



**U.S. ARMY**  
**RDECOM**

**ARL**

**Sciences for Maneuver Campaign**

**Mr. Eric Spero**  
**Sciences for Maneuver Campaign**  
**U.S. Army Research Laboratory**



Science & Technology enabled air and ground platform capabilities to significantly increase Army:

- Force effectiveness
- Rapid expeditionary global responsiveness

in complex environments.

Mobility technologies to enable adaptive vehicle configurations and subsystem architectures critical to the future Army's:

- Deployment
  - Maneuverability
  - Sustainment



Level 2



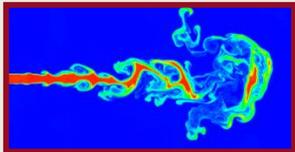
**ENERGY & PROPULSION:** Exploit innovations in energy sources, storage, generation, conversion, transmission, distribution, and management to provide technologies and configurations to **improve operational effectiveness and efficiency** of Army platforms ensuring military power projection superiority.

**Energy Storage for Mobility**

**Power/Energy Conversion**

**Distribution and Transfer**

**Intelligent Power**



*Fuel Injection & Combustion*



*Turbine Engine Efficiency and Sand Tolerance*



*Lightweight Hybrid Gears*

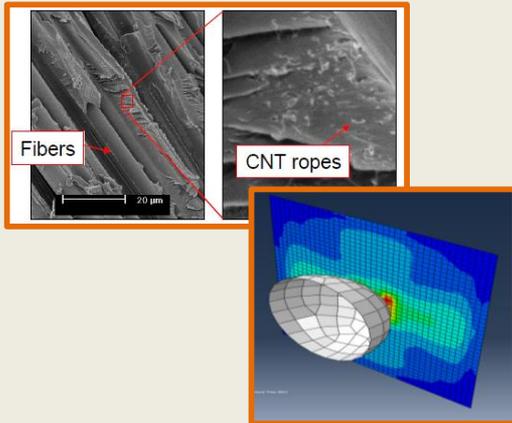


*ARL-Developed Power Electronics Components*

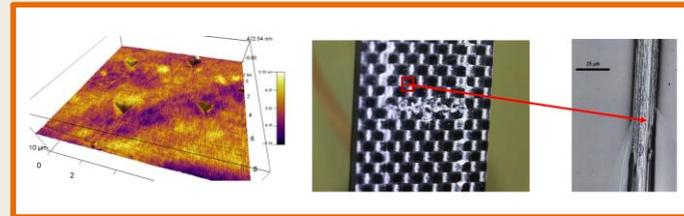
**LOGISTICS AND SUSTAINABILITY:** Fundamental research to enable the rapid and accurate assessment of health status, usage and readiness of Army platforms, sub-systems, and components to provide unmatched adaptable maneuverability, reliability, affordability, and availability.

**Reliability**

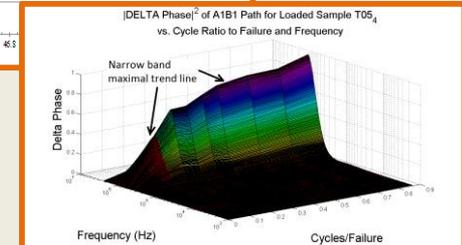
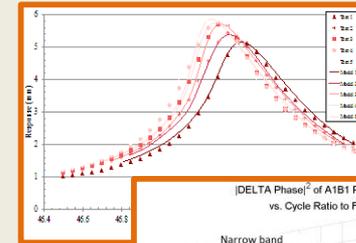
**Mechanism State Awareness (health)**



*Extremely Lightweight, Adaptive, Durable & Damage Tolerant (XLADD) Structures*

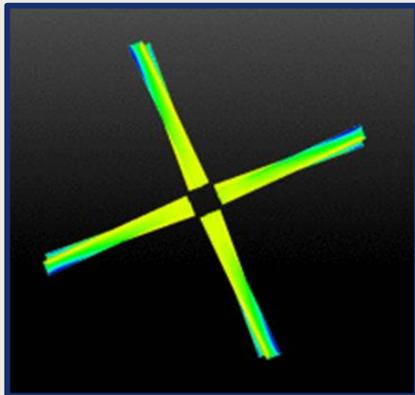
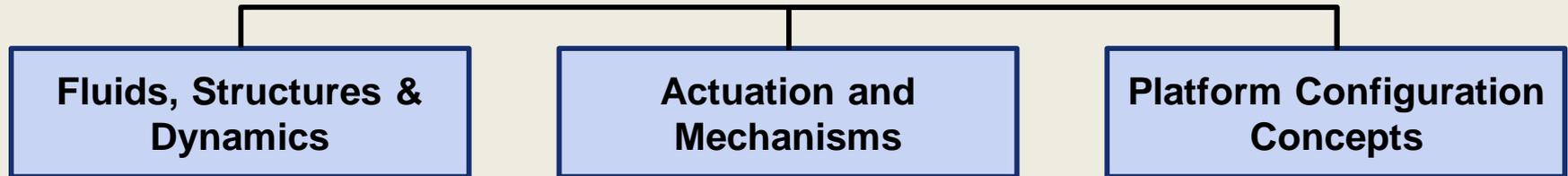


*Failure Characterization and Precursor Detection & Identification*

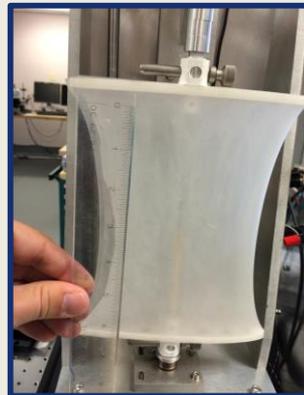


*Damage Indication & Remaining Useful Life (State Awareness) Models*

**PLATFORM MECHANICS:** Fundamental research to enable highly-maneuverable high-speed air and ground vehicle platforms and subsystems for the future Army, ranging from large combat/cargo vehicles to micro-scale devices.



*Rotor  
Aeromechanics*



*Adaptive Wing Span  
Mechanisms*



*Platform Capability Assessment &  
Tradeoff Environment*

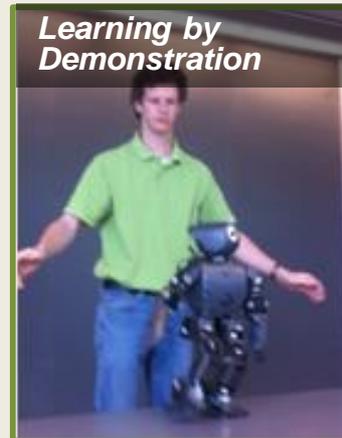
**VEHICLE INTELLIGENCE:** Focus on fundamental research to enable effective teaming of Soldiers and unmanned vehicles to conduct maneuver and military missions. Centered on enhancing autonomous capabilities of unmanned / intelligent systems in real world environments.

**Perception**



*Semantic Labeling of  
Objects in the Environment*

**Intelligence & Control**



*Learning*

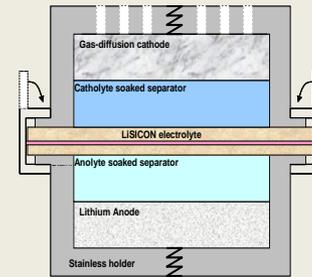
**Human-Robot  
Interaction**



*Natural  
Communication*

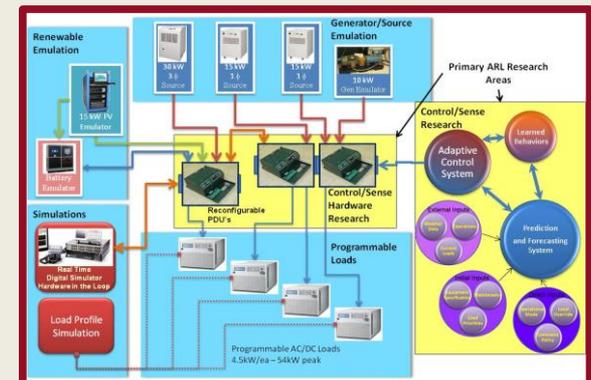
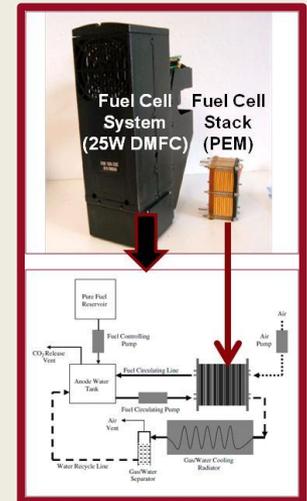
## Key Campaign Initiative: Advanced, Electrical Power Technologies and Components

- Improve mission effectiveness of Army platforms through development of energy and power underpinning materials and devices to enable electric-based component technologies.
- Reduce logistics burden through the development of more efficient electrical power generation, distribution, and conversion components and systems.



Advanced Battery Energy Storage

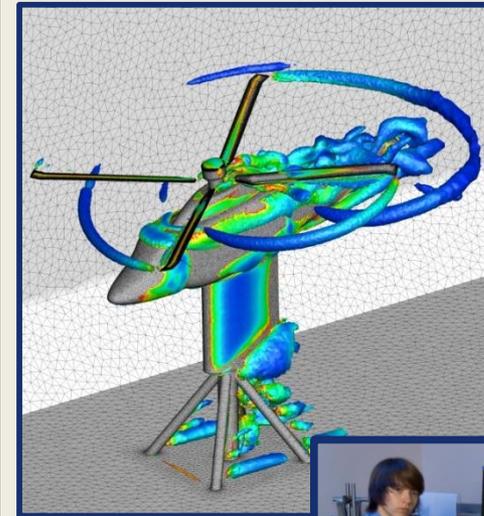
Fuel Cell Energy Conversion



Intelligent Power Distribution

## Key Campaign Initiative: Discover & Advance VTOL Innovations, Novel Concepts, and Ideas (DAVINCI)

- Technologies to enable fielding of next generation VTOL platforms and application to current platforms to produce significantly increased speed without degradation of hover efficiency
- Technologies to enhance maneuverability in complex environments at higher operating speeds
- Next generation micro and small unmanned autonomous air vehicles



*Rotorcraft  
Aeroelasticity  
Research*

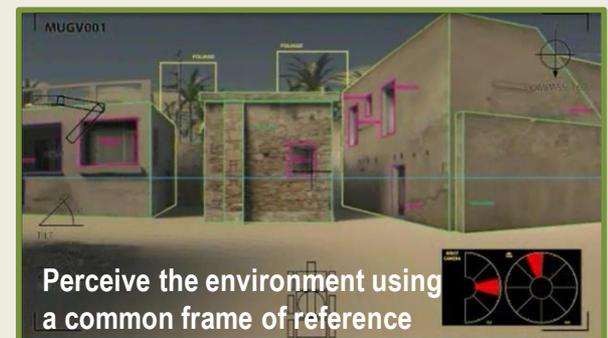


*Small  
Autonomous  
System Airfoil  
Research*



## Key Campaign Initiative: Force Projection & Augmentation through Intelligent Vehicles

- Army development of autonomous and semi-autonomous operational capabilities to increase lethality and protection, and augment, enable and, in some cases, replace Soldiers, thus freeing them to maneuver and operate to their advantage.
- Technological advances for affordable, interoperable autonomous and semi-autonomous systems that improve effectiveness of Soldiers and units.



*Intelligent Systems Research  
Reason, Learn, Plan, Act*



U.S. ARMY  
**RDECOM**

Sciences for Maneuver  
Research Facilities

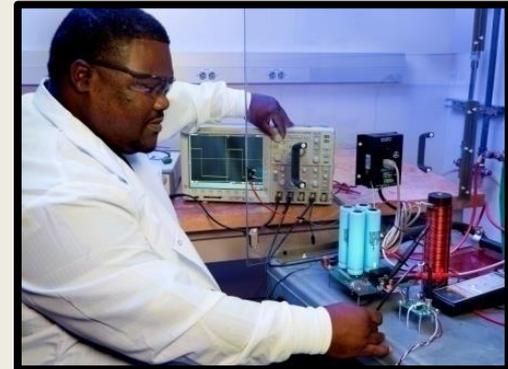
**ARL**



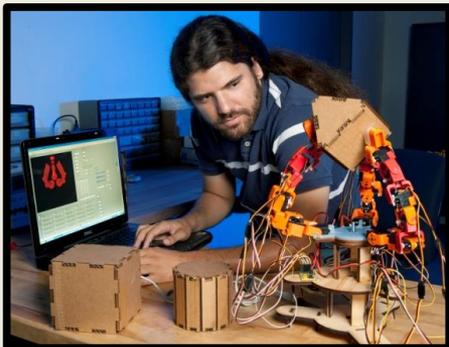
Intelligent Systems Research  
Adelphi, MD



**ARL Vehicle Research Laboratory**  
**Aberdeen Proving Ground, MD**



Energy & Power Research  
Adelphi, MD



Autonomous Systems Research  
Aberdeen Proving Ground, MD



Robotics Research  
Ft. Indiantown Gap, PA



Propulsion Research  
(ARL Field Element)  
NASA Glenn Research Center



Aeromechanics Research  
(ARL Field Element)  
NASA Langley Research Center



# Technology Discovery & Innovation for Future Army Intelligent Unmanned Vehicles

## Artificial Intelligence

- Semantic Perception
- Machine Learning
- Abstract Reasoning

## Human-Machine Interaction

- Cognitive Models
- Human-Machine Communication
- Trust

## Multi-Modal Control

- Distributed/Embedded
- Hybrid Mobility/Manipulation

Cognitive Robotics Lab at APG, MD



Free Flight Facility at APG, MD



Micro-Systems Wind Tunnel at APG, MD



Indoor Experimentation Facility (Bldg 507) at Adelphi, MD



Robotics Research Facility at Ft. Indiantown Gap, PA

## Multi-Disciplinary / Multi-Campaign



U.S. ARMY  
**RDECOM**

Sciences for Maneuver  
Collaboration Opportunities

**ARL**

## Energy & Propulsion

- **Power Electronics for Tactical Energy Networks and Mobile Platforms**
- **Soldier and Small System Energy Harvesting**
- **Fuel Processing Power Sources**
- **High-Efficiency Gas Turbine Engine Components**
- **Tribology and Lubrication Science for High-Performance Power Transmission**
- **Combustion Sciences for Advanced Propulsion Systems**
- **Innovative Propulsion Technologies for Unmanned Aircraft Systems**
- **Probabilistic-Diagnostic Informed Innovations for Power Transmission Lightweighting**
- **Advanced Power Transfer Components and Concepts**

*<http://www.arl.army.mil/opencampus/>*



U.S. ARMY  
**RDECOM**

Sciences for Maneuver  
Collaboration Opportunities

**ARL**

## Platform Intelligence

- **Meta-Cognition, Self-reflection and Proprioception**
- **Semantic Spatial Understanding**
- **Intelligent Vehicle Technology Experimentation**
- **Human-robot Interaction**
- **Bot-Language**
- **Computational Intelligence**
- **Autonomous Mobile Robot Exploration with an Information-Gain Metric**
- **Hybrid Training Methods for Visual Classification and Autonomous Navigation**
- **Reasoning Under Uncertainty**
- **Size, Weight, Power, and Processing Constrained Sensors & Controls**
- **Automated Vehicle Routing**

*<http://www.arl.army.mil/opencampus/>*



U.S. ARMY  
**RDECOM**

Sciences for Maneuver  
Collaboration Opportunities

**ARL**

## Logistics & Sustainability

- **Extremely Lightweight, Adaptive, Durable, Damage Tolerant (XLADD) Structures for Future Vertical Lift**
- **Virtual Risk-informed Agile Maneuver Sustainment (VRAMS)**

## Platform Mechanics

- **Aeromechanics for Rotorcraft and Unmanned Aerial Systems**
- **Mission-Driven Microsystem Design and Validation**
- **Mechanics of Handheld Aerial Mobility**
- **Rotorcraft Capability Assessment and Tradeoff Environment**
- **Advanced Rotorcraft Aeromechanics Research**
- **Mobility and Manipulation for Next-Generation Unmanned Systems**

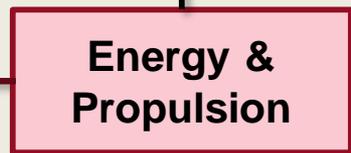
<http://www.arl.army.mil/opencampus/>



Level 1



Level 2



Level 3

