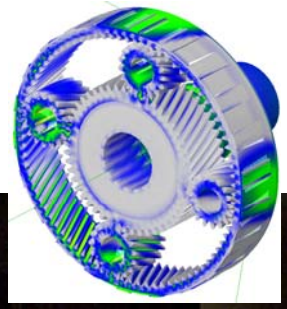
25 August 2008

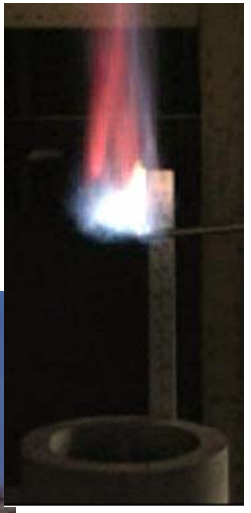
ARO Mechanical Sciences Division

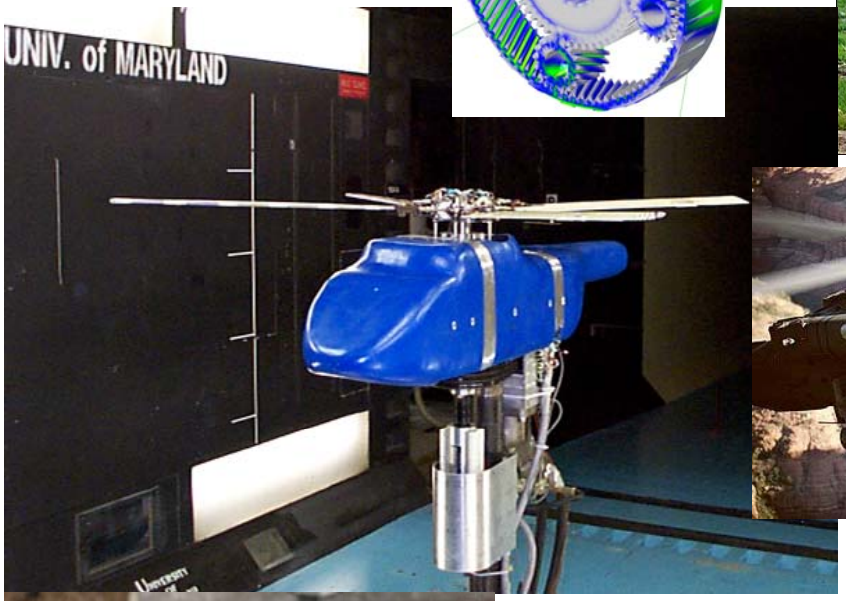
TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

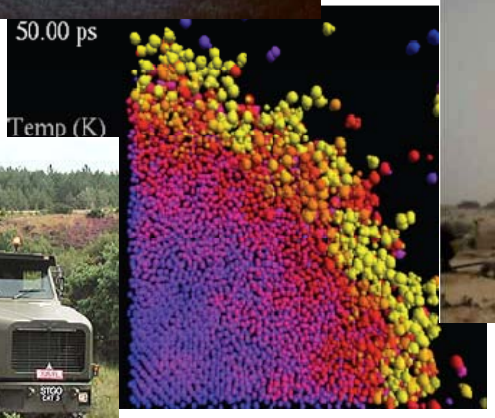
Dr. Ralph A. Anthenien Jr.
Division Chief (Acting)
Army Research Office
ralph.anthenien1@us.army.mil
919-549-4317

ARO Mechanical Sciences









TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

ARO Mechanical Sciences Vision

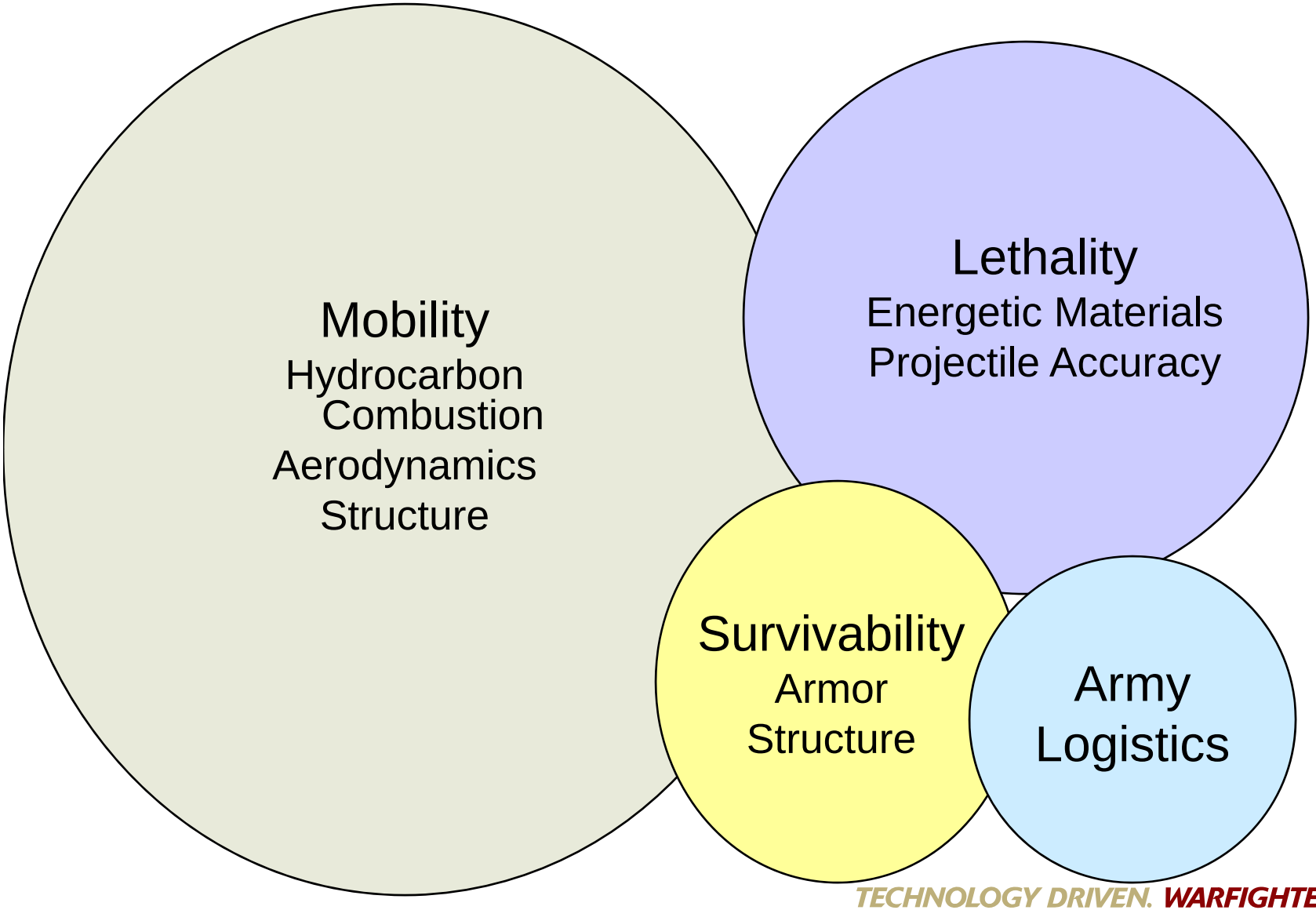
To identify and enable basic research opportunities in the Mechanical Sciences that have the potential to transform Army capabilities and help maintain U.S. technological superiority

To lead the Army by embracing long-term, high-risk, high-payoff opportunities with special emphasis on: Propulsion &Energetics, Fluid Dynamics, Structures & Dynamics, and Solid Mechanics

ARO Mechanical Sciences

ARO Mechanical Sciences Program	Program Manager
Propulsion and Energetics	Dr. Ralph Anthenien
Fluid Dynamics	Dr. Thomas Doligalski
Structures and Dynamics	Dr. Bruce LaMattina
Solid Mechanics	Dr. Bruce LaMattina

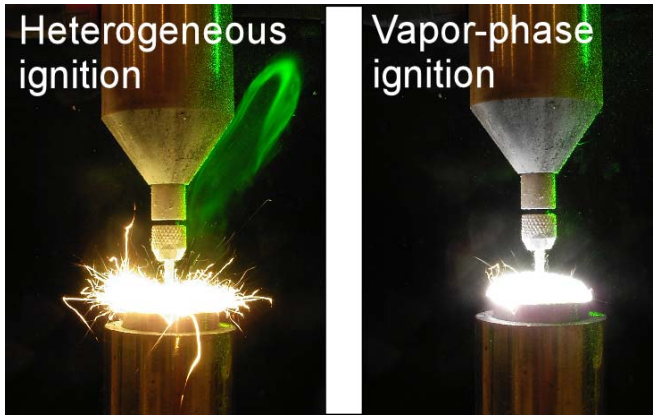
Mechanical Sciences Army Impacts



Propulsion & Energetics

To contribute to and exploit recent developments in kinetics and reaction modeling, spray development and burning, and understanding of extraction and conversion of stored chemical energy to enable:

- Higher performance propulsion systems
- Improved combustion models for engine design
- Higher energy density materials, insensitive materials, tailored energy release rate



ESD sensitivity experiments, Dreizin

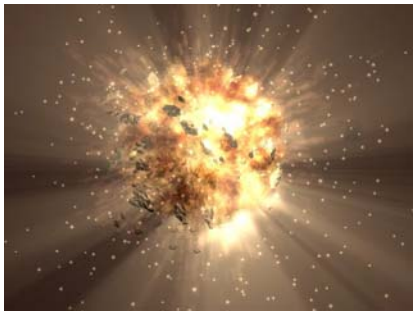
Propulsion &Energetics Research Area Opportunities

- **Energetics**

  Research Sub-Thrusts:

  a. Novel Materials – new designs, characterization, predictive cap, exploit nanotechnology & self assembly.

  b. Sensitivity – new test methods, understanding ignition, shock prop.



- **Hydrocarbon Combustion**

  Research Sub-Thrusts:

  a. Kinetics & Combustion – detailed & reduced models, surrogate fuels

  b. Sprays & Flames – spray development, high pressure combustion

Shock Tube Studies of Liquid Fuel Combustion Kinetics

R. K. Hanson, Stanford University

Allow use of liquid fuel introduced directly into test volume of shock tube

Test times extended to over 20ms

Allow for experimental chemical kinetic data to be taken on heavy hydrocarbons under representative engine conditions

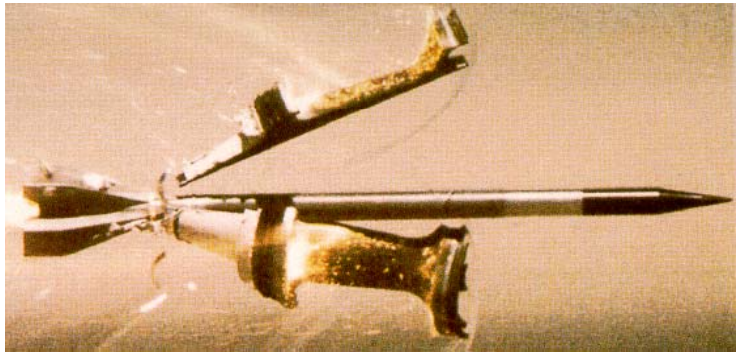
Fluid Dynamics

To develop new fundamental insights into the fluid dynamics underlying Army systems in order to:

- Improve performance, and reduce vibratory loads and acoustic emissions, of modern Army rotorcraft
- Increase range and decrease dispersion of Army gun-launched projectiles and tactical missiles

Philosophy:

- Fundamental understanding for accurate prediction methodologies and performance improvement for Army systems
- Focus on Army applications rather than the development of generic computational and experimental tools
- Balanced approach: computational, experimental, theoretical



Fluid Dynamics Research Area Opportunities

- **Dynamic Stall/Unsteady Separation for Rotorblade Airload Prediction and Control**

  Research Sub-Thrusts:

  a. DARPA Helicopter Quieting Program

  b. Dynamic stall flowfield measurements

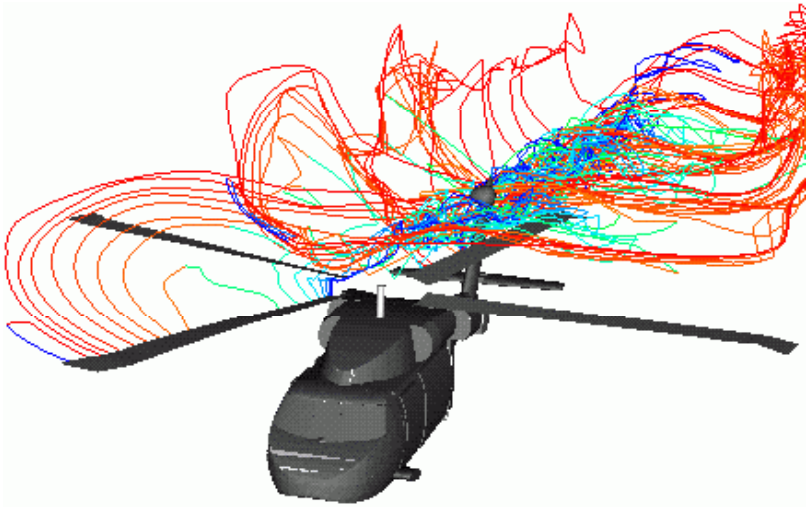
- **Micro Active Flow Control (MAFC)**

  Research Sub-Thrusts:

  a. DARPA MAFC Program: SCORPION

  b. Dynamic stall flow control

- **Micro Unmanned Air Vehicles**



Experimental Analysis of Vorticity and Turbulent Flow Dynamics of a Pitching Airfoil at Realistic Flight Conditions

R. Bowersox, Texas A&M

Improved understanding of the fundamental vorticity and turbulent flow physics for a dynamically stalling airfoil at realistic helicopter flight conditions.

Apparatus & Facility:

7 ft x 7 ft Wind Tunnel Flow Conditions

- M = 0.20, $Re_c = 2.1 \times 10^6$
- M = 0.32, $Re_c = 3.4 \times 10^6$

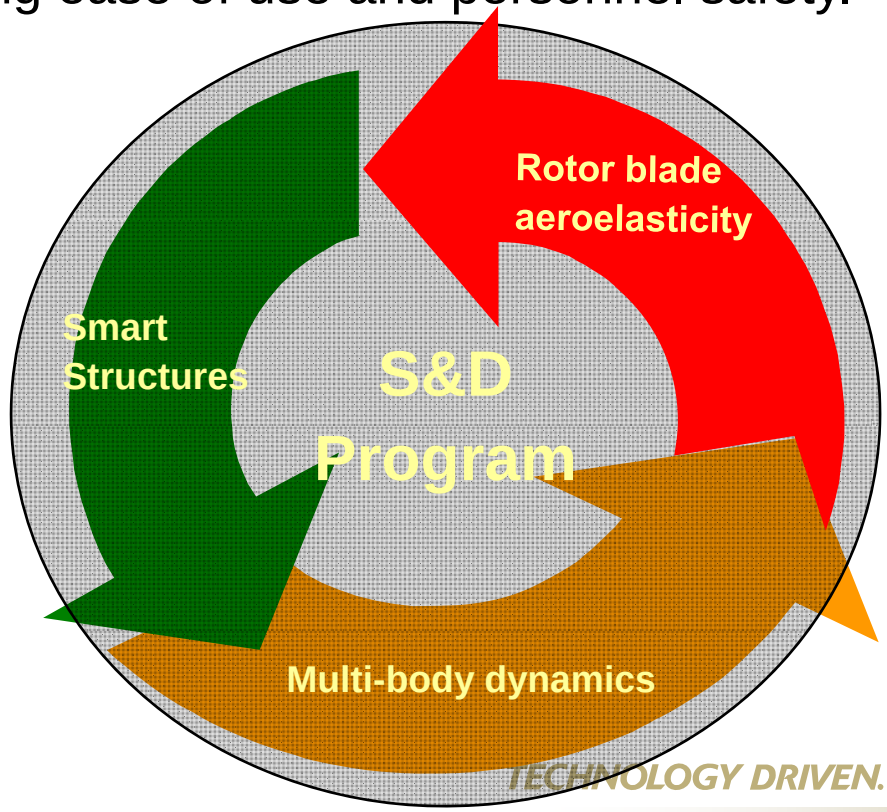
Airfoil Model

- NACA 0012
  - Chord length = 1.5 ft
- Hydraulic Actuation (0 – 10 Hz)
  - K = 0.17 (9 Hz) @ M = 0.20
  - K = 0.12 (9 Hz) @ M = 0.32

ARO Mechanical Sciences

Structures & Dynamics

Develop theoretical, numerical, and experimental techniques to quantify interactions of inertial, elastic, damping, and aerodynamic forces acting on ground, air, and weapon systems to promote the design and construction of reliable, durable, and maintainable Army critical equipment, respecting ease of use and personnel safety.



Structures & Dynamics Research Area Opportunities

Rotorblade Aeroelasticity

- Integrate technologies to model, compute, and assess structural response to improve air vehicle performance
- Exploit active control and adaptive systems for air vehicle performance

Multi-body Dynamics

- Perform vehicle simulation and reliability modeling to reduce vehicle weight, vibration, and noise

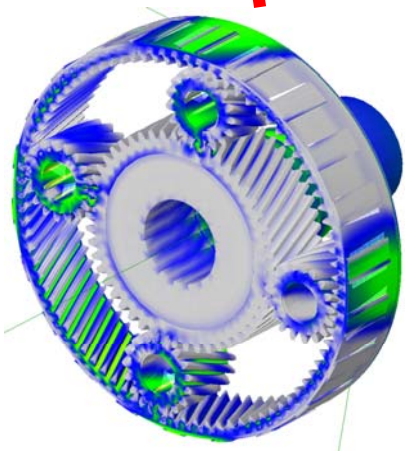
Smart Structures

- Develop structural damping techniques through combinations of viscoelastic, magnetic, and/or electroelastic materials, carbon nano-tubes, and non-linear adaptive control strategies for improving performance
- Structural health monitoring

Planetary Gear Dynamics in Rotorcraft Transmissions

Prof. R. Parker, Ohio State University

- Improved tools for analysis of planetary gear dynamics not previously achievable with existing models
- Identification of those parameters that most influence the transmission of vibrations, noise, and dynamic loads
- Design guidelines for development of gears with reduced weight, reduced noise, and high torque in future transmissions and upgrades



ARO Mechanical Sciences

Solid Mechanics

Develop mechanics-based tools for the prediction, control, and optimization of systems subjected to extreme environments to enable lighter weight solutions for protective systems

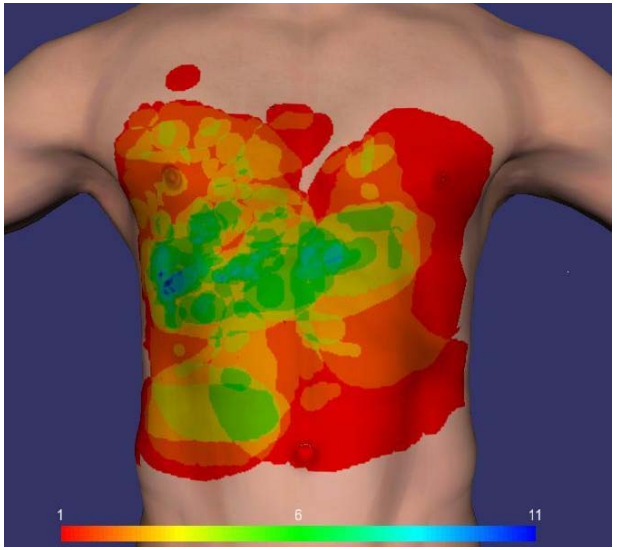
Solid Mechanics Research Area Opportunities

Impact Blast and Penetration (Armor/Anti Armor)

- Fracture and fragmentation
- High fidelity experimental approaches
- Advanced algorithms that bridge several scales

Mechanics/Biology

- Understanding injury under dynamic loading conditions (Armor)
- Mechanics of the cell

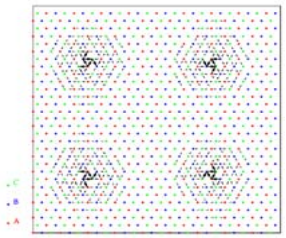


Mechanics of Heterogeneous Systems

- Material descriptions that account for microstructure
- Durability of MEMS
- Mechanics of structural batteries

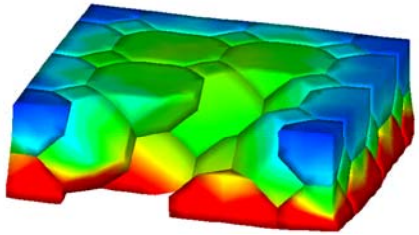
ARO Mechanical Sciences
Solid Mechanics

Microstructurally Engineered Armor Systems

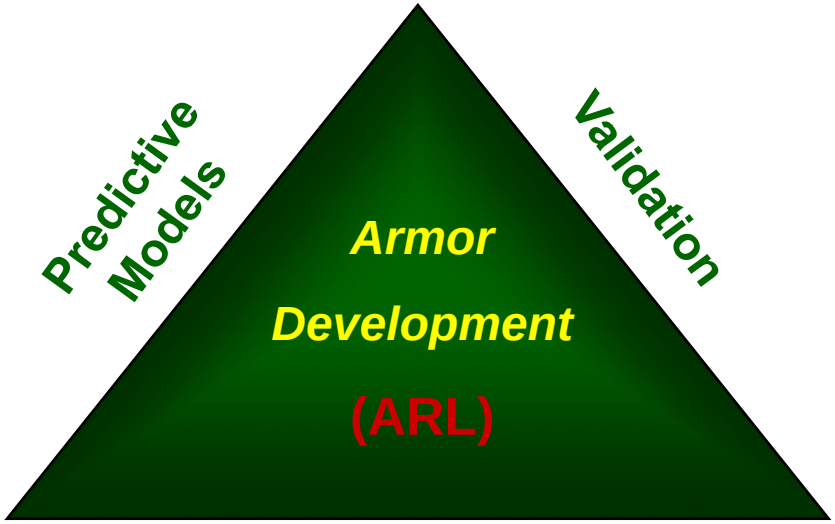


Theory and Modeling
First Principles
And Large Scale Microstructural Modeling

NCSU, WMRD



Structural Applications/ Large Scale Testing/Integration:
Industry and WMRD



Accelerated Dynamic Experiments
Caltech

Approach: An integrated predictive and experimental framework for the rapid development of new and significantly improved structural systems for survivability and damage resilience due to blast and fragmentation

Complementary RDECOM Mechanics Research

Energetic Materials
- ARO Chemistry Division
- ARL WMRD
- ARDEC
- AMRDEC

Impact and Penetration
- ARO Material Sciences Division
- ARL WMRD
- TARDEC
- NSRDEC

Mechanics/Biological Trauma
- ARO Life Sciences Division
- ARL WMRD
- ARL SLAD
- NSRDEC

Helicopter Aeromechanics
- ARL VTD
- AMRDEC

Power & Energy
- ARO Chemistry Division
- ARL VTD
- ARL SEDD
- CERDEC
- NSRDEC

http://www.aro.army.mil

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