Mr. David H. Lyon
Sciences for Lethality and Protection
U.S. Army Research Laboratory

ARL Open Campus – Opening the Aperture for Opportunity and Engagement
What does this S&T Campaign do?
Plans and conducts basic and applied research that leads to overmatch capabilities across both lethality & protection domains for US Land Forces

Science and Technology Focus Areas

- **Overmatch** (technological superiority)
  - Lethality and effects
  - Assured position, navigation, and timing
  - Network protection
  - Expeditionary Maneuver (global response in a timely fashion)
  - Reduced logistics "tooth to tail"
  - Lightweight structural materials
  - Lightweight, high efficiency combat vehicles

- **Protection technologies** (materials and mechanisms) beyond "hard armor"
  - Soldier protection from ballistic threats

**Technology Gaps**

- Protection technologies (materials and mechanisms) beyond "hard armor"
- Extended range precision fires (conventional and electric) in contested environments
- Soldier protection from ballistic threats
Collaborative Opportunities

- **Dynamic Failure of Materials** (ScLP CCE)
  - Failure and fracture at extreme states
  - Multi-scale behaviors
  - High rate experimental mechanics
  - Diagnostic development for ballistic exp.
- **Desired Lethal Effects at Standoff Ranges in Constrained Environments** (ScLP KCI)
  - Dynamics of launch and flight (flow fields)
  - Guidance, navigation, and control (flight dynamics)
  - High-G environments (structural survival)
- **Energetic Materials** (ScLP KCI)
  - Multi-scale, reactive modeling
  - Disruptive energetics (high yield)
  - Detonation science (high pressure fields)
- **Humans in Extreme Environments** (ScLP KCI)
  - Ballistic and blast insults
  - Adaptive Non-Linear Optics

Academic Disciplines

- Aerospace / Aeronautics Eng.
- Biology / Biomedical Engineering
- Chemistry / Chemical Engineering
- Computer and Information Sciences
- Computer Engineering
- Electrical Engineering
- Materials Science
- Mathematics
- Mechanics / Mechanical Eng.
- Optics
- Physics
- Systems Engineering
**Why work with us?** S&T campaign includes 500+ in-house scientists, engineers, and technicians, across a mixture of disciplines, enabled by world-class **experimental and M&S assets** (powered by HPC), that result in unique research capabilities.

ARL is the bridge between the Warfighter, S&T, and acquisition communities, translating the needs of Land Forces into scientific gaps, then planning and conducting the research to provide significant advances.
Objective:
Understand and control material deformation and failure during ultra-high rate loading events

Our Capabilities:
- High rate dynamic loading laboratories (shock, deformation, failure) 500-1M/sec
- Computational Mechanics
- High rate deformation and failure models between 10 GPa and 100 GPa
- Grain-level modeling of materials
- Dynamic Compression Sector (DCS) at Argonne National Laboratory

What We Are Seeking:
- Advanced instrumentation for in-situ imaging at lower length scales (noninvasive)
- Ability to bridge length scales (defects, inclusions, dislocations)
- Identifying failure mechanisms from recovered specimens
- High pressure isentropic loading
- Novel approaches for modeling discrete failure

Academic Areas:
- Solid Dynamics, Computational Mechanics, Shock Physics, Multi-scale Modeling of Mat’l, Numerical Modeling, Ultra High Strain Rate Instrumentation
Capabilities Supporting Failure and Fracture of Materials

The Nation’s Premier Laboratory for Land Forces

Shock Physics Lab at APG

Dynamic Compression Sector at Argonne Advanced Photon Source

Simulation (CTH) & experiment results (LANL)

Provides ability to observe ballistic phenomena using ultra bright, extremely short light sources
Objective:
Assure delivery of payload even in contested environments (24/7, all weather, GPS denied) while providing increased performance (speed, range & maneuver)

Technical Areas:
- Maneuver flight physics and experimental validation
- Computational fluid dynamics (CFD)
- Shock-boundary and vortex interactions, nonlinear dynamics and stability
- Nonlinear control laws / theory
- Robust navigation approaches & algorithms

What We Are Seeking:
- Control mechanisms, nonlinear control algorithms and assessment tools for controlling high maneuverability flight bodies across omnisonic speeds (all Mach regimes)
- Low cost/high accuracy experimental techniques to capture flight maneuvers

Academic Areas:
Guidance Research Facility
Research and validation for advanced guidance methods

Transonic Experimental Facility
Captures flight behavior & flow phenomena

Muzzle Blast
High pressure, reacting flows
Objective:
Understand the multi-scale response of Energetic Materials (atomistic to bulk material)
Increased performance of conventional explosives (30% increase)
Discover novel high-yield materials & release mechanism (3-10 times greater)

Our Capabilities:
Center for Novel Energetic Research
- Synthesis and characterization of advanced novel insensitive energetic ingredients and formulations
- Computationally aided propellant charge design
- Multi-scale reactive modeling of insensitive munitions
- Multi dimensional, multiphase, physics-based gun and rocket propulsion modeling

What We Are Seeking:
- Enabling experimental technologies for full dynamic range of explosive imaging
- Measurement of species formation and consumption at detonation front

Academic Areas:
- Molecular Modeling, Formulation Chemistry, High Pressure Synthesis, Experimental Diagnostics
Center for Novel Energetic Research

Formulation

Synthesis on Multiple Scales

Characterization

Modeling and Simulation

Experimental Validation
Objectives:
• Fully understand the human response to ballistic loading conditions (blast, bullets and acceleration) - insult to injury
• Develop improved personal protection systems

Our Capabilities:
• In-house expertise in biomechanics, constitutive model formulation, and ballistic event loading
• Suite of DOD, DOE, and COTS software running on multiple high performance computing platforms
• Unique blast and ballistic experimental capabilities for model development and validation

What We Are Seeking:
• Tissue injury criteria and thresholds for hard and soft tissues
• Biomechanics research facility with experience in high-rate testing of biological tissues (beyond automotive rates)
• Understand the effects of mechanical loading on human physiology and clinical outcome

Academic Areas:
• Bio Material Characterization, Numerical Modeling, Injury Criterion, Experimental Diagnostics, Anthropomorphic Devices, Neuroscience
Crew and Compartment Protection Facilities
Laboratory simulators replicate loadings from blast threats

Model and Experimental Validation of Complex Load/Target Interactions
### Sciences for Lethality and Protection Poster Locations

**Mallette Center Second Floor**

Rooms 11 and 12

![Map of Sciences for Lethality and Protection](image)

### Current Active CRADAs

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<th>CRADA Partner</th>
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<td>Orbital ATK (#10-06-03)</td>
<td>Demonstration of 0.50-Caliber HE Projectile, CFD Analysis of Guided Projectiles</td>
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<td>Federal Cartridge (#11-17)</td>
<td>Precision Weapon System Analysis</td>
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<td>CoorsTek Vista (#12-13)</td>
<td>Development of Advanced Armor Materials</td>
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<td>DuPont (#12-16-02)</td>
<td>Evaluation of PMMA Polymers as Armor Materials</td>
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<td>Simmonds Precision Products (#13-06)</td>
<td>Aeroballistics Diagnostic Instrumentation</td>
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<td>Positioning and Attitude of Weapon Systems</td>
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<td>Missouri University of Science &amp; Technology (#15-22-01,02)</td>
<td>Emerging Control Theory for Guided Weapons, Prediction of Projectile Aerodynamics</td>
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