



# U.S. Army Research Laboratory Army Combat Capabilities Development Command (DEVCOM)



## Funding Opportunities at the Army Research Office

**Dr. Peter Reynolds**

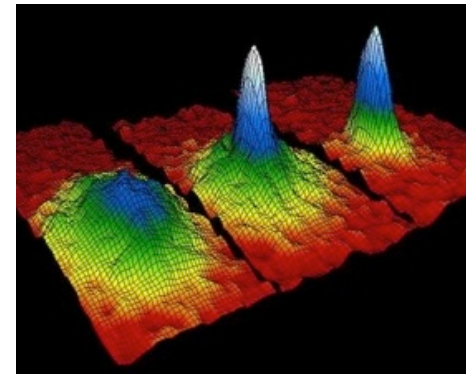
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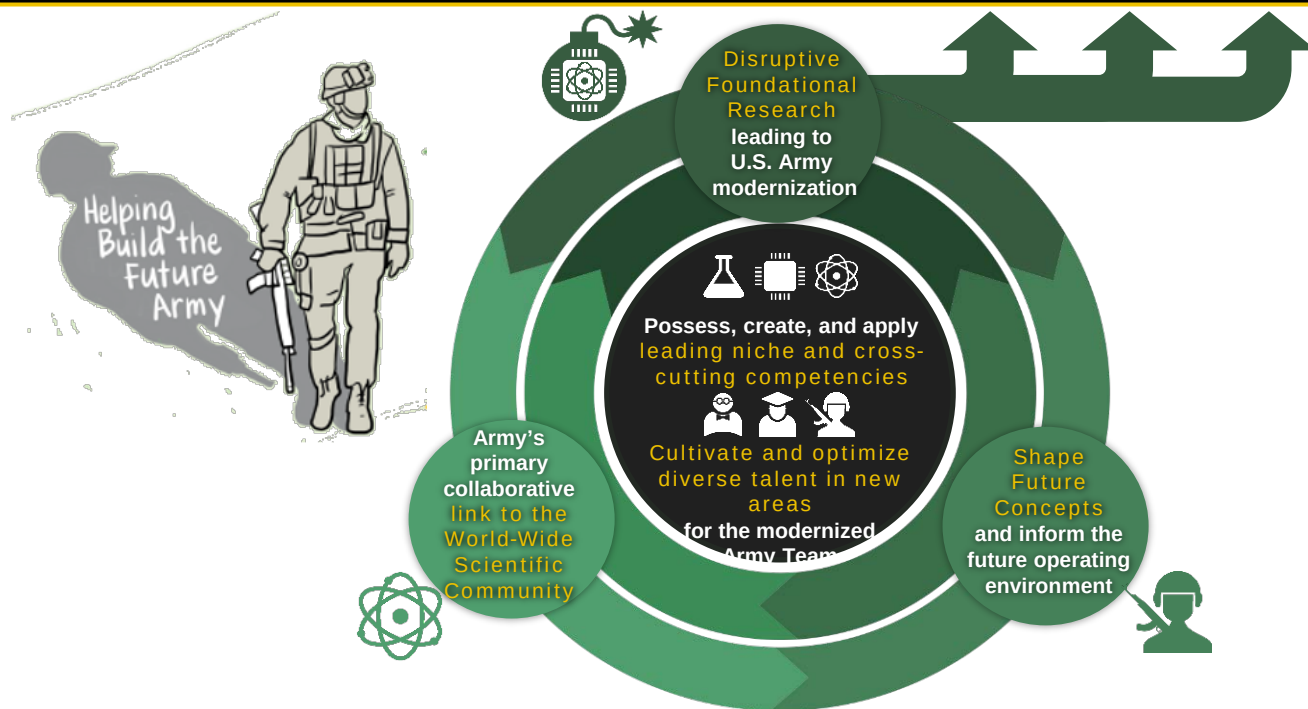


# ARMY Research Office (ARO)

part of DEVCOM ARL

## The Army's Corporate Research Laboratory

**DEVCOM ARL MISSION: Operationalizing Science for Transformational Overmatch**





# ARO Strategy



## **Pose bold scientific questions**

to extramural basic research community to initiate new areas of basic research

**Seek collaborative opportunities**  
with DoD and other government agencies to leverage investments and multiply the possible impact

**Engage Army Labs S&Es**  
to prioritize Army relevant scientific opportunities and to explore tech-transition paths of basic research outcomes

**Support, promote and embrace high risk, high pay-off**  
long term basic research opportunities that otherwise may not get support elsewhere

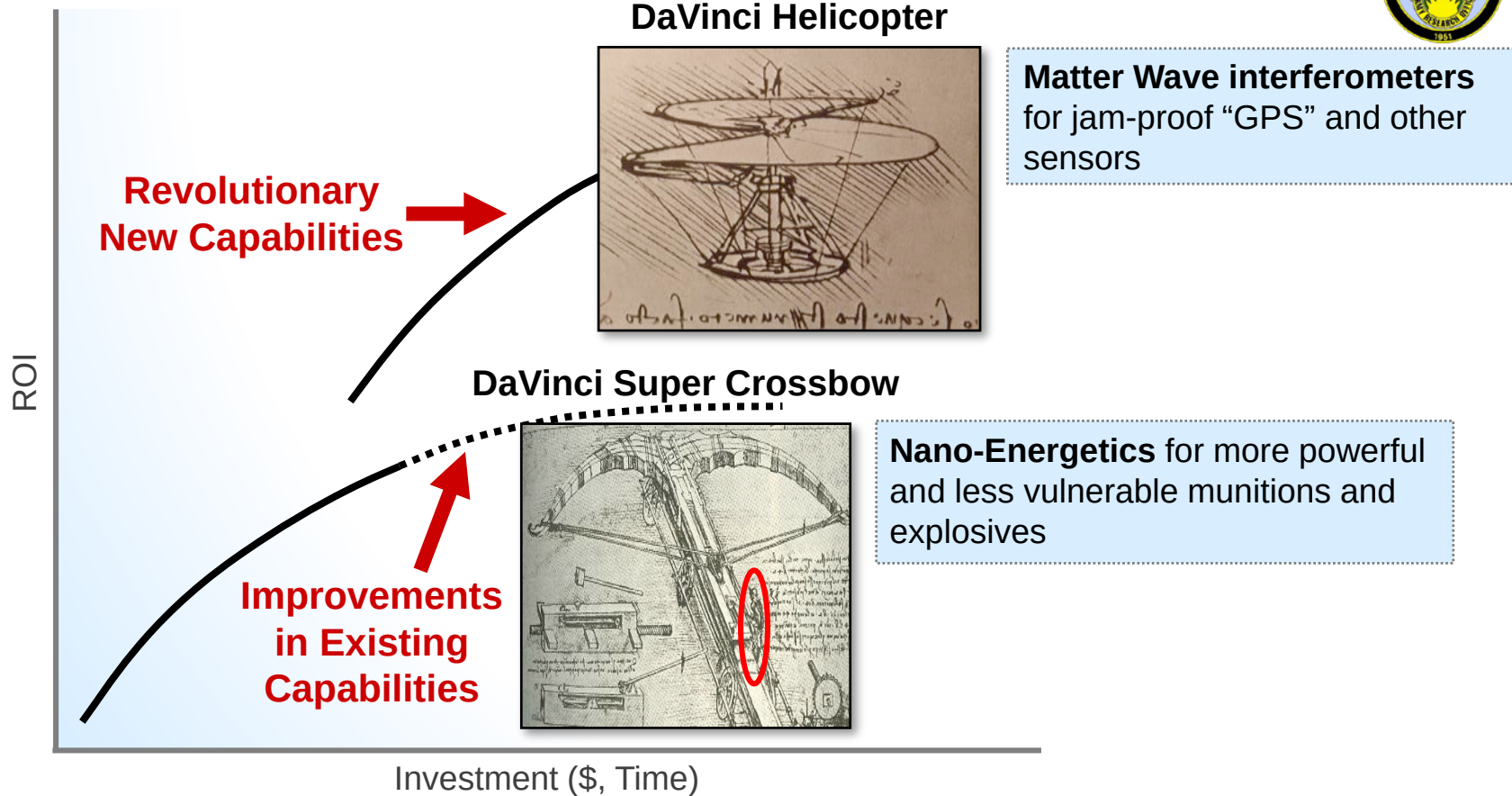
**Monitor and Continue to learn to venture in to new areas**  
with long term impact on enhancing Army capabilities

**Hire and retain excellent workforce**  
to carry out the ARO mission and enable training of future work force



UNCLASSIFIED

# Army Research Office Spans the Basic Research Continuum



## Generates the New Knowledge Required to Maintain Technological Superiority

- Discovers and creates new science that produces revolutionary new capabilities
- Applies innovative scientific advances to improvements in critical existing capabilities



# FY21 ARO-administered Mission Instruments

**\$100.8M**

## SI Single Investigator Program

Grants with one or two faculty and graduate students and / or postdocs.

- ~\$125K/yr for 3-5 yr periods
- All States
- >256 Universities

**\$64.7M**

## URI University Research Initiative

**MURI** Multidisciplinary University Research Initiative Program supports university teams whose research efforts intersect more than one traditional science and engineering discipline ~\$1.25M per year, 3-5 year period, 8 new initiatives annually

**DURIP** Defense University Research Instrumentation Program improves capabilities for basic research in defense S&T areas and promotes education and training of future STEM pros

**PECASE** Presidential Early Career Awards for Scientists and Engineers enhance career development of early career investigators. \$200K per year for a five-year research grant

**\$>19.8M\***

## SBIR & STTR Small Business Innovation Research and Small Business Technology Transfer

Established to provide small businesses and research institutions with opportunities to participate in gov't.-sponsored research and development.

\*FY21 SBIR/STTR funds typically received in summer; also includes FY20 funds received and executed in FY21

**\$15.0M**

## UARCs University Affiliated Research Centers

Large centers associated with the U.S. Army, ARO manages the 6.1 portion of the Institutes for Collaborative Biotechnologies (ICB), Soldier Nanotechnologies (ISN), Creative Technologies (ICT)

- 5 year efforts
- ~\$5 – 10M per year

**\$1.6M**

## HBCU/MI Historically Black Colleges & Universities/Minority Serving Institutions ARO Core Grants

Matching funds support primarily single investigator research expanding and diversifying the Army research base via the HBCU/MI Community

- Topics from ARO BAA
- ~\$120K/yr for 3 year periods

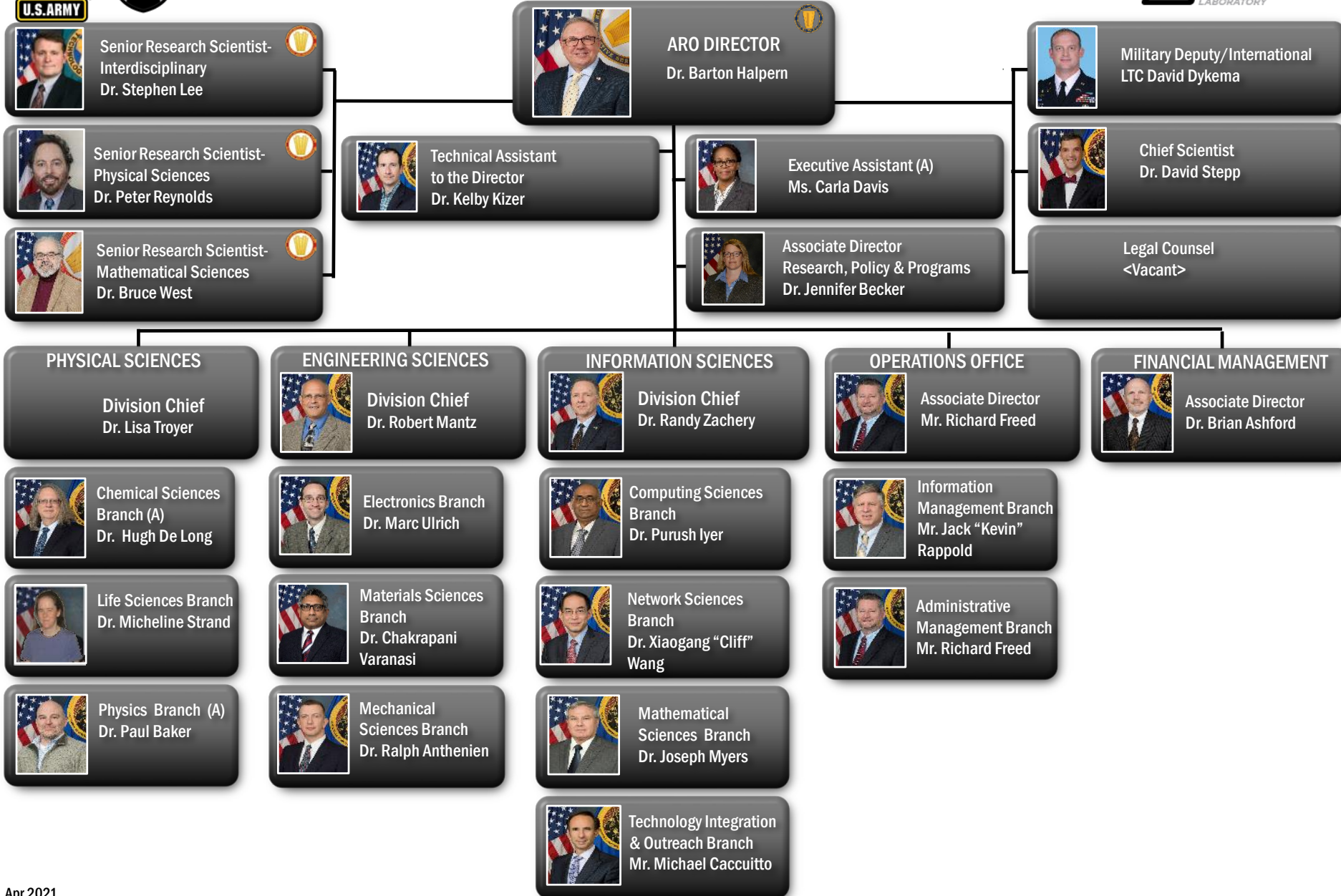
**\$30.4M**

## REP DOD Research & Educational Program for HBCU/MIs

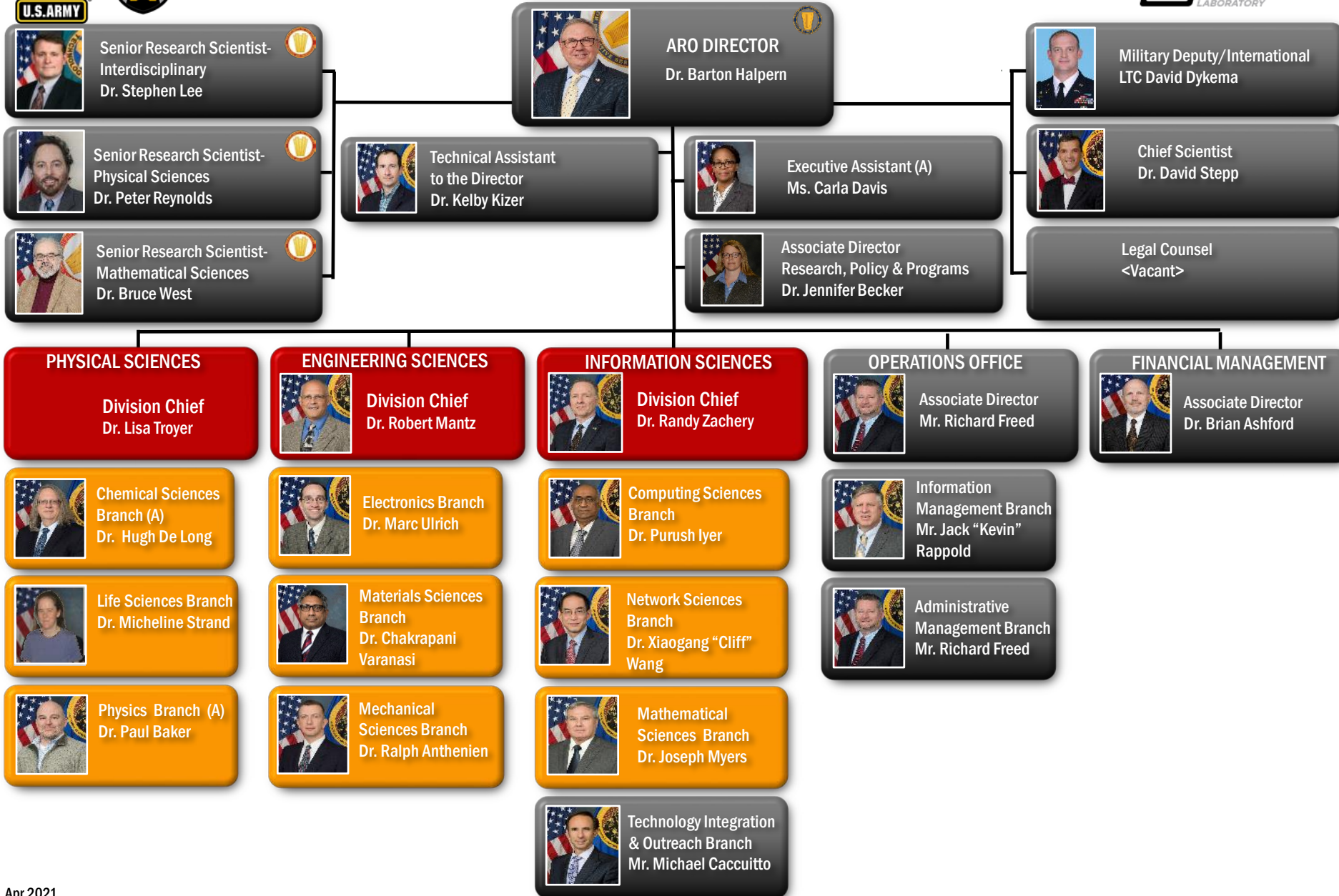
ARO has administered REP on behalf of OSD since 1992. REP aims to enhance research capabilities of HBCUs and MIs and to strengthen their education programs in STEM disciplines that are relevant to the defense mission.

Under this program, qualifying institutions were able to submit proposals to compete for basic research equipment and instrumentation grants. In FY19, 59 grants totaling \$23.3 million were made to 18 HBCUs, 26 MIs, and 1 Tribal College or University (TCU).

# ARO Organizational Structure

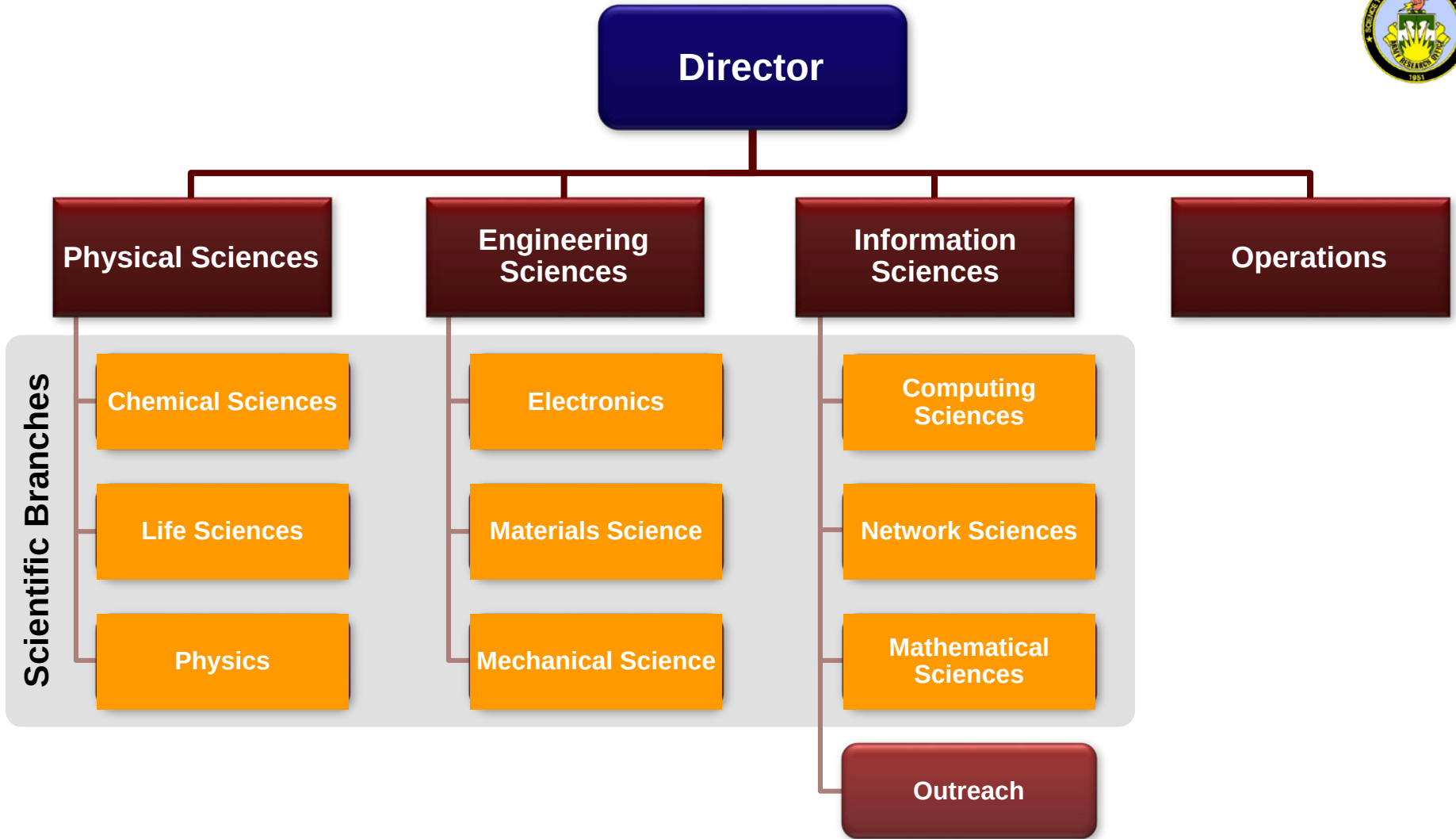


# ARO Organizational Structure





# ARO Organizational Structure



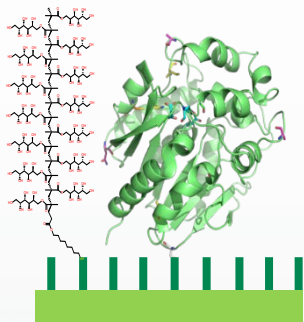


# Chemical Sciences

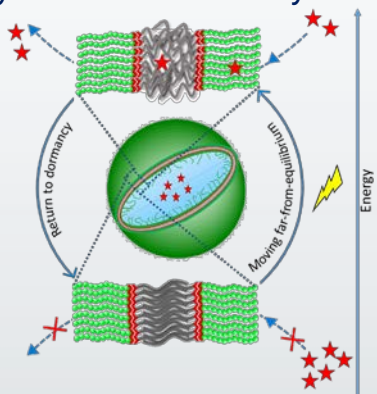


## Reactive Chemical Systems

### Nanostructure Surface Interactions and Reactivity



### Synthetic Molecular Systems

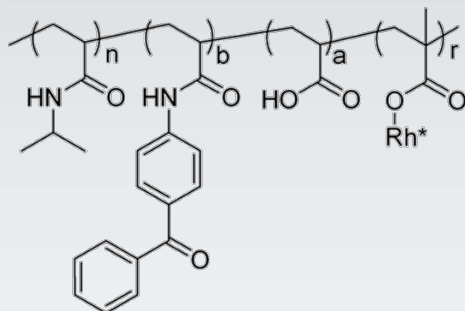


Functional Concepts: Sustainment, Maneuver Support

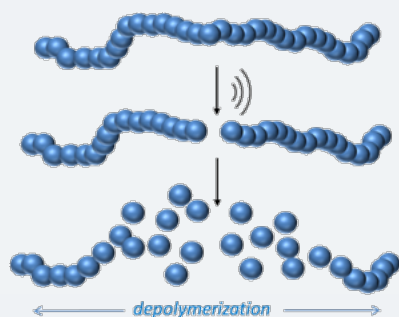
Future: responsive, protective materials; sensors for hazardous materials

## Polymer Chemistry

### Precision Polymeric Materials



### Complex Polymer Systems

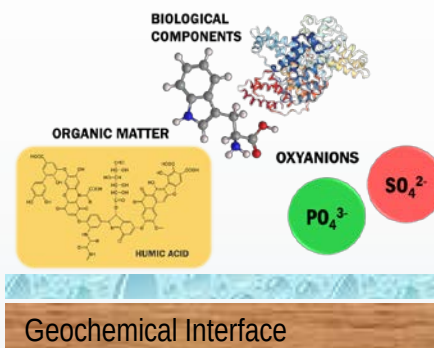


Functional Concepts: Sustainment, Maneuver Support

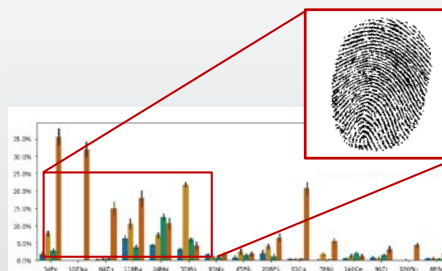
Future: self-healing materials; breathable-barrier fabrics; lightweight armor

## Environmental Chemistry

### Chemical Structure and Reactivity in Multiphase Environments



### Novel Techniques for Detection and Prediction

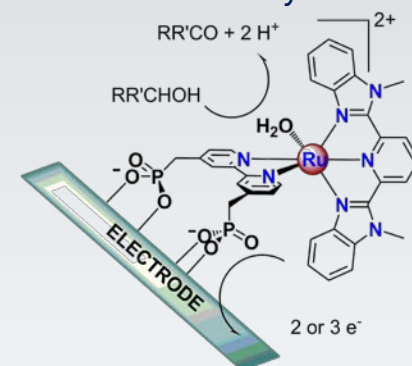


Functional Concepts: Intelligence, Sustainment, Maneuver Support

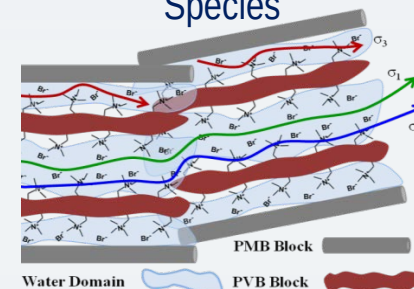
Future: sensing/detection; CBRNE degradation; water purification; corrosion mitigation

## Electrochemistry

### Redox Chemistry and Electrocatalysis



### Transport of Electroactive Species



Functional Concepts: Sustainment, Maneuver Support Movement and Maneuver, Intelligence

Future: new power storage and generation; sensors; electrosynthesis, displays



# Life Sciences



## Neurophysiology of Cognition

### Multisensory Synthesis



### Neuronal Computation

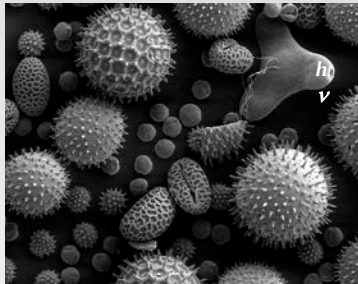


*Functional Concepts: Mission Command, Human Dimension, Maneuver Support, Intelligence, Sustainment*

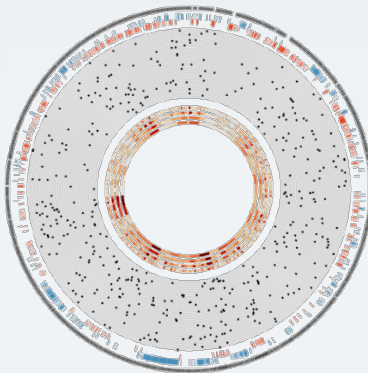
*Future: optimized attention; improved selection and training; prosthetics*

## Genetics

### Organismal Genetics



### Population Genetics

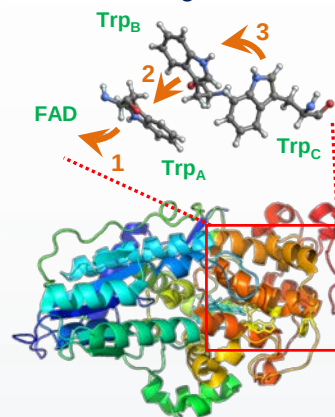


*Functional Concepts: Sustainment, Mission Command, Human Dimension, Maneuver Support*

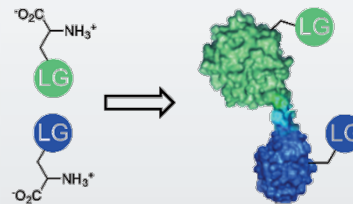
*Future: bioforensics; Soldier protection and performance*

## Biochemistry

### Biomolecular Specificity and Regulation



### Biomolecular Assembly and Organization

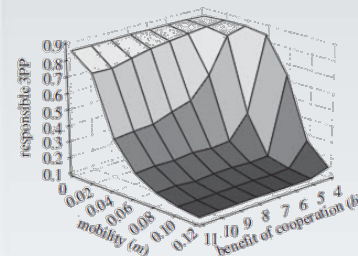


*Functional Concepts: Sustainment, Human Dimension, Maneuver Support*

*Future: responsive materials; nanoscale biomechanical devices*

## Social and Behavioral Science

### Measures of Social and Behavioral Concepts



### Identify Causes and Predict Institutional and Behavioral Change

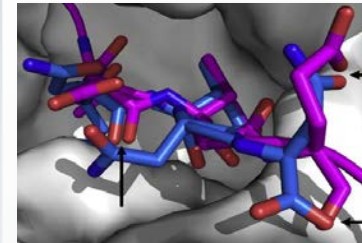


*Functional Concepts: Mission Command, Human Dimension, Maneuver Support, Intelligence, Sustainment*

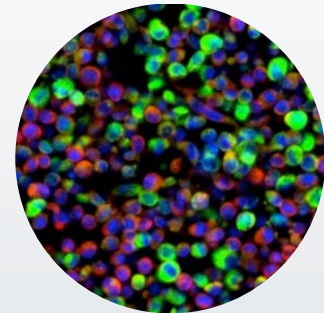
*Future: improved training; rapid foe ID; predict impact of planned US actions*

## Microbiology

### Microbial Survival Mechanisms



### Analysis and Engineering of Microbial Communities



*Functional Concepts: Sustainment, Mission Command, Human Dimension, Maneuver Support*

*Future: limit material degradation; therapeutics*

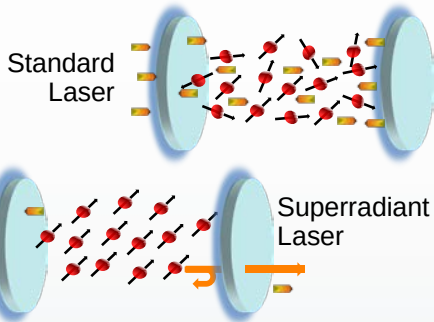


# Physics

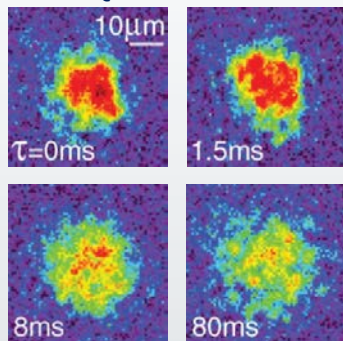


## Atomic and Molecular Physics

### Advanced Quantum Many-body Dynamics



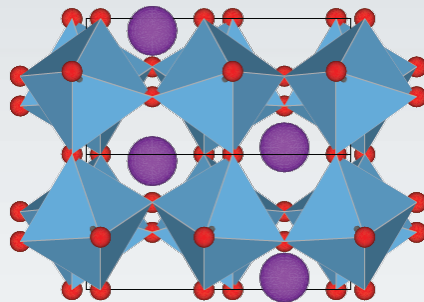
### Novel Quantum Methods



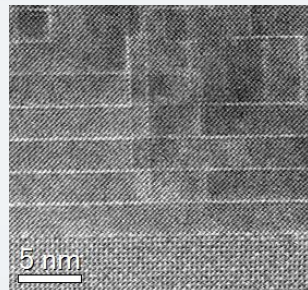
*Functional Concepts: Intelligence, Fires, Movement and Maneuver, Maneuver Support, Sustainment*  
*Future: GPS-independent navigation, improved computation, and sensing*

## Solid State Physics

### Strong Correlations and Novel Quantum Phases of Matter



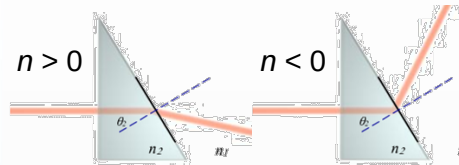
### Topologically Non-Trivial Phases in Condensed Matter



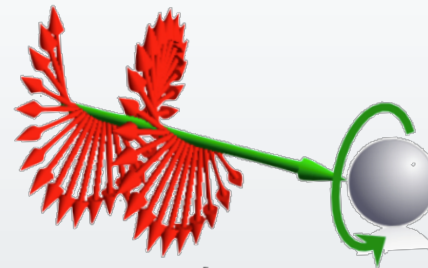
*Functional Concepts: Movement and Maneuver, Maneuver Support, Sustainment*  
*Future: ultra-sensitive detectors; low-power electronics*

## Modern Optics

### Extreme Light



### Meta-Optics and Non-Electromagnetic Fields

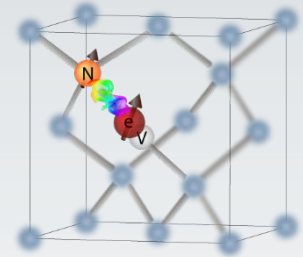


$$S_{fi} = -ie \int d^4x \bar{\psi}_f \gamma^\sigma A_\sigma \psi_i$$

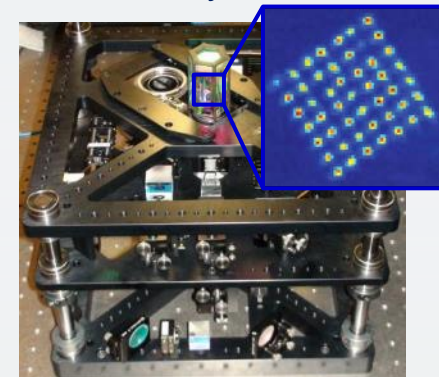
*Functional Concepts: Intelligence, Fires, Movement and Maneuver, Maneuver Support, Sustainment*  
*Future: superlens; ultra-precise spectroscopy; stand-off detection*

## Quantum Information Science

### Quantum Sensing, Imaging, and Metrology



### Foundational Quantum Physics



*Functional Concepts: Intelligence, Fires, Movement and Maneuver, Maneuver Support, Sustainment*  
*Future: secure communications; covert imaging*

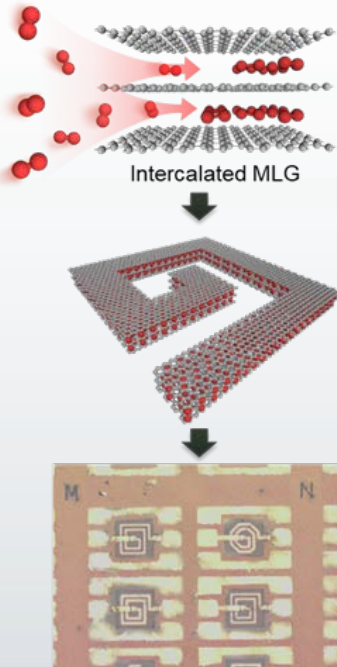


# Electronics



## Solid State Electronics and Electromagnetics

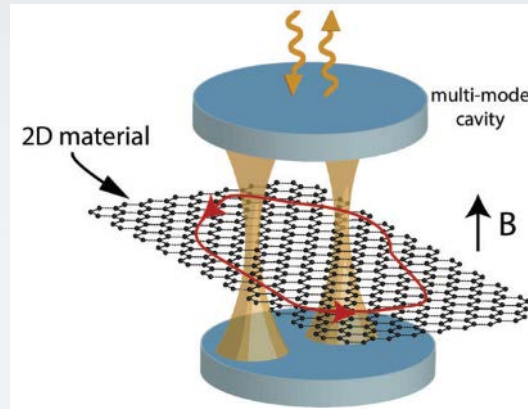
### Emerging Device Sciences Innovative Electromagnetic Structures



*Intercalation-tuned van der Waals Heterostructures*

## Solid State Physics

### Topological and Magnetic Physics Non-equilibrium Materials Physics

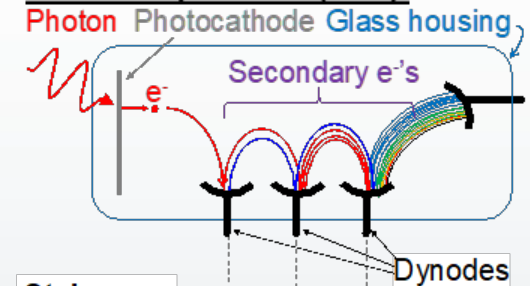


*Resonant coupling between light and quantum Hall states*

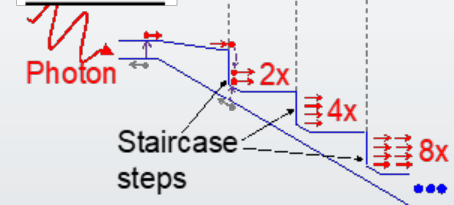
## Electronic Sensing

### Photovoltaic detectors (UV/IR) Thermal radiation detection

#### Photomultiplier tube (PMT):



#### Staircase:



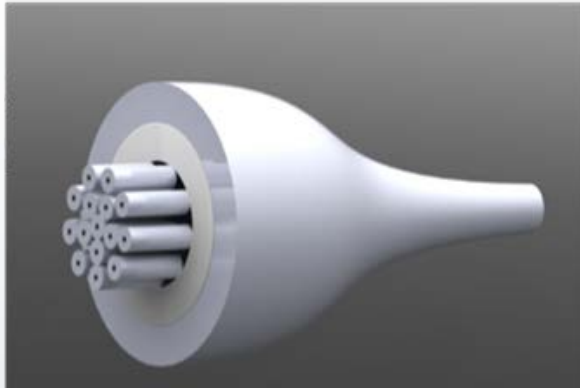
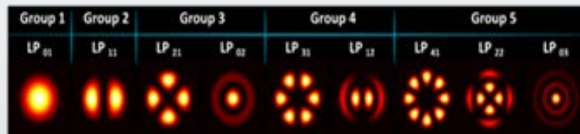
*Multistep Staircase Avalanche Photodiode*



# Electronics

## Optoelectronics

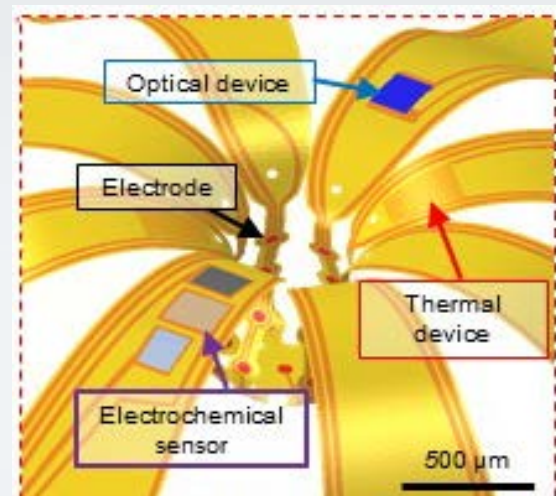
Low energy, high-speed  
optoelectronics  
High intensity radiation



*Photonic Lantern*

## Biotronics

Bioelectric Fields  
Bioelectronics  
Electrogenetics



*Neural Interface for Cortical  
Spheroid*



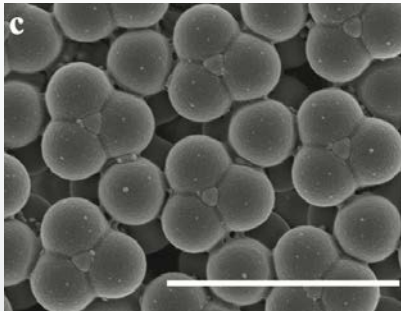
# Materials Science

## Materials Design

The Science of Self-Assembly

Reconfigurable Hierarchical Materials

Computer-aided Materials Design

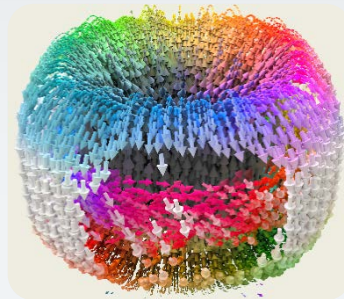
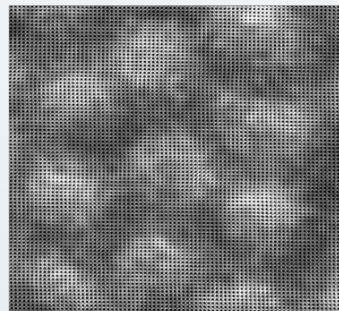


*Colloidal Self-Assembly*

## Physical Properties of Materials

Discovery of Novel Functional Materials

Science & Engineering of Crystal Imperfections

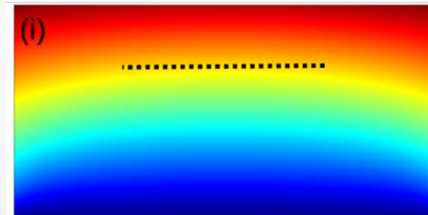
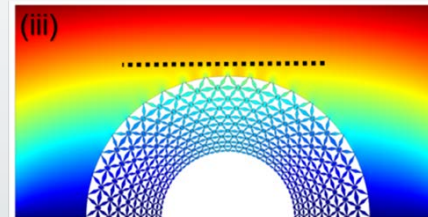


*Electric Skyrmions*

## Mechanical Behavior of Materials

Active Mechanical Response

Extreme Mechanical Behaviors

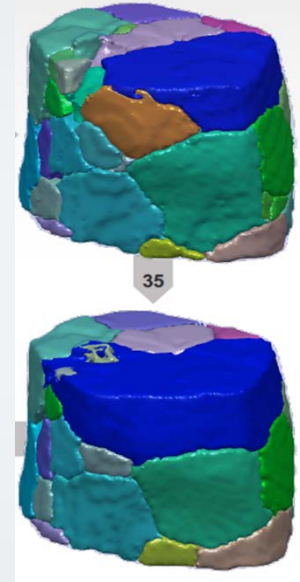


*Stress Steering in Materials*

## Synthesis & Processing of Materials

New Structural Materials Processing Approaches

Governing phenomena of processing



*Grain Growth Visualization*



# Mechanical Science

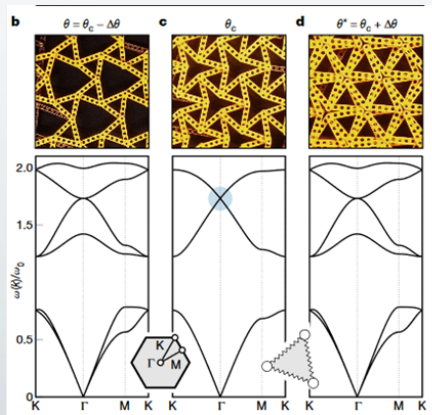
## Complex Dynamics & Systems

High-Dimensional  
Nonlinear Dynamics

Nonlinear Mechanical  
Metastructures

Embodied and  
Distributed Control,  
Sensing, and Actuation

Statistical Physics of  
Control and Learning



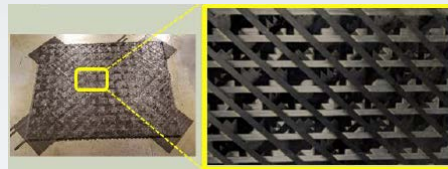
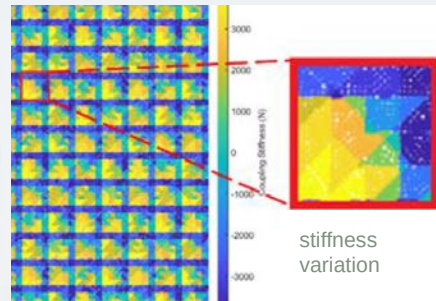
**Dynamic Structure in  
High-Dimensional Systems**

## Solid Mechanics

High Strain-rate Material  
Damage Mechanisms

Hierarchical Systems

Material  
Inhomogeneities

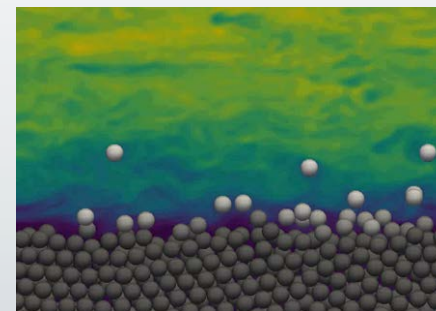


**Complex Hierarchical  
Prototype Structures**

## Earth Materials & Processes

Earth Surface Interaction  
with Air and Water

Information  
Transmission in  
Challenging  
Environments



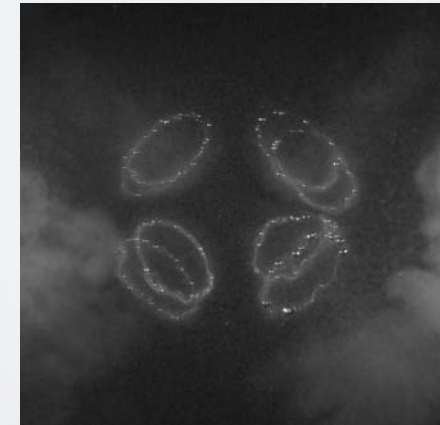
**Sediment Transport in  
Rivers**

## Fluid Dynamics

Dynamics of Unsteady  
and Separated Flows

Nonlinear Flow  
Interactions and  
Turbulence

Dynamics of Particle-  
laden Flows



**Colliding Vortex Rings**



# Computing Sciences



## Information & Software Assurance

Resilient and Robust Information Systems

Highly Assured Mobile Computing and Communications



Army Impacts: Information dominance and mission assurance

## Intelligent Systems

Advanced Learning Theory, Methodology, and Techniques

Intelligent systems for Better Decision Making and Mission Execution

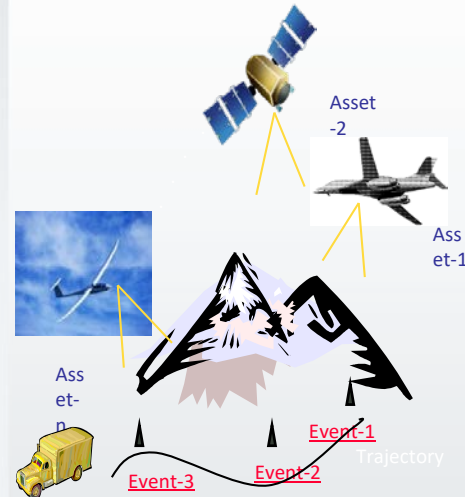


Army Impacts: Intelligent battlefield systems for soldiers

## Information Processing & Fusion

Image Processing and Understanding

Data and Information Fusion

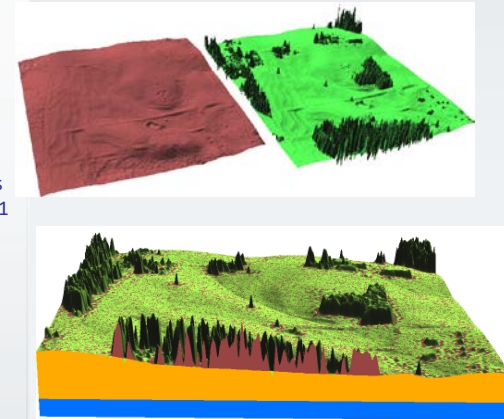


Army Impacts: Better C4ISR and decision making

## Computational Architect. & Visualization

Interactive Simulation and Visualization

Novel SW & HW Architectures



Army Impacts: Battlefield real-time computing; soldier training through simulation



# Mathematical Sciences

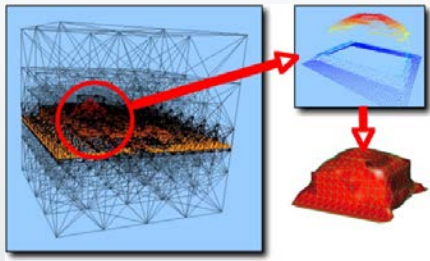


## Modeling of Complex Systems

Geometric Modeling of Complex Data and Irregular Objects

Non-smooth Analysis

Geometric Flows over Human/Human-Machine Spaces

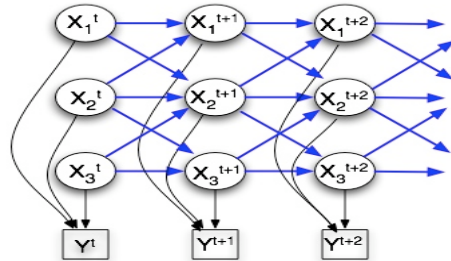


Army Impact: NexGen combat vehicle, future vertical lift, universal threat detection, network C3I; soldier lethality

## Probability & Statistics

Stochastic Analysis & Control of Complex and Quantum Systems

Statistical Methods for Defense & Security



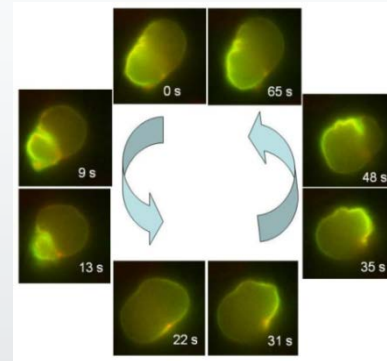
Army Impact: CEMA for complex environments; defense vs. hypersonic threat; exploitation of quantum effects, universal threat detection

## Biomathematics

Computational Biology

Fundamental Laws of Biology

Multiscale/Inverse Methods



Army Impact: Human performance, neuro-cognition, accelerated learning

## Computational Mathematics

Partial Differential Equation Methods

Multiscale Methods

$$\rho \left( \frac{\partial \mathbf{v}}{\partial t} + \mathbf{v} \cdot \nabla \mathbf{v} \right) = -\nabla p + \nabla \cdot (\nabla \mathbf{v} + \nabla \mathbf{v}^T)$$

$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \mathbf{v}) = 0$$

$$\rho \frac{Dh}{Dt} = \frac{Dp}{Dt} + \nabla \cdot (k \nabla T) + \Phi$$

$$\Phi = \mu \left( 2 \left( \frac{\partial u}{\partial x} \right)^2 + 2 \left( \frac{\partial v}{\partial y} \right)^2 + 2 \left( \frac{\partial w}{\partial z} \right)^2 + \left( \frac{\partial u}{\partial y} + \frac{\partial v}{\partial x} \right)^2 + \left( \frac{\partial v}{\partial z} + \frac{\partial w}{\partial y} \right)^2 + \left( \frac{\partial w}{\partial x} + \frac{\partial u}{\partial z} \right)^2 \right)$$

Army Impact: Precision fires, advanced energetics, energy independence, CEMA



# Network Sciences



## Intelligent Networks

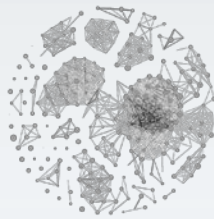
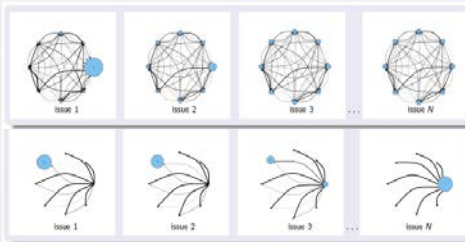
- Network Games
- Networks and Knowledge Discovery
- Crowds: Intelligence, Learning and Control



**Army Impact:** Machine Learning, Battlefield Internet of Things, Exploitation of Quantum Effects, Accelerated Learning

## Social and Cognitive Networks

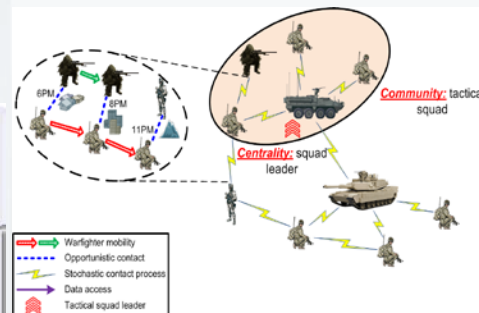
- Designing High Performance Teams
- Computational Social Science
- Connecting social, cognitive, and neural networks



**Army Impact:** Accelerated Learning, Human Performance, Neuro-cognition, Machine Learning, Battlefield Internet of Things

## Communication & Hybrid Networks

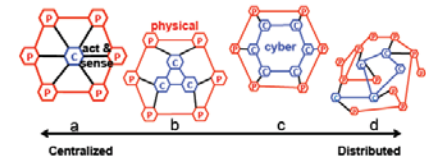
- Programmable and Mission Critical Networks
- Mobile Ad Hoc and Internet of Things Networks
- Interactions between Communications, Information and User Networks



**Army Impact:** Battlefield Internet of Things, Machine Learning, Assured PNT in A2AD, Exploitation of Quantum Effects,

## Multi-agent Network Control

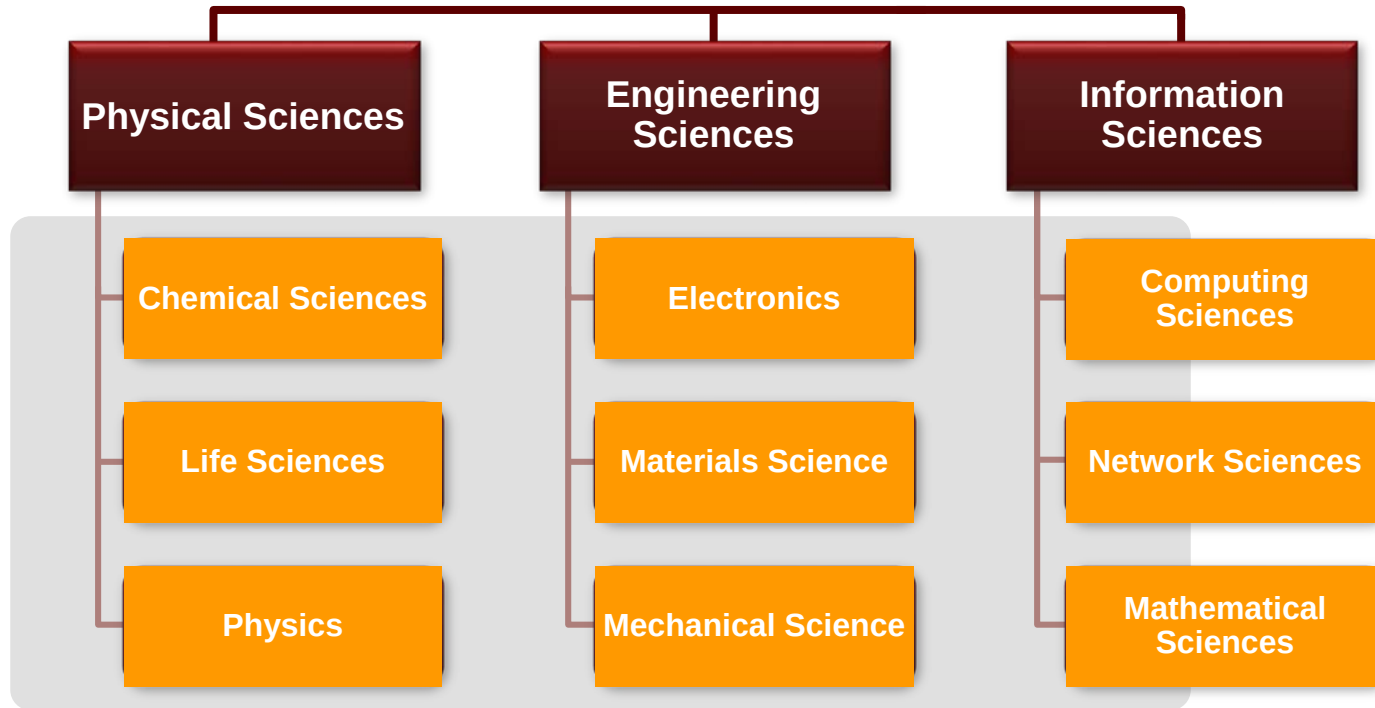
- Distributed control and optimization
- Stochastic dynamical systems of networks of interacting agents
- Collective information processing



**Army Impact:** Battlefield Internet of Things, Human Performance, Neuro-cognition, Machine Learning



# ARO Scientific Disciplines & BAA



For full program descriptions, BAA is at

[https://www.arl.army.mil/wp-content/uploads/2021/04/AROBAA\\_W911NF17S0002-Amendment-9.pdf](https://www.arl.army.mil/wp-content/uploads/2021/04/AROBAA_W911NF17S0002-Amendment-9.pdf)