*Presented to:*

**National Sponsored Program Administrators Alliance of HBCUs**

# AMRDEC OUTREACH



**TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.**

**Date: 7 June 2018**

*Presented by:*

**Juanita M. Harris Ph.D.**
**Executive Director**
**AMRDEC**

# AMRDEC Mission

**Deliver collaborative and innovative aviation and missile capabilities for responsive and cost-effective research, development and life cycle engineering solutions.**

# Who is AMRDEC?

**~9,211**
FY17 Strength

**2,945**
Civilian

**16**
Military

**6,250**
Contractor

907 / 5343
SETA Non-SETA

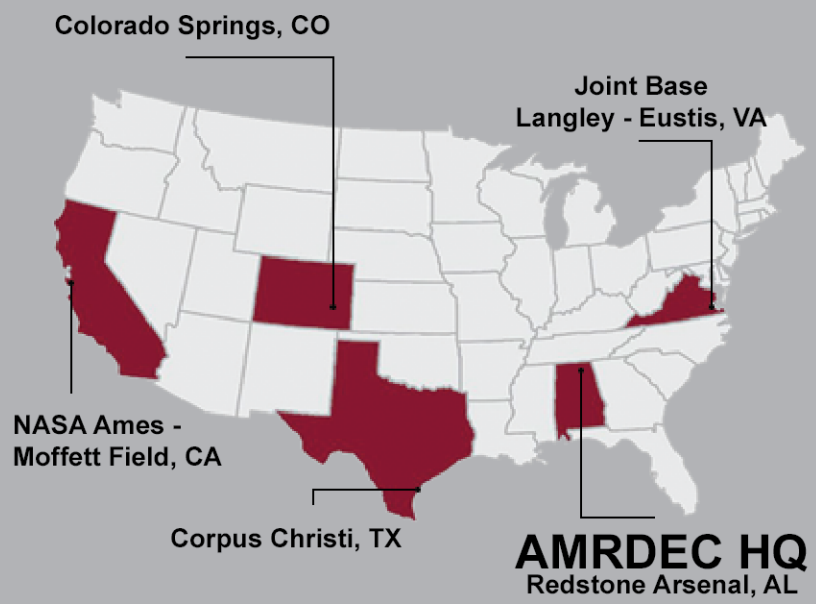
FY17
**$2,904M**

**6%**
Aviation S&T

**7%**
Missile S&T

**63%**
Army

**24%**
Other




## Core Competencies

- Life Cycle Engineering
- Research, Technology Development and Demonstration
- Design and Modification
- Software Engineering
- Systems Integration
- Test and Evaluation
- Qualification
- Aerodynamics/ Aeromechanics
- Structures
- Propulsion
- Guidance/Navigation
- Autonomy and Teaming
- Radio Frequency (RF) Technology
- Fire Control Radar Technology
- Image Processing
- Models and Simulation
- Cyber Security

# AMRDEC Leadership

**Director**

Dr. Juanita Harris (SES)

**Chief of Staff**

Mr. Steve Fisher

**Military Deputy**

Mr. James White (Acting)

**Scientific & Technical Positions (STs)**

- Flight Control Technology
- Optical Sciences
- Aviation Advanced Design
- Radio Frequency Sensors

**Aviation Development**

Dr. Bill Lewis (SES)

**Aviation Engineering**

Mr. Keith Darrow (SES)

**Weapons Development & Integration**

Mr. Stan Sherrod (Acting)

**Engineering**

Mr. Mike Bieri (SES)

**System Simulation, Software, & Integration**

Mr. Jeff Langhout (SES)

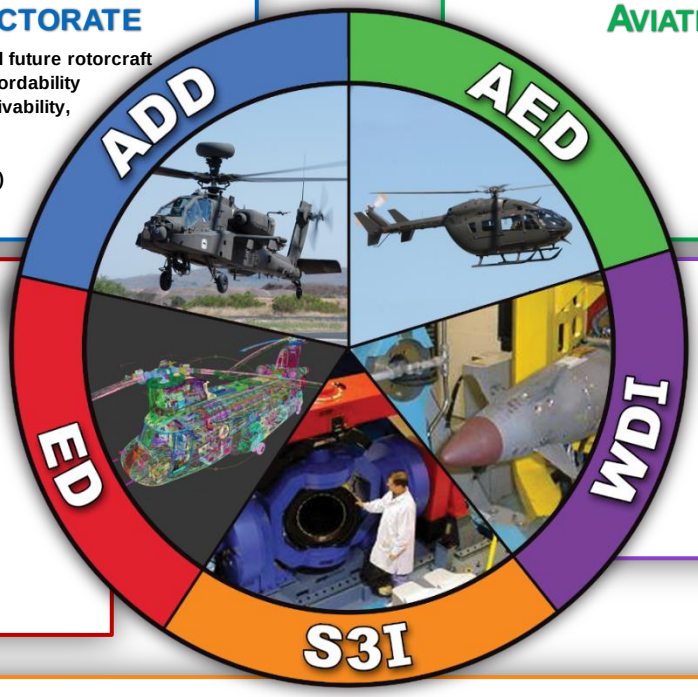
# Aviation and Missile Research, Development, and Engineering Center

## Aviation Development Directorate

- Aviation S&T supports both the current helicopter and future rotorcraft fleets in improving survivability, performance, and affordability
- Current efforts are focused on platforms, power, survivability, vehicle management, and operations support and sustainment
- Future efforts are focused on Future Vertical Lift (FVL)
- Joint Multi-Role (JMR) Technology Demonstrator (TD)
- Focus on Transition to PEO Aviation

## Aviation Engineering Directorate

- Delegated Airworthiness (AW) Authority
- Systems Engineering
- Aeromechanics
- Propulsion
- Structures and Materials
- Mission Equipment
- Maintenance/Sustainment Engineering
- Foreign Military AW Authority Recognitions




## Engineering Directorate

- Systems Engineering
- Test and Evaluation
- Production Engineering
- Product Assurance
- Configuration Management
- Prototype Integration Facility / Rapid Response
- Logistics Engineering
- Industrial Base Assurance
- Life Cycle Cost Reduction
- Manufacturing Technology
- Reliability and Maintainability Engineering
- Quality Engineering
- Quality Management

## Weapons Development & Integration Directorate

- Life Cycle Management for DoD missile technology
- Conducts research, exploratory and advanced development, technology demonstration and provide engineering and scientific expertise in all aspects of weapon system design, development, improvement and integration for the Army
- Lead Army agent in the execution of the Missile Science and Technology Enterprise

## Systems Simulation, Software, & Integration Directorate

- Hardware-In-the-Loop (HWIL) Models and Simulations for Aviation and Missile Systems
- Conduct Performance and Effectiveness Evaluations for Aviation and Missile Systems
- Design and Develop Virtual Prototyping Facilities for User Evaluations of Aviation and Missile Applications
- Define and Develop Modeling and Simulation Methods and Technologies for DoD Applications
- Computer Hardware/Software Technology
- Independent Verification and Validation (IV&V)
- Aviation Flight Safety/Airworthiness Software Assessments
- Software Development and Sustainment
- Information Assurance/Cyber Security
- Interoperability Engineering and Test (IET)
- Software Fielding/New Equipment Training
- Configuration and Data Management
- Software Quality Engineering

# AMRDEC Priorities

## #1: Readiness

Provide aviation and missile systems solutions to ensure victory on the battlefield today.

## #2: Future Force

Develop and mature Science and Technology to provide technical capability to our Army's (and nation's) aviation and missile systems.

## #3: Soldiers and People

Develop the engineering talent to support both Science and Technology and the aviation and missile materiel enterprise

# AMRDEC Supporting Readiness

## Patriot Missions

- Provides verification that software meets all performance and reliability requirements by performing system, software and operation testing
- Maintains an interoperability test bed that is used to perform all PATRIOT Joint Tactical Data Link Certification testing

## Corrosion Mitigation

- Developing new procedures and techniques to combat corrosion on aircraft and missile platforms, ground support equipment and parts and components in storage facilities

## Aviation and Missile Composites

- On-site fabrication capabilities ensure aviation and missile structures are built and tested to the requirements demanded by the Army's combat environments

## UH-60V

- Features a digital cockpit that updates legacy analog gauges
- Similar to UH-60M Pilot Vehicle Interface
- Meets Global Air Traffic Management requirements

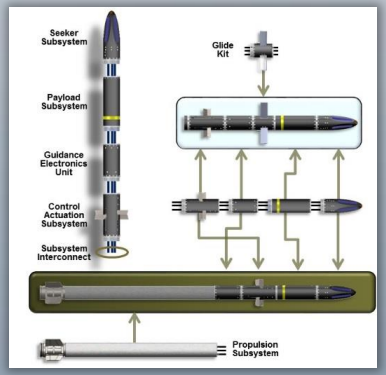
# AMRDEC Supporting Readiness

## Airworthiness

- Safely attain, sustain, and complete flight in accordance with approved usage limits
- Deliver responsive airworthiness solutions throughout the system life cycle

## Modular Missile Technologies (MMT)

- Based on a Modular Open Systems Architecture for guided missiles
- Consists of two different airframe types: a canard-controlled forward firing missile and a tail-controlled drop/glide munition




## Simulations, Trainers, & Integration Labs

- New methods include creating a PVI that closely replicates the actual aircraft
- Optimal mix of tactical and simulated hardware to keep trainers concurrent with aircraft

## Lethal Miniature Aerial Missile System (LMAMS)

- Soldier-carried, Soldier-launched precision weapon system
- Allows precision engagement of enemy combatants without exposing the Warfighter to direct enemy fire

# Army Modernization Priorities

#1: **Long Range Precision Fires**

#2: Next Gen Combat Vehicles (NGCV)

#3: **Future Vertical Lift (FVL)**

#4: Network/C31

#5: **Air & Missile Defense**

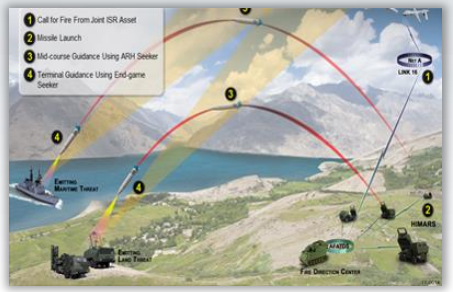
#6: Soldier Lethality

**Sustain & Train – Crosscutting**

# AMRDEC & Modernization

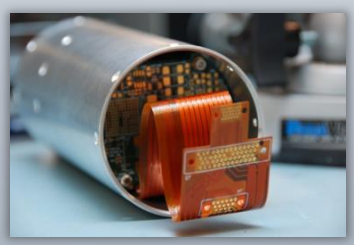
## Long Range Precision Fires

- Low-Cost Tactical Extended Range Missile (LC TERM)
- Seekers
- Precision Target Acquisition Seeker (PTAS)
- Land-Based Anti-Ship Missiles (LBASM**)**
- Long Range Maneuverable Fires (LRMF)



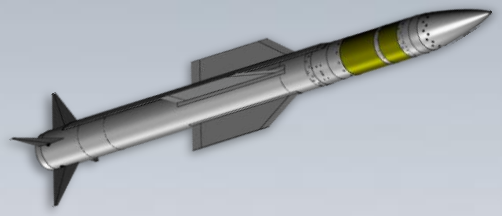

## Future Vertical Lift

- Joint Multi-Role Technical Demo (JMR-TD)
- Modular Open System Approach
- Modular Missile Technology
- NexGen Tactical UAS
- Multi-Role Small Guided Missile (MR-SGM)
- Single Multi-Mission Attack Missile (SMAM)
- Degraded Visual Environment-Mitigation



## Air & Missile Defense

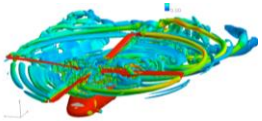
- Low-cost Extended-Range Air Defense (LowER-AD)
- Maneuvering Air Defense Technologies (MADT)
- Digital Array Radar Testbed (DART)



# AMRDEC Top Aviation S&T Initiatives

## Platforms

- Structures
- Sustainment
- Concept Design & Assessment



## Major Program Areas


- Joint Multi-Role Technology Demonstration
- Degraded Visual Environment – Mitigation
- Next Generation Tactical UAS Technology Demonstration

## Mission Systems

- Survivability
- Avionics & Networks


## Power

- Engines & Other Power Sources
- Drives

## Vehicle Management & Control and Rotors

- Rotors
- Vehicle Management & Control

## Basic Research

- Computational Aeromechanics
- Experimental Aeromechanics

## Autonomous and Unmanned Systems

- Autonomy & Teaming
- Human System Interface

# Autonomy and Teaming Success Story

- **Autonomous Dual lift**
  - **Multi-ship, autonomous cooperative formation flying**
  - **170% of single aircraft lift capacity**
  - **Load control using trajectory planning and cable tension**

- **Synergistic Manned Unmanned Teaming**
  - **Built System Integration Lab (SIL)**
  - **Study ongoing for 8-to-1 UAS control**

**2017 Flight Test**

Stability, Control, and Simulation of a Dual Lift System Using Autonomous R-MAX Helicopters

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Professor Emeritus
Department of Aeronautics and Astronautics
Stanford University, CA, USA

ABSTRACT

Cargo missions of the near future will require transportation of increasingly heavy loads to remote locations that are at elevations farther, and at altitudes higher, than what can be accomplished by current helicopters. Using two helicopters to carry a single load, termed dual lift, provides heavy lift on demand and avoids the very costly design and development of a special purpose heavy lift helicopter. This paper discusses the stability and control aspects of dual lift, with a focus on the control system. The dynamics of the load, the cable, and the coupled rotorcraft and helicopter attitude responses and should be considered while designing an inner-loop attitude-based controller. One such mode is unstable and is characterized by the helicopters drifting away from each. In order to stabilize this mode, a control system based on the Model Predictive Control (MPC) framework is developed for a representative dual lift configuration and a cable angle that is relative to a low swing plane is intended to isolate the swinging motion and improve damping of the payload. With the identified control challenges as a foundation, a multi-objective parameter optimization approach is used to design a controller for a dual lift system that meets a comprehensive set of ADS-33E stability and performance specifications.

NOTATION

| | |
|---|---|
| $a_{A/B/C}$ | Acceleration of point $B_{1,2}$ in reference frame C |
| $\frac{d}{dt}$ | Inertia dyadic of $B1$ about $B_{1,2}$, $slug \cdot ft^2$ |
| $I_{B_{1,2}/C}$ | Roll moment of inertia of $B1$ about $B_{1,2}$, $\frac{slug \cdot ft^2}{rad^2}$ |
| $I_{B_{1,2}/C}$ | Yaw moment of inertia of $B1$ about $B_{1,2}$, $slug \cdot ft^2$ |
| $I_{B_{1,2}/C}$ | Yaw moment of inertia of $B1$ about $B_{1,2}$, $slug \cdot ft^2$ |
| $r_{B_{1,2}/C}$ | Position vector from point $B_1$ to $B_{1,2}$, $ft$ |
| $v_{B_{1,2}/C}$ | Velocity of point $B_{1,2}$ in reference frame C, $\frac{ft}{s}$ |
| $\omega_{B_{1,2}/C}$ | The angular acceleration of $B1$ in N, $\frac{rad}{s^2}$ |
| $\omega_{B_{1,2}/C}$ | The angular velocity of $B1$ in N, $\frac{rad}{s}$ |
| $\Delta\theta$ | Attitude change in radians, $rad$ |
| $\Delta\theta$ | Attitude change in radians, $rad$ |
| AFCS | Automatic Flight Control System |
| AFDD | Aeroflightdynamics Directorate |
| ARP | Aeronautical Rotorcraft Project |
| ARR | Aeronautical Research |
| DRB | Disturbance Rejection Bandwidth, $\frac{rad}{s}$ |
| DRP | Disturbance Rejection Peak, $dB$ |
| FBD | Free Body Diagram |

Presented at the AHS 70th Annual Forum, Montréal, Québec, Canada, May 20–22, 2014. This is a work of the U.S. Government and is not subject to copyright protection in the U.S. DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

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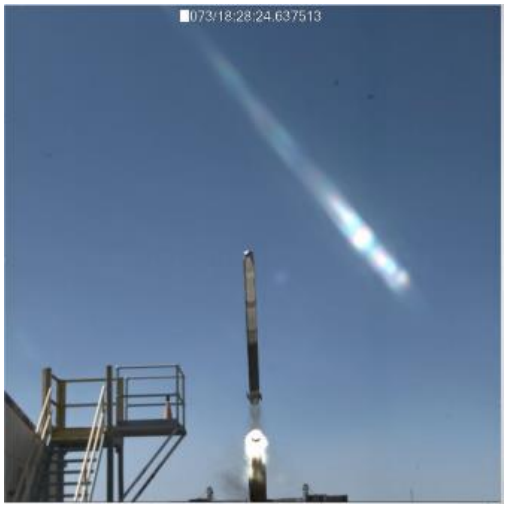
**Stability, Control, and Simulation of a Dual Lift System Using Autonomous R-MAX Helicopters, 2014**

# Modular Missile Technology Success story

- FVL Weapons
  - Modular Missile Technologies
    - Increased stowed kills via:
      - Reduced Size & Weight (25lbs, 70mm diameter)
      - Trajectory Shaping
    - Tailorable and Scalable Design
    - Modular Open Systems Architecture for:
      - Rapid Evolution to keep ahead of threat
      - Life Cycle Cost Reduction




# AMRDEC Missile S&T Areas


TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

# HBCU ENGAGEMENTS

# Benefit of Diversity at National Level

**"Our greatest asset in protecting the homeland and advancing our interests abroad is the talent and diversity of our national security workforce.... Research has shown that diverse groups are more effective at problem solving than homogeneous groups".**

*Excerpt from Presidential Memorandum -- Promoting Diversity and Inclusion in the National Workforce, October 5, 2016*

# Army Materiel Command Strategic Plan

## HBCU/MI OUTREACH

**Outcome**

- Expanded Competition
- More Student Diversity on DoD/Army Projects
- Larger Potential Workforce to Recruit for DoD Army Positions in STEM
- More Diversity in the STEM Workforce in DoD/Army
- Better Situational

### Research & Development Opportunities

- RDECOM (ARL, ARO, RDECs, Industry, & Academia)
- University Mentor/Protégé Relationship
- STTRs
- BAA, Grants

### Awareness

- Minority Conference Attendance (i.e., BIG, WHI HBCU, BEYA, HENAAC, HACU, Etc.)
- AMC Academia Days
- University/College Career Fairs
- Social Media

### Internship Opportunities

- Diversity Inclusion Strategy
- AMC 1000 Interns
- AMC Academia Days
- Partnering w/Industry and Gov't agencies

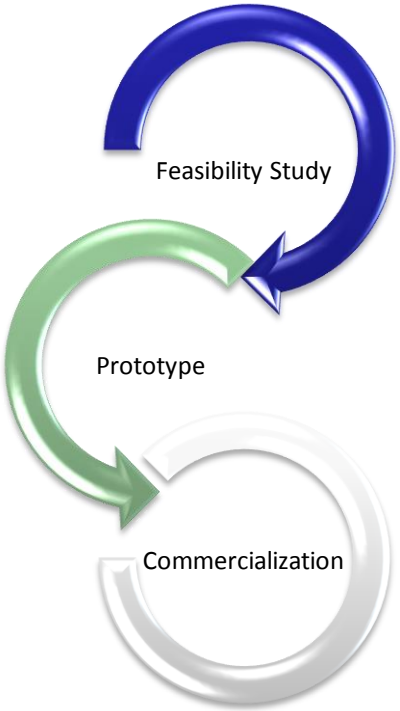
*Taken from U.S. AMC 2015-2020 Strategic Plan*

# HBCU Diversity - Meeting Innovation's Challenge

- **Army Commitment: We must work together at the leadership levels to engage with HBCUs to find aligned opportunities for research**
  - Includes SBIR/STTR opportunities
  - Educational Agreements
  - Must actively engage on all available opportunities and partnerships

# Phases of SBIR/STTR

- **Phase I – Feasibility Study**
- **Phase II – Prototype Development**
- **Phase III – Commercialization**




ARMY SBIR
SMALL BUSINESS INNOVATION RESEARCH

# Army SBIR Technology Areas

- Advanced Materials & Manufacturing
- Microelectronics and Photonics
- Sensors and Information Processing
- Simulation and Modeling for Acquisition, Requirements, and Training (SMART)
- Engineering Sciences
- Advanced Propulsion Technologies
- Power and Directed Energy
- Biological, Chemical, and Nuclear Defense
- Life, Medical, and Behavioral Sciences
- Environmental and Geosciences





ARMY SBIR
SMALL BUSINESS INNOVATION RESEARCH

# Upcoming SBIR/STTR Solicitations

| SOLICITATION | PRE-RELEASE | OPEN | CLOSE |
|---|---|---|---|
| DoD SBIR 2018.2 | 20 Apr 2018 | 22 May 2018 | 20 Jun 2018 |
| DoD STTR 2018.B | 20 Apr 2018 | 22 May 2018 | 20 Jun 2018 |
| DoD SBIR 2018.3 | 24 Aug 2018 | 24 Sep 2018 | 24 Oct 2018 |
| DoD SBIR 2019.1 | 28 Nov 2018 | 08 Jan 2019 | 06 Feb 2019 |
| DoD SBIR 2019.2 | 19 Apr 2019 | 20 May 2019 | 19 Jun 2019 |

SBIR DOD Submission Website:
https://sbir.defensebusiness.org

ARMY SBIR
SMALL BUSINESS INNOVATION RESEARCH

# Educational Agreements & CRADAs

## AMRDEC has 32 active Education Partnership Agreements (EPA)

- EPAs are with a not-for-profit, university, or a local education agency
- The goal of an EPA is to encourage and enhance the study of the scientific disciplines at all levels of education.
- 6 are with HBCUs
  - Alabama A&M Univ.
  - North Carolina A&T
  - Prairie View A&M Univ.
  - Alabama State Univ.
  - Oakwood Univ.
  - Tuskegee Univ.

## AMRDEC has 3 Cooperative Research and Development Agreements (CRADAs)

- CRADAs allow federal laboratories and Research & Development (R&D) centers to conduct collaborative R&D with non-government organizations.
- Federal government cannot provide funding, but may provide manpower, equipment and facilities

# Partnership Example

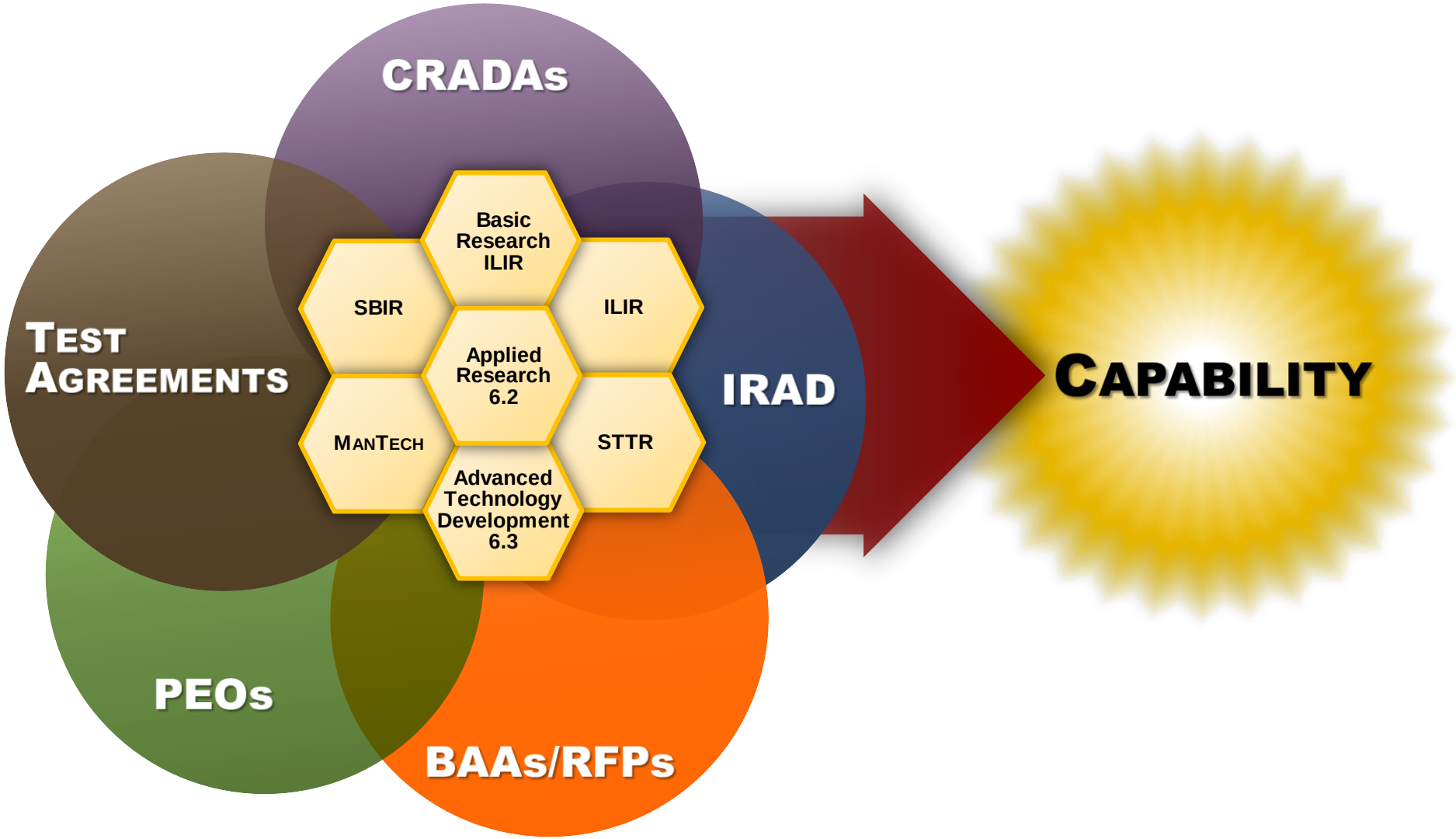
- **GTRI is the identified University Affiliated Research Center (UARC) for DoD.**
  - Grew from a $48M 5yr vehicle to a $2.2B 10 yr. vehicle.
  - Customer base: AMRDEC, PEO IEWS, PEO STRI, NASA, CECOM, Army SMDC, Army NGIC, Army REF, etc.
- **GTRI can exercise subcontract efforts up to 10-15% of the ceiling - must align with the competencies on this vehicle**

# GTRI UARC Core Competencies

1. RF, MMW, IR, EO missile sensors, ultraviolet and acoustical airborne and ground sensors, and guidance and control systems (including simulation and modeling).*
2. Phenomenology analysis tools, measurement methodologies, and instrumentation implementation techniques.*
3. Materials and electronics manufacturing technology for portable, air, and ground-launched applications.
4. Advanced electronics design and packaging for very compact, high performance signal processing, automatic target recognition, and guidance and control subsystems.
5. Next generation photonics components and subsystems for radar control.
6. Computer and physical modeling and analysis of threat systems/subsystems based on sensor spectrum, missile-target geometry, and natural and man-made environmental features.
7. Performance analysis, simulation, and modeling of weapon and sensor interactions.
8. System accessibility, susceptibility, and vulnerability analysis, modeling, and counter-countermeasure development.
9. Missile endgame modeling and analysis.
10. Hardware-in-the-loop, hybrid, and real-time simulation and analysis of major Army missile systems.
11. Independent evaluation, modeling, and testing of ballistic missile defense phased-array radar systems at the system, subsystem, and component levels.
12. Analysis, modeling, and development of adaptive digital beamforming techniques and technologies for missile defense applications.
13. Prototype and proof-of-principle hardware design and development, including component test fixtures and advanced technology subsystems and systems for missile defense systems.
14. Generic databases, networks, software engineering, telecommunications, and information infrastructure.*
15. Technical and software developmental activities associated with the Digital Infrared Seeker and Missile Simulation/Georgia Tech Synthetic Imaging simulations (DISAMS/GTSIMS) family of IR missile and systems models.
16. Technologies affecting sustainment decision processes, secure communications, and communication systems.*
17. Analysis, systems engineering, integration, and rapid cyber tool development to address defensive/offensive cyber operations and cyber mission assurance requirements.

** Basic and applied research and advanced development*

# AMRDEC
# Collaborative Incubation of Ideas

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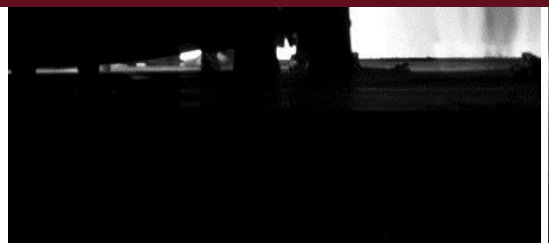
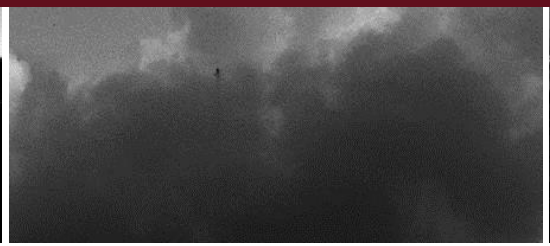
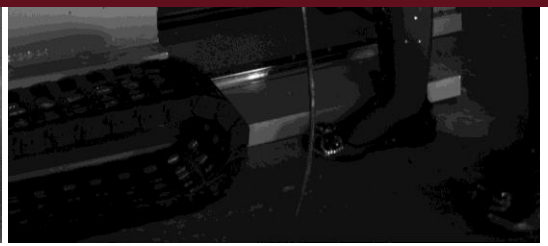
# Questions?



**"You can only deter your opponent if your opponent believes that you have the will and the capability…readiness has a deterrent value, as well as a war-fighting value."**

**Gen. Mark A. Milley, Chief of Staff of the Army**

## AMRDEC Web Site
**www.amrdec.army.mil**

## Facebook
**www.facebook.com/rdecom.amrdec**

## YouTube
**www.youtube.com/user/AMRDEC**

## Twitter
**@usarmyamrdec**

## Public Affairs
**AMRDEC-PAO@amrdec.army.mil**

# BACKUP

# AMRDEC Missile S&T Alignment to Army Modernization Priorities

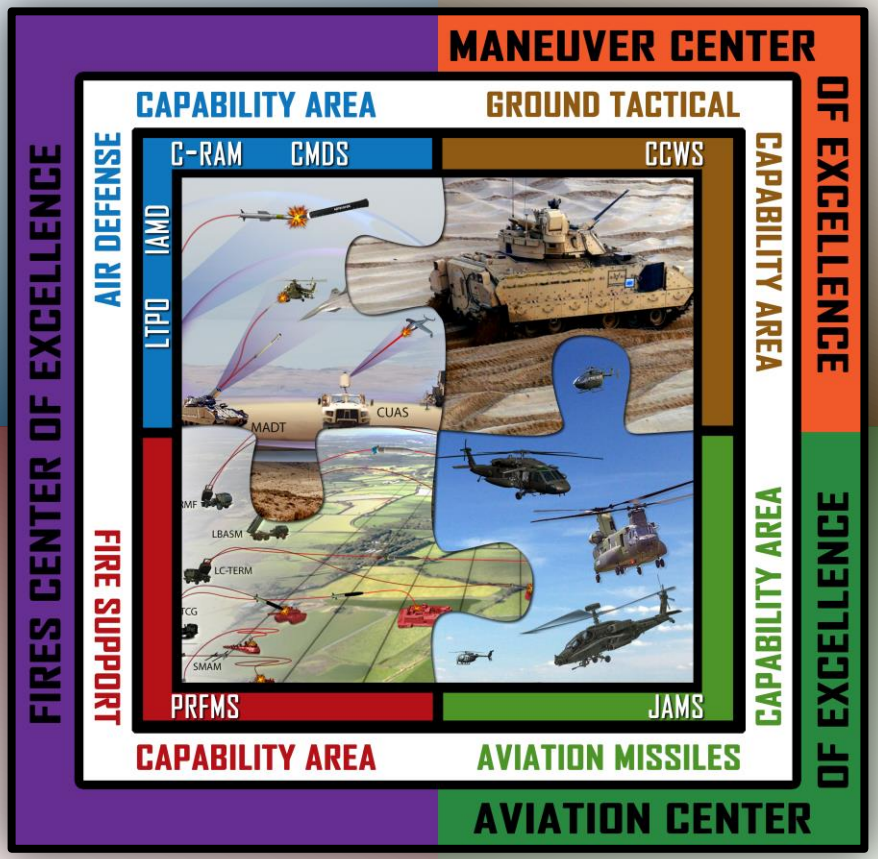
## Army Modernization Priorities

### Air & Missile Defense

Technologies for the development of mobile air defense systems that reduce the cost curve of missile defense, restore overmatch, survive volley-fire attacks, and operate within sophisticated A2AD and contested domains

### Long Range Fires

Technologies for the development, integration and delivery of long range fires at the tactical, operational, and strategic echelons to restore overmatch, improve deterrence, and disrupt A2AD on a complex, contested and expanded battlefield.




### Next Generation Combat Vehicle

Technologies for active protection systems that will increase our ability to survive and win in the complex and densely urbanized terrain of an intensely lethal and distributed battlefield where all domains are continually contested.

Technologies for enhanced lethal effects that will increase our capability to win in the complex and densely urbanized terrain of a lethal and distributed battlefield.

### Future Vertical Lift

Technologies for the development, integration, and delivery of aviation launched air-to-ground and air-to-air missile systems to restore overmatch within sophisticated A2AD and contested domains

**Engage First** **Expand the Dome** **On the Move**

*TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.*

# Redstone Missile Facilities

## Regionally Managed – Globally Executed

# Over 3.0 Million Square Feet of Missile RDTE Space

**Radar Operations Facility**

Improved Tactics, Training, and Doctrine

**Guidance Integration Facility**

Integration, Flight Hardware Component Verification

**Prototype Integration Facility**

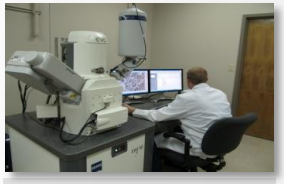
Rapid Response for Warfighter Solutions

**Missile Research & Innovation**

Basic and Applied Research in Microfabrication and Nanotechnology

**Composites Research**

Aviation and Missile Composites Research



**Corrosion Research**

AMCOM Corrosion Prevention Office

**Component Development**

Sensors, Seekers, Guidance, Navigation, and Control Development, Measurement and Processing

**Advanced Prototype Experimentation**

Warfighter-in-the-Loop Simulation Facilities for Missile, Aviation and Unmanned Systems

**Aerophysics Research Center**

Hypervelocity Interior Ballistics Free-Flight Test Range

**Propulsion & Structures**

Energetics Development and Enhanced Lethality

# Other Unique Facilities

## Regionally Managed – Globally Executed

### Test Facilities and Wind Tunnels

**Ft. Eustis, VA | Hampton, VA | Moffett Field, CA**

**Ballistics Test Facility**
Ft. Eustis, VA

Survivability and Vulnerability Testing

**National Full Scale Aerodynamics Complex**
Moffett Field, CA

Advanced Testing of Full Scale Rotorcraft

**Countermeasures Test Facility**
Ft. Eustis, VA

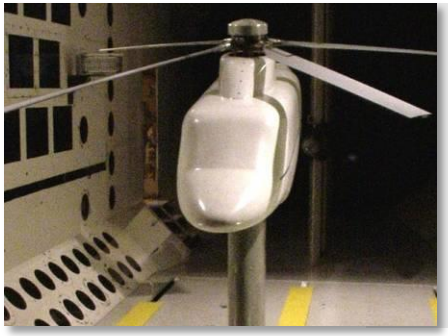
Acoustic/Infrared Radiation Testing of Turbine Engines

**Large Rotor Test Apparatus**
Moffett Field, CA

Full Scale Rotorcraft Component Testing

**Structural Test Facility**
Ft. Eustis, VA

Rotor Blade Test Fixture for Loads and Fatigue Testing



**Transonic Dynamics Tunnel**
Hampton, VA

Helicopter Performance, Loads, and Stability Testing