



U.S. Army Research, Development and Engineering Command

Army Maneuver Center of Excellence

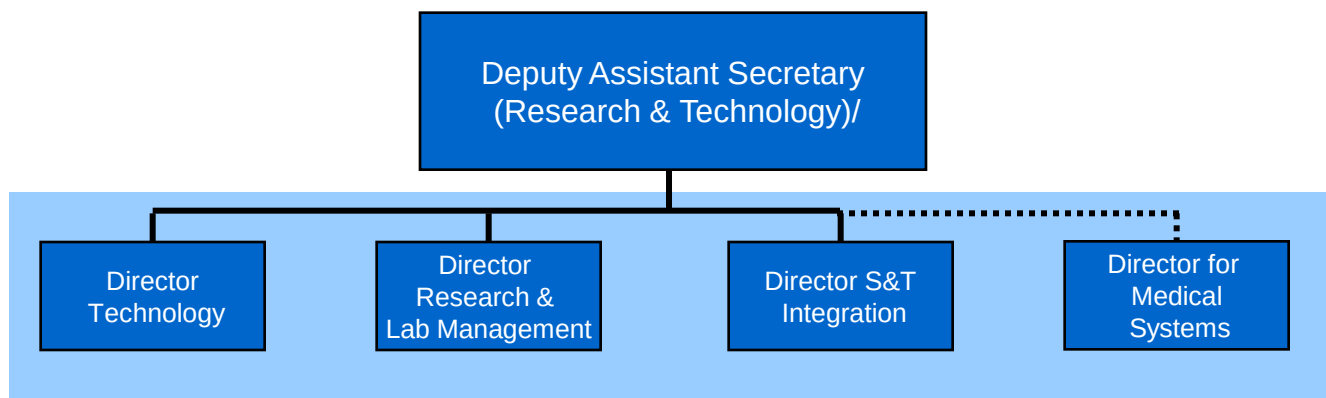
18 October 2012



TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

**Dr. Stephen Lee (ST)
Chief Scientist
US Army Research Laboratory**

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*Percent
of S&T
program
executed

80%*

Army
Materiel
Command

Research,
Development &
Engineering
Command

Army Research
Laboratory /
Army Research
Office

Research,
Development,
& Engineering
Centers

10%*

U.S. Army
Medical
Command

Army
Medical Research
& Materiel
Command

Laboratories

5.4%*

U.S. Army
Corps of
Engineers

Engineer
Research &
Development
Center

Laboratories

3%*

U.S. Army Space
& Missile
Defense
Command

Space
& Missile
Defense
Technical Center

1.6%*

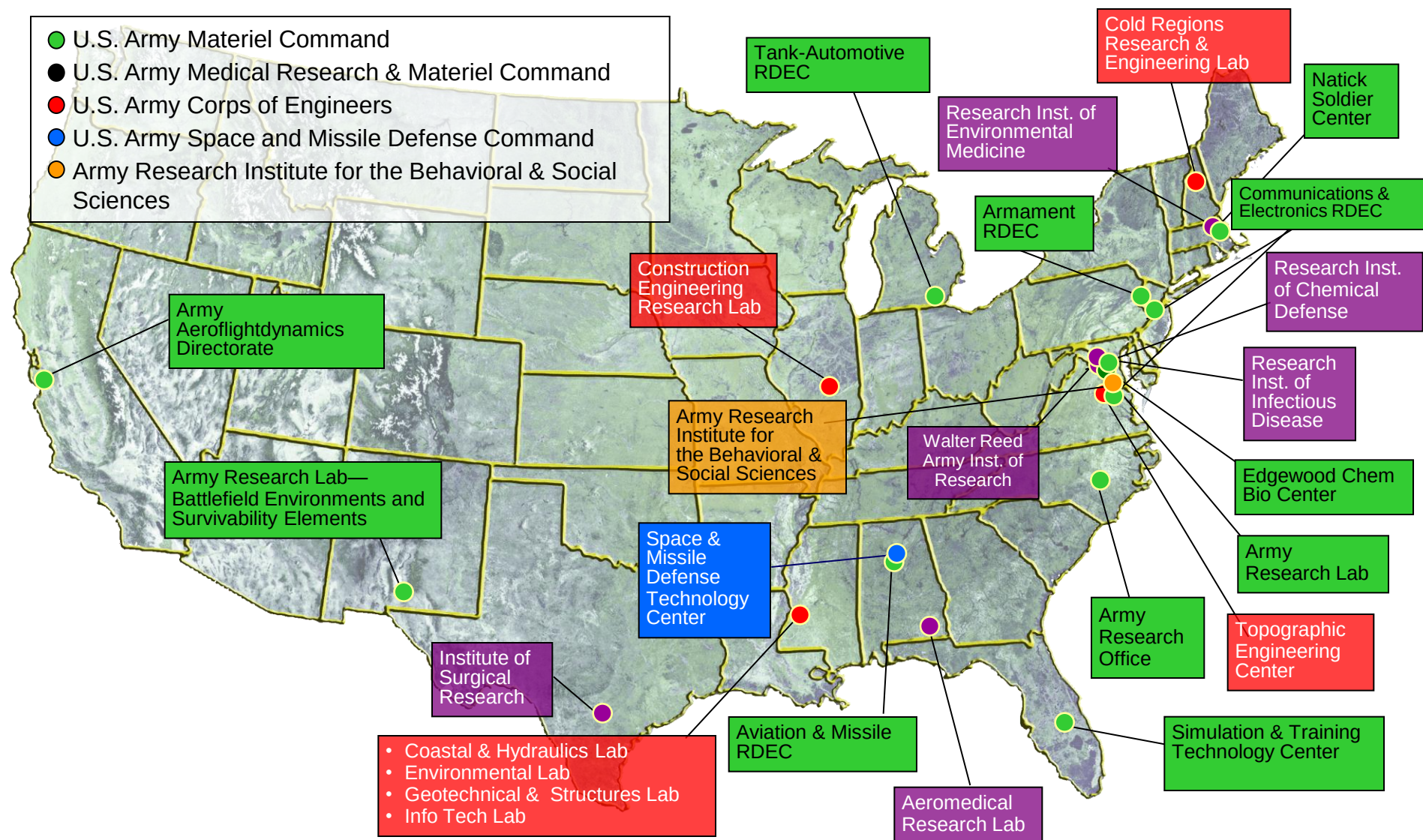
HQDA, G-1
Personnel

U.S. Army
Research Institute
for the Behavioral
and Social Sciences
(ARI)

DAS(R&T) provides Policy and
Oversight for
Army-wide S&T program



- U.S. Army Materiel Command
- U.S. Army Medical Research & Materiel Command
- U.S. Army Corps of Engineers
- U.S. Army Space and Missile Defense Command
- Army Research Institute for the Behavioral & Social Sciences



Fostering innovation and accelerating/maturing technology to enable Future Force capabilities while exploiting opportunities to rapidly transition technology to the Current Force

Current Force



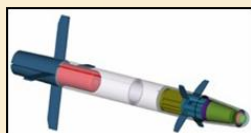
Modular Protective Systems



Micro Air Vehicle



IED/Mine Detection
Ground Penetrating
Radar



120mm Mid-Range Munition

Enabling the Future Force

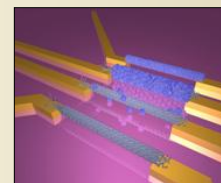


Enhancing the Current Force

Future Force



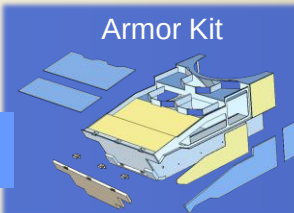
Immersive Training



Virus-based Self-
Assembling Electrodes



Flexible Displays



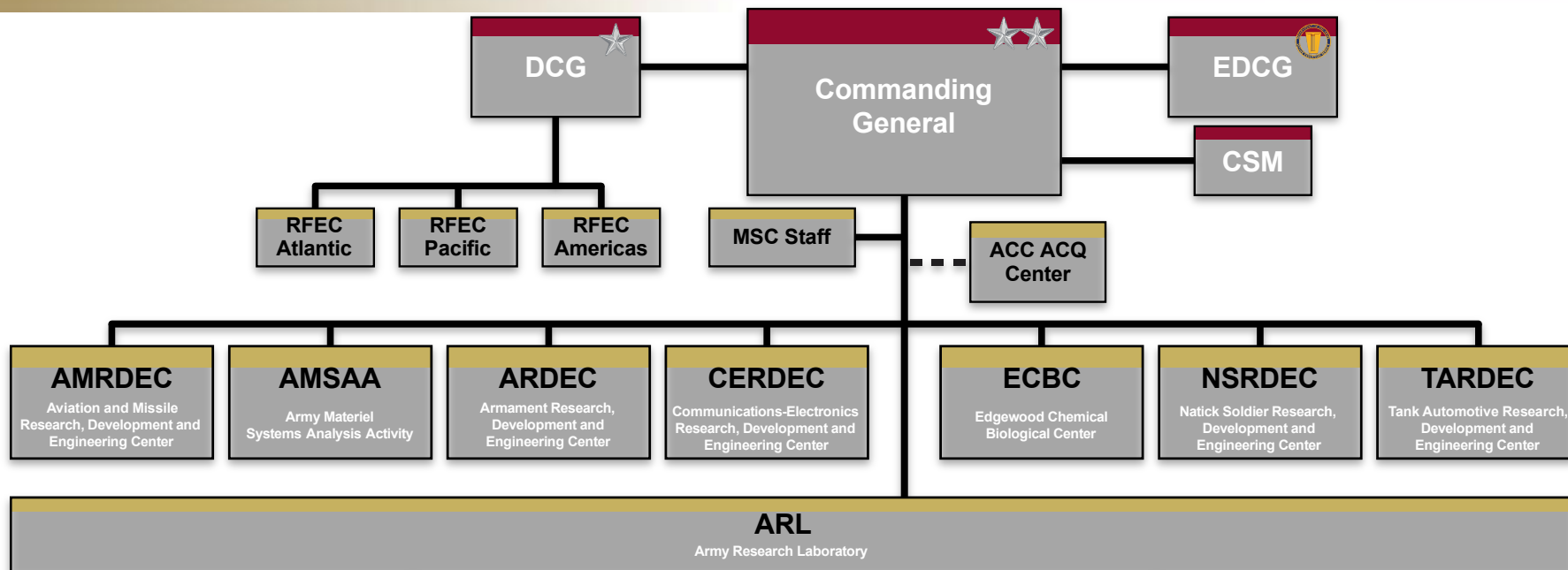
Armor Kit



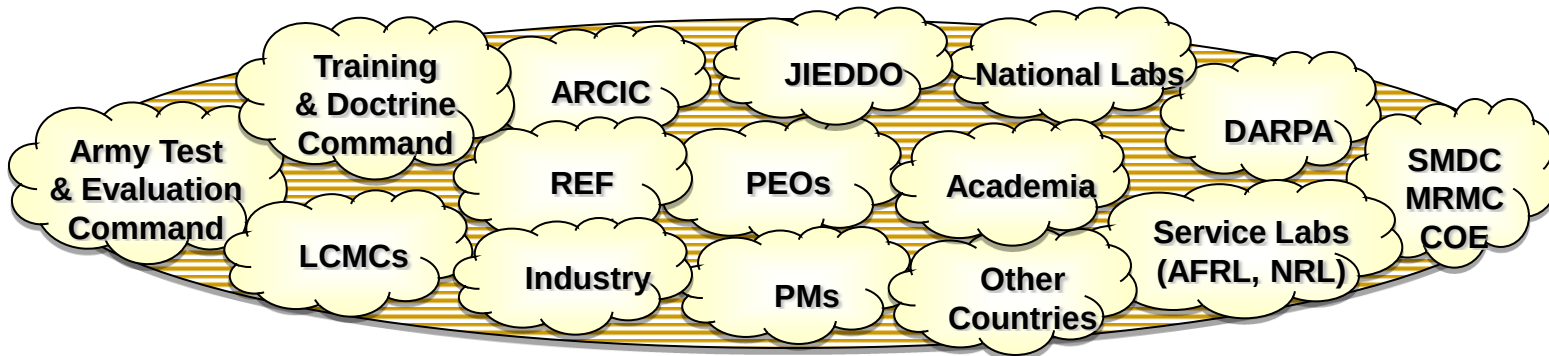
Mounted Combat
System (MCS)



Organization



Partners



Air & Missile RDEC (AMRDEC)

- Engines & Drive Trains for Aviation
- Platform Design & Structures
- National Rotorcraft Technology Center
- Rotors and Vehicle Management
- Unmanned & Optionally Manned Systems
- Aircraft and Occupant Survivability
- Airworthiness Approval and Direction
- Mission Critical Computer Resources
- Active Protection
- Air Defense
- Mission Critical Computer Resources

Natick Soldier RDEC (NSRDEC)

- Clothing & Protective Equipment
- Airdrop / Aerial Delivery
- Expeditionary Basing
- Joint Service Combat Feeding
- Soldier/SCU Technology Maturation & Demo
- Human Systems Integration Sciences

Armaments RDEC (ARDEC)

- Grenades and Demolitions
- Warheads
- Fire Control Systems
- Fuze. Energetics
- Small / Medium Caliber Weapons and Ammo
- Large Caliber Weapons and Ammo
- Aeroballistics, Shot Detection, High-g
- Munitions
- Explosive Ordnance

Tank-Automotive RDEC (TARDEC)

- Ground Vehicle
- Survivability
- Active Protection Systems
- Vehicle Electronics and Architectures
 - Mobility
- Sustainment Engineering
 - Water Purification
 - Power & Energy
 - Robotics
- Military Adaptation of Commercial Technology
- National Automotive Center



Army Research Lab (ARL)

- Information Sciences
- Human Sciences
- Materials and Manufacturing Sciences
- Ballistics and Aeromechanic Sciences
- Extramural Basic Research

Edgewood Chemical & Biological Center (ECBC)

- Aerosol Physics
- Chem & Bio Agent Spectr/Algorithm Devel
- Chemistry & Bioscience of CB Warfare
- Emerging Threats Science/Technology
 - Filtration Sciences
 - Inhalation Toxicology
 - OPCW Laboratory
- Smoke and Obscurants Advanced Technology
- CB Concept Through Sustainment Solutions
 - Life Cycle CB Materiel Acquisition
 - Full Service CB Testing
 - CB Agent Handling and Surety
- Chemical Munitions Field Operations
 - Single Small Scale Facility

Communications-Electronics RDEC (CERDEC)

- C2 Enabling Technology
- Electronic Warfare Technology
- Aircraft Survivability
- Radar
- IR
- Counter IED
- Power
- Antennas
- Network Enterprise Management
- Cyberwarfare
- Intelligence & Surveillance
- Displays
- Tactical Biometrics
- C4ISR Systems Integration
- Wireless Transport / Mobile Networking

• Researchers

- 6.1 Basic Research (Novel Concepts and Ideas)
- 6.2 Applied Research (Concept Exploration)



• Technology Developers

- 6.3 Advanced Technology Development (Technology Integration and Demonstration)
- 6.4 Quick Reaction Capabilities (Fielded Capabilities)



• Acquisitions Support

- 6.4 Matrix workforce for PM/PEO community



• Smart Buyers

- 6.4 Support DoD concept evaluation
- 6.4 Feed to Requirements
- 6.4 Technology Readiness Assessment



Academia

- 326 university level institutions
- More than 1,200 Single Investigator Research Projects
- 63 Multi-Disciplinary University Research Initiatives
- 4 University Affiliated Research Centers

Industry

- Collaborative Technology Alliances
- More than 450 Cooperative Research and Development Agreements
- More than 600 Small Business Innovative Research agreements

International

- Offices in 9 countries
- 239 agreements with 26 countries

Interagency

- 904 agreements throughout DoD, DARPA, JIEDDO, DHS, FAA, DoE, NSA, NASA, SMDC, etc.

Strategic Partnerships Benefit the Army Materiel Enterprise

SATCOM Satellite Communication



Common Remotely Operated Weapons Station, CROWS II (Norway)



Night Vision & Crew Counter Radio



TOW Improved Target Acquisition System



PVI Armor, IMG Armor (Israel) (from Army Research Lab Designs)



Boomerang/Doubleshot Long Range Advanced Shot Surveillance



Gunner Restraint System



Overhead Protective Cover



Objective Gunner Protection Kit



Advanced GPS Receiver



Multiband Radio System



General Dynamics, Canada Capsule fabrication, welding and final assembly South Africa



KEY:

 = CERDEC

 = ECBC

 = TARDEC

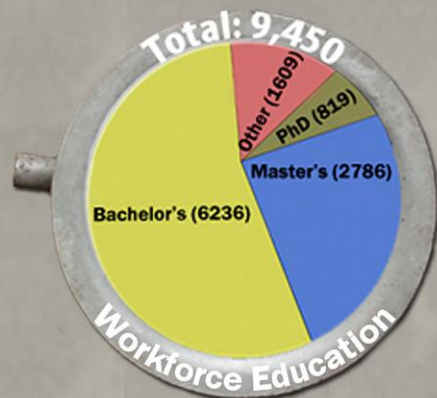
 = ARDEC

 = ARL

 = AMRDEC

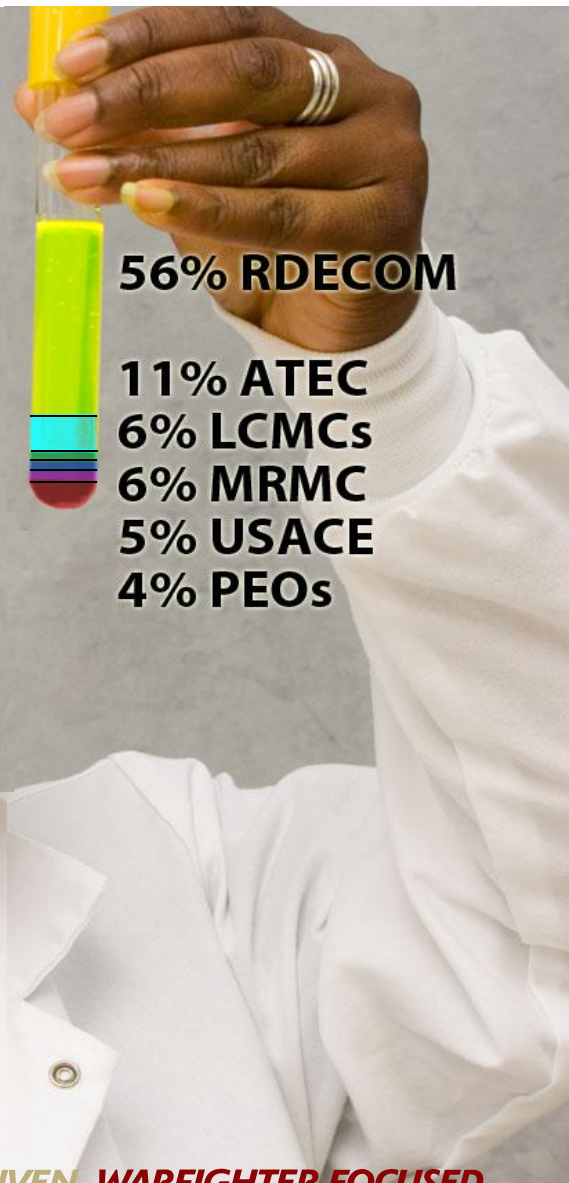
 = INDUSTRY

 = RDECOM



Army Scientists & Engineers: ~ 17,000

3442	Computer/Electrical/Electronics Engineers
565	Physicists/Physical Scientists
1630	Mechanical Engineers
3387	General/Industrial Engineers
561	Aerospace Engineers
155	Materials Engrs./Metallurgists
100	Psychologists/Social Scientists
608	Chemical Engineers/Chemists
130	Biologists/Biomedical Engineers
9	Medical Research Technicians
368	Mathematicians/Statisticians
23	Meteorologists
472	E&S Technicians



56% RDECOM

11% ATEC

6% LCMCs

6% MRMC

5% USACE

4% PEOs

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

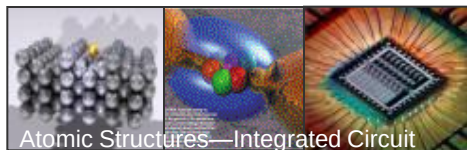
3 Different Types of S&T Investments

S&T PB09 **Development** \$8.9B (6.8% of TOA, 25.8% of RDA) **Acquisition** \$23.8B (18.3% TOA, 69.2% RDA)

\$1.84B (5.25% RDA & 1.32% TOA)

6.1: Basic Research \$379.4M (21% of S&T)

Nanoscience

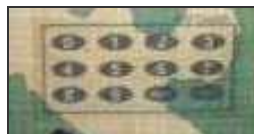


- Understanding to solve Army-unique problems
- Knowledge for an uncertain future

6.2: Applied Research \$723.5M (39% of S&T)

Integrated Textile Conductors

Embedded Input Device

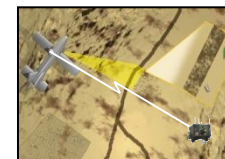


- Applications research for specific military problems
- Components, subsystems, models, new concepts

6.3: Advanced Technology Development \$738.9M (40% of S&T)

IED and Minefield Detection Payload for Shadow TUAV

IED/minefield detection at realistic altitudes & advanced RSTA



- Demonstrate technical feasibility at system and subsystem level
- Assess military utility
- Path for technology spirals to acquisition—rapid insertion of new technology

62% Universities/Industry

35% Industry

60% Industry

Far Term

Mid Term

Near Term

Mission

Provide innovative science, technology, and analyses to enable full spectrum operations.

Vision

America's Laboratory for the Army: *Many Minds, Many Capabilities*,
Single Focus on the Soldier

Acknowledged Scientific, Technical and Analytical
Excellence

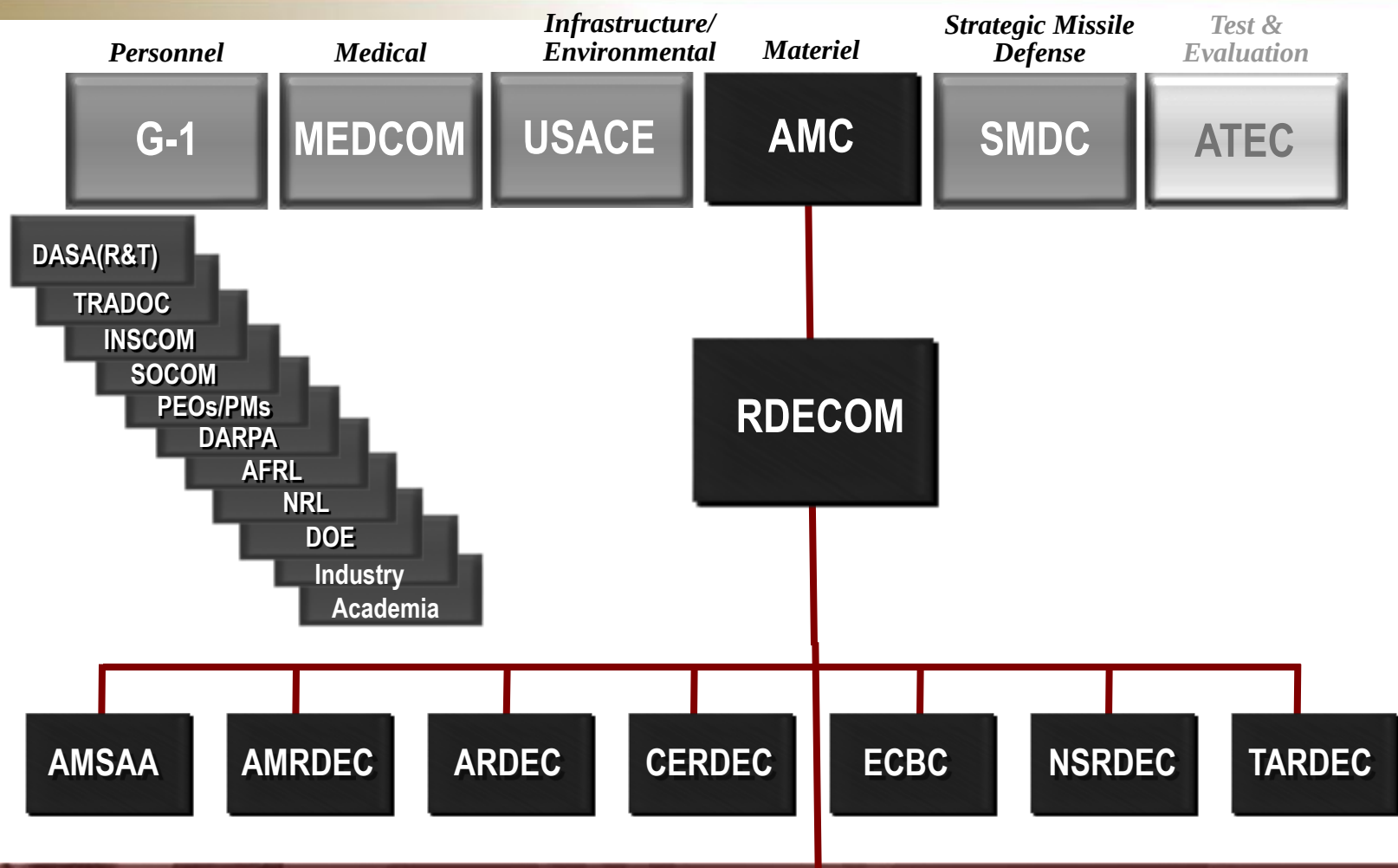
Recognized bridge between the Nation's Scientific
and Technical Communities and the Army

Leadership in providing innovative solutions for
the current and future Army

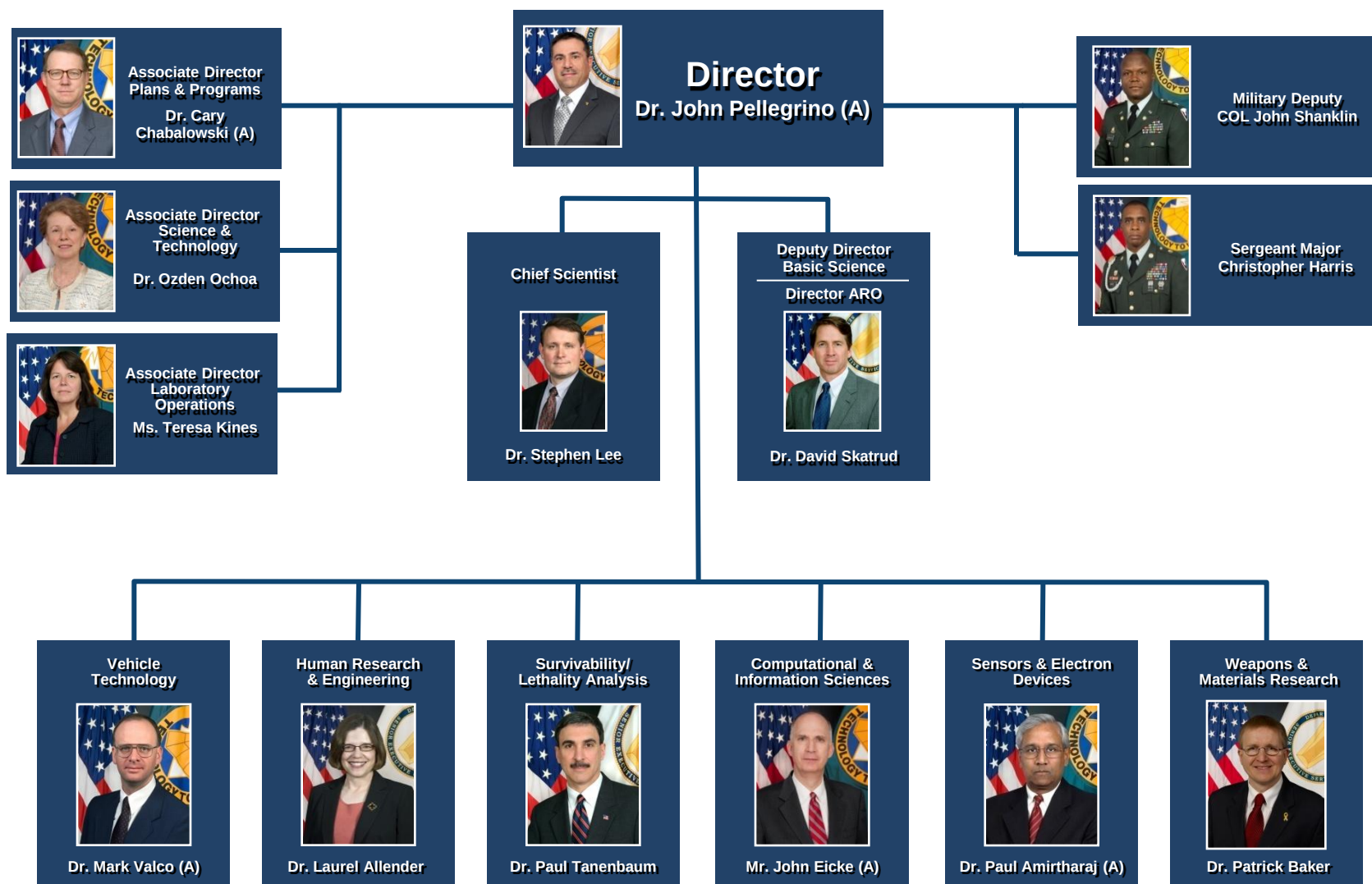




Army S&T Performing Organizations



ARL provides underpinning Science, Technology, and Analysis to the Army





ARL's Core Technical Competencies



Materials Sciences

- Structural Materials and Components
- Electronic Materials and Devices
- Photonic Materials and Devices
- Energy Materials and Components

Ballistics and Aeromechanic Sciences

- Energetics and Propulsion Science
- Impact Physics
- Ballistic Vulnerability
- Aeromechanics

Extramural Basic Research

- | | |
|--------------------------|-----------------------|
| • Chemistry | • Materials Sciences |
| • Physics | • Mechanical Sciences |
| • Life Sciences | • Mathematics |
| • Network Science | • Computing Science |
| • Environmental Sciences | • Electronics |

Information Sciences

- Network Sciences
- Decision Support Sciences
- Computational Sciences
- Autonomy
- Atmospheric Sciences
- Electronic & Info Warfare Vulnerability

Human Sciences

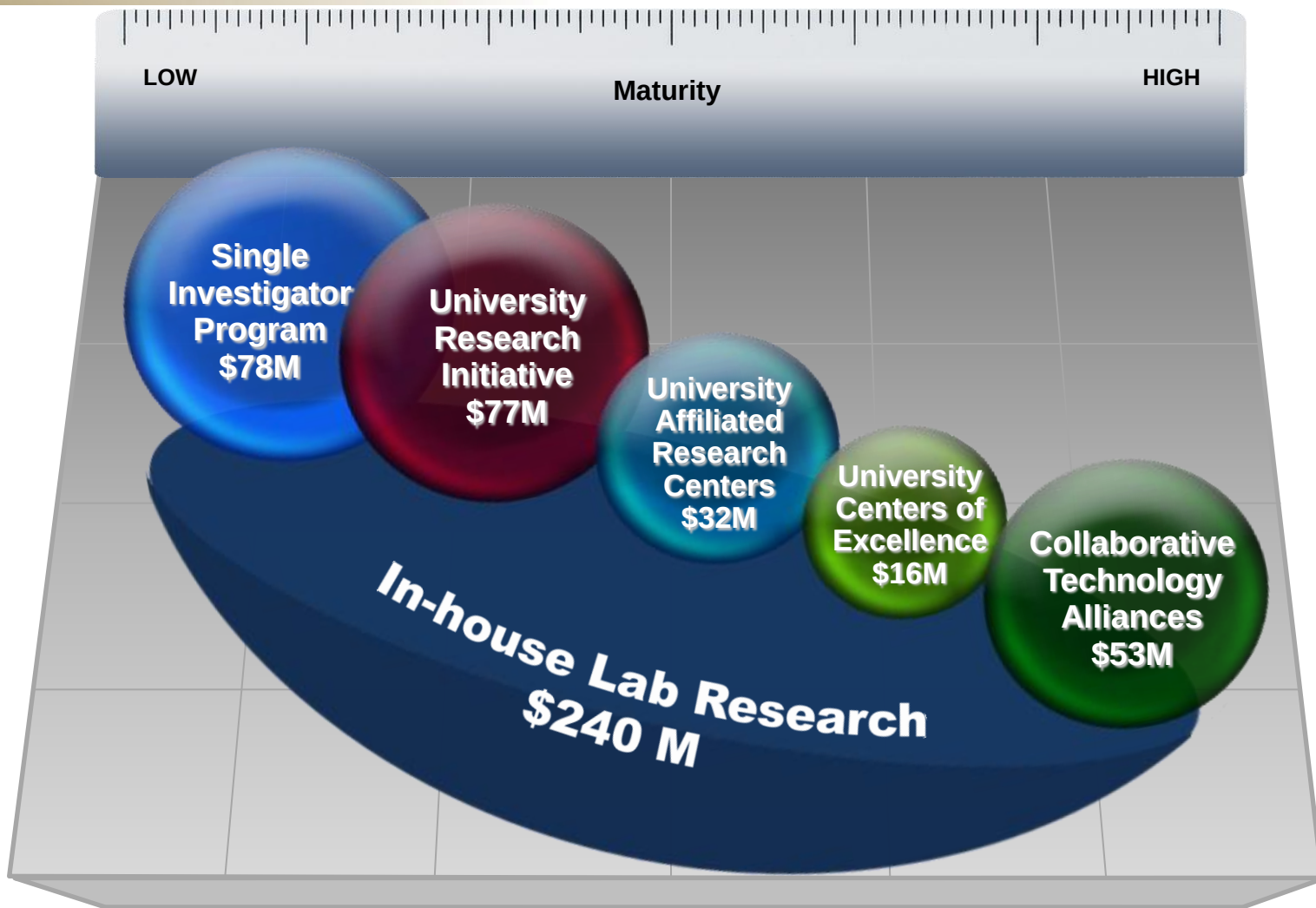
- Soldier Performance
- Simulation and Training Technology
- Human Systems Integration

SLV Assessment and Analysis

- Ballistic Vulnerability Analysis and Assessment
- Electronic & Info Warfare Vulnerability Analysis and Assessment



ARL Research Portfolio

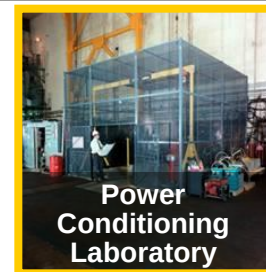
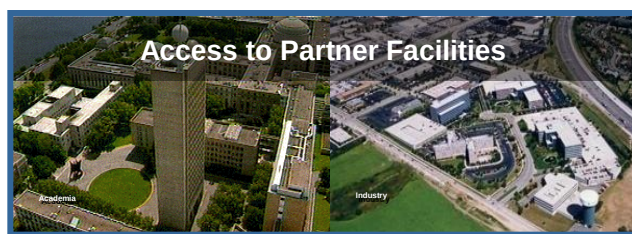
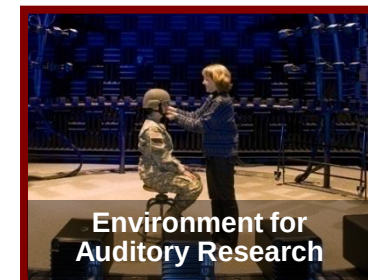
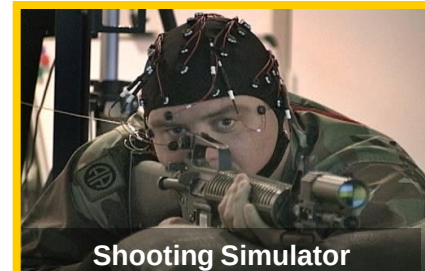


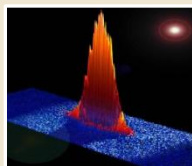
Complementary programs cohesively planned and executed

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.



State of the Art Research Facilities





New State of Matter for
Revolutionary Sensors and
Detectors



Tilt Rotor



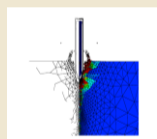
DEMNI – Insensitive Munitions



Ballistic Survivability



IED Countermeasures



Multiscale
Computation for
Impact Dynamics



FIDO for Explosives
Detection



ANS Robotics
LADAR



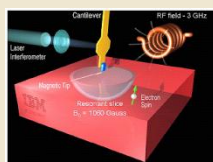
EPS



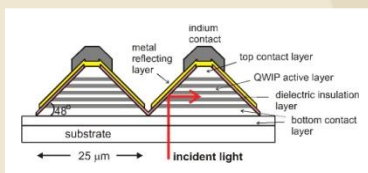
Language Translation



Persistent Surveillance



Single Electron
Spin MRFM



C-QWIP FPAs



Flexible Displays



Advanced RF



Human-Figure Workspace
Modeling for MRAP

Basic Science

Evolving Technologies

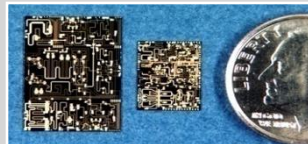
Current Ops

Technology Maturity

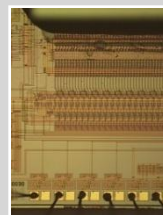
Legacy Accomplishments



- ENIAC Digital Computer
- Proximity Fuze
- Integrated Printed Circuit Board
- Photolithography enabling integrated circuits
- Special Armor for M1 tank
- Lithium primary batteries
- M829A2 "silver bullet" KE Penetrator



Continuing a Legacy of Firsts

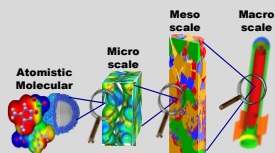


- Quantum Well Infrared Photodetectors
- Autonomous Navigation for Unmanned Systems
- Explosive Fill for Insensitive Munitions
- Flexible Displays
- Electric Armor
- M855A1 Enhanced Performance Round



Focus on the Future

Materials & Devices in Extreme Environments



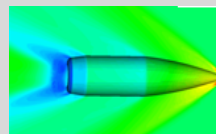
Battlefield Neuroscience



Network Sciences



Hierarchical Computing



Extreme Energy Science



Autonomous Systems Technology

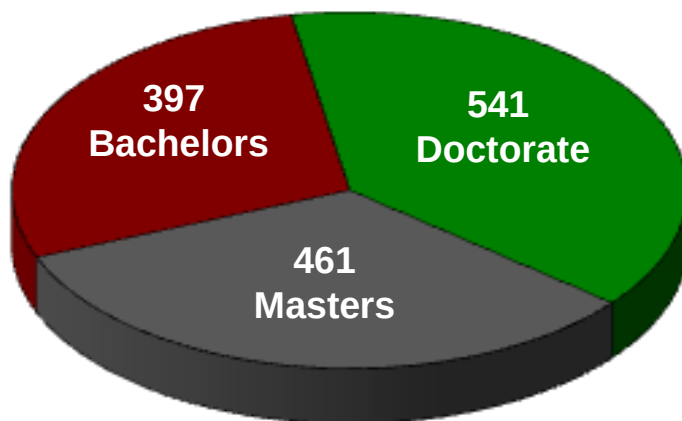


Emerging Sciences



Technical Workforce

(50% Research S&Es w/PhDs)



1399 S&E Workforce

1608 Technical Staff

Average Age S&E Workforce = 47

Average Age Civilian Workforce = 47



Technical Staff Disciplines

44	Aerospace Engineers
10	Biologists
4	Biomedical Engineer
95	Chemical Engineers/Chemists
169	Computer Scientists/Engineer
312	Electrical/Electronics Engineers
57	Engineering Psychologists
101	General/Industrial Engineers
81	Materials Engineers
40	Mathematicians/Statisticians
196	Mechanical Engineers
14	Meteorologists
7	Neuroscientists
53	Operations Research Analysts
207	Physicists/Physical Scientists
2	Research Audiologist
7	Other
209	E&S Technicians

Influence and contribute to the body of scientific research at the lab and in partnership with the university, industry, & fellow DoD organization community to provide

Unprecedented capabilities...

- **Enhanced protection and lethality**
→ *multi-functional lightweight materials enabled by multi-scale modeling*
- **Information to Soldiers**
→ *network science, data to decision, and advanced computing*
- **Smaller, lighter, less power intensive devices**
→ *novel energy harvesting and innovative materials*
- **Enhanced situational understanding and protection**
→ *autonomous systems at maneuver and man-portable scales*
- **Improvements in Soldier-system overall performance**
→ *operational neuroscience and advanced simulation and training technologies*

...enabled by “first-ever” research achievements.



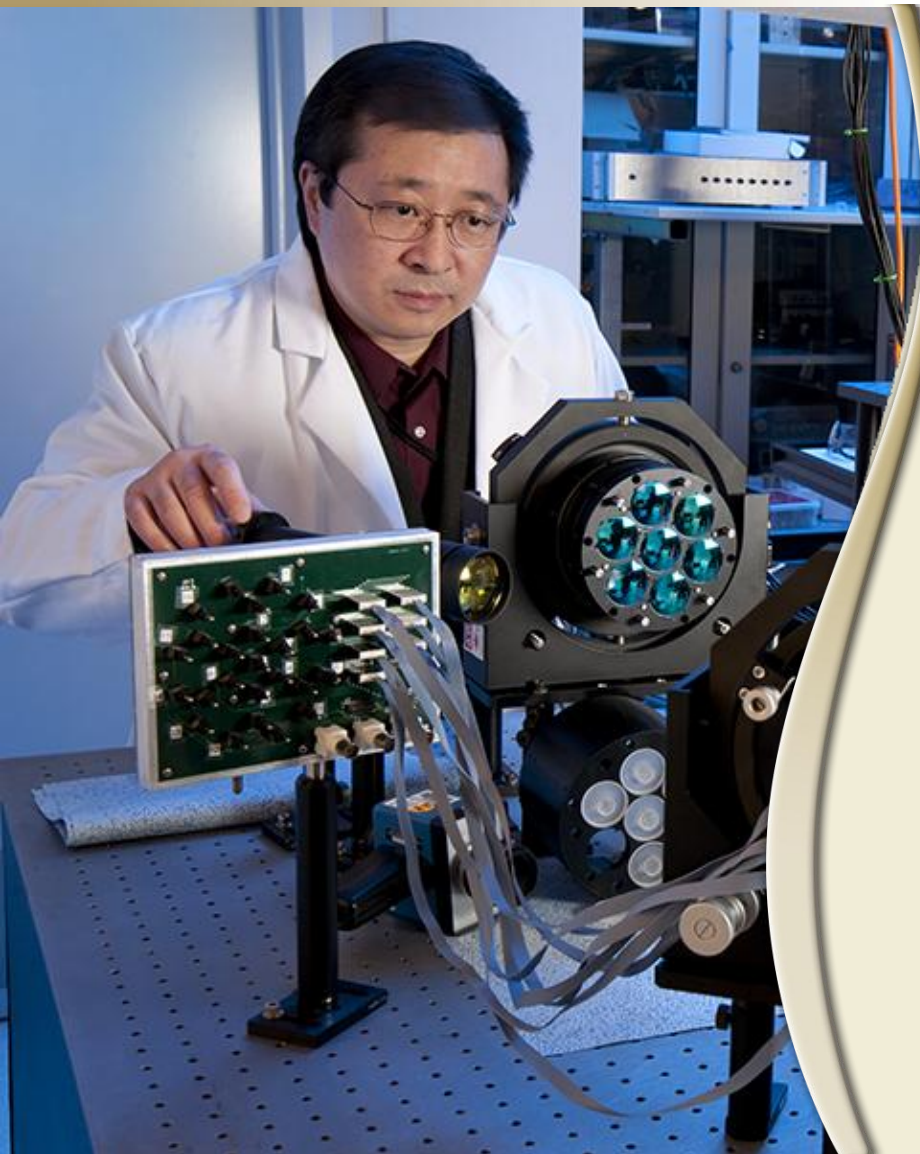
Business Model Key Characteristics



- In-house research focused on critical Army technical challenges
- In-house expertise to capitalize on university/industry research
- Extensive partnerships for integrated collaboration and direction with academic/industry and test/evaluation communities
- Portfolio Planning
 - Integrated annual process
 - ARO/Directorate individual and co-leadership for portfolio planning and management
 - Collaborative program planning and execution with RDEC partners
 - Partnered throughout RDECOM in planning for technology transition



Partnership Features



- Joint planning
- Collaborative implementation
- Research at university and industry partner locations
- Inclusive of Covered Educational Institutions
- Research at ARL locations
 - ~ 75 post doc fellows
 - 236 visiting researchers
 - 250 students this summer
- Sharing of facilities
- Continuous engagement to seek new partners
- Constant search for new directions in science, technology and applications

ARL/Private Sector Partnerships

Mechanism	Program	Academia	Industry
Grants	Single Investigation	✓	
	MURI	✓	
Coop Agreements	CTA	✓	✓
	CRA	✓	
	AHPCRC/MCOEs/FDC	✓	
	PIRT	✓	
OTA	ITA	✓	✓
	Flex Tech Alliance	✓	✓
Contracts	SBIR		✓
	UARCs	✓	✓
CRADA/TSA	Case by Case Opportunities		✓



Co-op Agreements, OTAs, TSAs, Contracts, Grants, CRADAs

University Affiliated Research Centers



Biotechnology

- Biologically-derived:
- Sensors
 - Electronics
 - Information Processing



Soldier Survivability

- Protection
- Performance Enhancement
- Injury Intervention and Cure



Electromechanics & Hypervelocity Physics

- EM Launch
- Pulsed-power
- Electric Armaments



Immersive Environments

- Full Sensory Immersion
- 3-D Mobility
- Compelling Interactive Stories

Centers Of Excellence

High Performance Computing

- Stanford University
- New Mexico State University
- Morgan State University
- University of Texas, El Paso
- High Performance Tech, Inc
- NASA - Ames

Flexible Displays

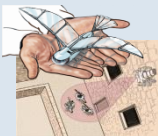
- Arizona State University

Materials

- University of Delaware
- Johns Hopkins University
- Rutgers University
- Drexel University
- Virginia Tech

Collaborative Technology Alliances

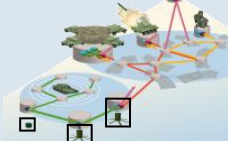
Micro Autonomous Systems & Technology



Robotics



Network Science

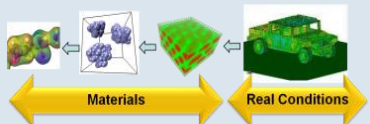


Cognition and Neuroergonomics



Collaborative Research Alliances

Multiscale Multidisciplinary Modeling of Electronic Materials

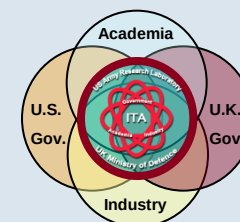


Materials in Extreme Dynamic Environments

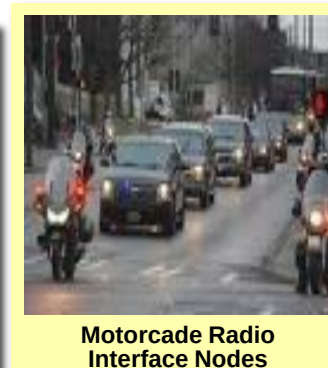
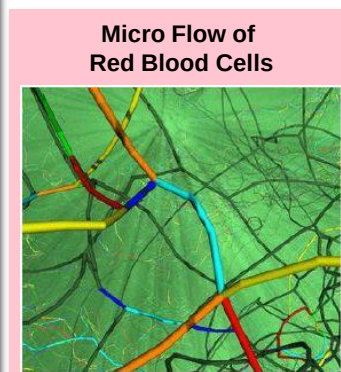
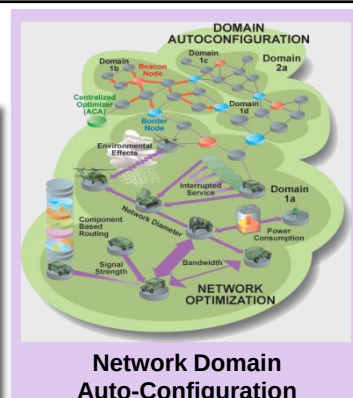
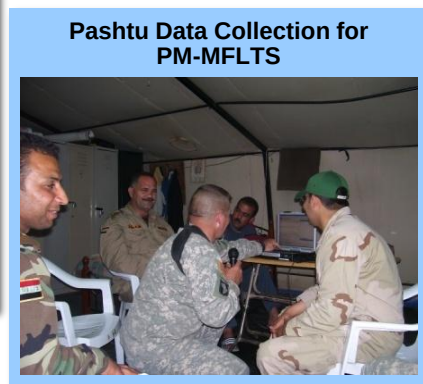


International Technology Alliance

Information Science



Organization	Comments
RDECs	• Transitions from mission research programs to RDECS via TPAs • Example: Vision-based localization to TARDEC Advanced Technology Objective and to CERDEC
PEOs & PMs	• Instances in which tech transition does not require further maturation by an RDEC • Example: Data and statistical translators to PM-Machine Foreign Language Translation Systems
Industry	• Technologies developed collaboratively by ARL and its partners • Example: Communications & Networks CTA automated network domain auto-configuration to CERDEC and WIN-T
Academia	• Transitions directly from an ARL partner center to an Army customer • Example: Army High Performance Computing Research Center scalable algorithms and software to CERDEC, ARL, & MRMC
Users	• Technology that can be transitioned directly to an outside activity • Example: Mobile ad hoc Networking concepts to the White House Communications Agency • Example: Modeling methodologies and expertise





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