technologies: 2025 & Beyond

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Army Enduring Challenges

- Greater **force protection (Soldier, vehicle, base)** to ensure survivability across all operations
- Ease **overburdened** Soldiers in Small Units
- Timely **mission command & tactical intelligence** to provide situation awareness and communications in all environments
- Reduce logistic burden of **storing, transporting, distributing** and **retrograde** of materials

- Create **operational overmatch** (enhanced lethality and accuracy)
  - Achieve operational **maneuverability** in all environments and at **high operational tempo**
  - Enable ability to **operate in CBRNE environment**
  - Enable **early detection and improved outcomes for Traumatic Brain Injury (TBI) and Post Traumatic Stress Disorder (PTSD)**
  - Improve **operational energy**
  - Improve **individual & team training**

- **Reduce lifecycle cost** of future Army capabilities
Future Environments

Mega Cities and Subterranean

Triple Canopy and Forested

Caves

Large Area Coverage

Urban and Mixed Populations
ARL S&T Campaigns

Human Sciences
Fundamental understanding of Warfighter performance enhancement, training aids, and man-machine integration.

Information Sciences
Fundamental understanding of information generation, collection, assurance, distribution, and exploitation.

Sciences for Lethality & Protection
Fundamental understanding of emerging technologies that support weapon systems, protection systems, and injury mechanisms affecting the Warfighter.

Sciences for Maneuver
Fundamental understanding of the design, integration, control, and exploitation of highly adaptive platforms in complex environments.

Materials Research
Fundamental understanding of structural, electronic, photonic, and energy materials & devices.

Computational Sciences
Fundamental understanding of computer hardware, high efficiency algorithms, and novel mathematical methods.

Assessment and Analysis
Quantitatively assess the development and application of analytical tools and methodologies to quantitatively assess the military utility of Army, DoD, and select foreign combat systems.

Extramural Basic Research
Steering and oversight of the systematic study to increase fundamental knowledge and understanding in physical, engineering, environmental, and life sciences related to long-term national security needs.
Moving Targets
- Affordable precision kill of moving targets with and without terminal guidance
- Robust navigation in GPS challenged environments

Non-lethal Technologies
- Technologies from 0 to 1000 m against human targets

Full spectrum capability of lethality in the hands of Individual Soldiers
Small Arms
- Single munition system for multiple targets: non-lethal, soft, medium, hard, structure
- Ability to produce large holes in tough walls
- 0 – 2km defeat of soft targets in defilade
- 0 – 150% scalable warheads

Next generation lethal systems (complex system of systems)
- Robotic vehicles to enable new capabilities
- Insensitive disruptive energetics
- Throttleable rockets and missiles
Key Campaign Initiative (KCIs)

Substantive, long-lived, technical programs focused on pursuing scientific discoveries, innovations, and knowledge product transitions that are expected to lead to greatly enhanced capabilities for the operational Army of 2040

Lethality KCIs

- Scalable Lethal Adaptable Weapons Concepts
- Desired Lethal Effects at Standoff Ranges in Constrained Environments
- Disruptive Energetic Materials

Assured and Instantaneous Delivery of N Lethal Payloads at Extended Ranges through Complex and Denied Environment

Enabling Technologies
- Propulsion
- Maneuverability
- Navigation
- Effects
- Weapons Engineering

Affordable
Lethality Over Time

Assured Delivery, Desired Effects

Material and Ballistic Science, Structural/System Design critical for revolutionary lethality
Objectives: To develop the underpinning science and technology for significant enhancements in assured delivery of the lethal payload

Impact and Relevance: Assured delivery of munitions on the battlefield more precisely with lower collateral damage and reduced logistics burden

Increase the mission space:
- engagements at extended range
- moving targets
- defilade targets

Complex environment at low cost
- GPS denied
- countermeasures

Technical Areas
- Aeromechanics
- Controls
- Maneuverability
- Navigation
- Structures

Leverage external advancements in processing, measurements, and actuation for navigation and maneuver technologies

Advanced computational and experimental tools
Effectiveness studies suggest efficiencies, increased performance, widened engagement space of modular/swarming lethality

How to deliver?
- low cost
- reliable (GPS denied, …)

Seek understanding for wide classes of land warfare missions
Background/Past Work

**Parent Projectile Equipped with Higher Performance Components Guides to Target**

**Child Projectile(s) Equipped with Simpler Components Maneuvers Off Parent Projectile**

Efficient, low-cost extended range delivery of reduced size lethal payload against complex target layout in countered environments for land warfare missions

- caliber-agnostic (direct/indirect)
- stationary/moving air and ground targets
- tight distribution to critical points of hard targets
- tailored distribution to light vehicles and distributed personnel
The Nation’s Premier Laboratory for Land Forces

Strategy
Long-Term Roadmap and Key Technologies

### MANEUVERABILITY

<table>
<thead>
<tr>
<th>FY14 – FY23</th>
<th>FY24 – FY33</th>
<th>FY34 – FY43</th>
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<tbody>
<tr>
<td><strong>MANEUVERABILITY</strong></td>
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<tr>
<td>spin-stabilized projectile maneuvers</td>
<td>variable thrusters / vector control</td>
<td>optimally morphing airframes</td>
</tr>
<tr>
<td>high maneuverability unstable &amp; enhanced lifting surface/deployment</td>
<td>extremely high-G, aerodynamic control</td>
<td>hybrid variable-thruster arrays and aerodynamic control</td>
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<td>high maneuverability unstable &amp; enhanced lifting surface/deployment</td>
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<td>force/moment arrays for arbitrary three-dimensional acceleration profiles</td>
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### NAVIGATION

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<td>image-based navigation (IBN): simple targets</td>
<td>IBN: realistic air targets with high speed or high maneuverability</td>
<td>IBN: countermeasures</td>
</tr>
<tr>
<td>radiofrequency (RF): data-linking, GPS</td>
<td>IBN: realistic air targets with high speed or high maneuverability</td>
<td>IBN: multispectral</td>
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<td>inertial measurement unit (IMU): heuristics</td>
<td>IBN: realistic ground vehicle, personnel, urban targets</td>
<td>network-based RF data-linking</td>
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<td>miniature high-G, high-dynamics, low power spot detectors</td>
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<td>high accuracy IMU arrays</td>
<td>miniature rangers</td>
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<td>flash LIDAR</td>
<td>hybrid sensor navigators</td>
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External Advancements in Performance and SWaP/C of:
- Processors (GPUs, …) → algorithms
- Measurements (IMUs, RF antenna / receiver, imagers / optics, …)
- Actuation Technologies

ASSURED DELIVERY

- HIGHER GS
- SMALLER CALIBER
- LOWER COST
- EXTREME ACCURACY
- MORE COMPLEX ENVIRONMENT
- FASTER DYNAMICS (MACH, SPIN RATE, TIME-OF-FLIGHT)
Objectives:
Research in energetic materials expected to offer revolutionary advancement in soldier lethality and long range precision fires.

Impact and Relevance:
- Understanding of new class of energetics with high-energy density
  - 30% Improvement in Performance Characteristics over Conventional Energetics
  - 5-10x Improvement in Performance Characteristics over Conventional Energetics with extended solids
  - Identification of methods to release energy on desired timeframe
- Single Munition systems for multiple target types in order to empower Individual Soldiers with full spectrum capability
- Creation of next generation lethal systems
- 0-150% scalable warheads

Technical Areas
- Disruptive Ingredients
  - Chemical Synthesis
  - Mechanochemical Synthesis
- Disruptive Technologies
  - Explosives, propellants
- Enabling Technologies
  - M&S, diagnostics & characterization

Synthesis of New CHNO Molecules
High Pressure Synthesis and Scale-up of Extended Solids
Create new classes of higher energy and power materials for use in propulsion and effects concepts.

- **Ingredients**: Current Explosives (TNT, RDX, HMX, CL20) and Disruptive Energetics (Nuclear Fission $^{235}U$, Nuclear Fusion D-T, Anti-Matter Annihilation $e^-/e^+$).
- **Formulations**: Performance, Affordable, Green, Hazards, Aging.
- **Enabling Technologies**: Energy Density Scale (J/g) with energy densities ranging from $10^3$ to $10^{15}$ J/g.
Disruptive Energetics and Propulsion Technologies

**Disruptive Ingredients**

- C, H, N, O w/ 30% Energy gain
- Poly-CO, poly-N2
- Nano-Diamond

**Experimental Miniaturization**

**Disruptive Technologies**

- Gun, Explosives & Propellant Formulations
- High Pressure Scale-Up
- Muzzle Pressure Management
- Gun Propulsion

**Enabling Technologies**

- Quantum Modeling
- Multi-Scale Modeling
- Advanced Mathematical Theorems & Data Analysis

**FY14 – FY23**

- Extended Solids, Organometallics
- Metal Organics, Metal Clusters, Coulomb Explosives, Metallic Hydrogen, Spin Isomers, Fermi Liquids

**FY24 – FY33**

- RDX 0 µs 8
- RDX 0 µs 83 ms

**FY34 – FY43**

- Composite Rocket Propulsion

*Figure 1: Several images (300 ns exp.) of the explosive near field for 450g C-4 sphere.*
Objectives: Conduct S&T to provide the Soldier with lethal overmatch across the full range of calibers for both direct and indirect fire weapons.

Impact and Relevance: New gun and missile technologies will be realized to deliver increased energy at range with lower SWAP.

New lethal mechanisms capable of defeating the toughest targets at:
- Redistributed energy
- Reduced caliber
- Reduced missile size

Technical Areas
- Enhanced Lethality & Warhead Mechanisms
- Enabling Technology for Kinetic Energy Lethal Mechanisms
- Scalable Effects
- System Effectiveness

Investigating concepts to create a man-sized hole in double-reinforced concrete (single shot)

Probability of high obliquity impact increases quickly in urban scenarios

Perforate walls at obliquity while maintaining air bust capability
## Scalable Lethal Adaptable Weapons
### Long-Term Roadmap

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### Overwhelming Lethality
- **Significantly More Capability in Current Weapons**
- **Significantly More Capability in Modified Weapons** E+
- **New and Better Lethal Mechanism**

#### New and different Threats
- **More Direct Methods of Shutting down Humans** (both reversible and non-reversible)
- **Very Different Approaches to Lethal Mechanisms**
  - New styles of weapons and munitions

### Underpinning Science
- **Penetration Mechanics, Fracture and Failure of Materials, Material Science, Understanding of Environmental and Toxicology Effects of Materials, Deep Understanding of how the Body works**

### Relevance
- **Identification of Opportunity, Definition of Technical Goals and Achievement, Business Case**

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**Maintain Significant Overmatch for Army Systems**

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Lethality S&T Strategy
Critical Research Areas

- Launcher
  - Higher energy containment structures
  - High rate of Fire
  - Reduced platform loading
- Propulsion
  - Muzzle pressure management
  - Temperature compensated
  - Higher energy (disruptive energetics)
  - Hybrid rocket propulsion
- Flight and guidance
  - Omnisonic flight
  - Image based (non GPS and not easily countered)
  - Unobtrusive control mechanisms to include fuzing
- Terminal Effects
  - Modular and Scalable
  - Novel penetrators
  - Higher energy output (disruptive energetics)
  - Directed Energy
- Materials
  - Higher strength, lighter materials