U.S. ARMY COMBAT CAPABILITIES

DEVELOPMENT COMMAND

ARMY RESEARCH LABORATORY

BROAD AGENCY ANNOUNCEMENT FOR

BASIC AND APPLIED SCIENTIFIC RESEARCH

W911NF-17-S-0003-11
01 April 2017 – 30 September 2022

ISSUED BY:

U.S. Army Contracting Command
Aberdeen Proving Ground
Research Triangle Park Division
P.O. Box 12211
Research Triangle Park, NC 27709-2211

Special Notes

1. Formatting of the Announcement

The following table provides an overview of the outline structure of this announcement:

I.							
	A.						
		1.					
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2. See Appendix 1 for a Table of Acronyms used in this announcement.

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I. OVERVIEW OF THE FUNDING OPPORTUNITY

The U.S. Army Combat Capabilities Development Command (DEVCOM) Army Research Laboratory (ARL) is the Department of the Army's sole fundamental research laboratory. It is dedicated to scientific discovery, technological innovation, and the transition of knowledge products. ARL is situated within DEVCOM – a U.S. Army Futures Command (AFC) Major Subordinate Command (MSC). The ARL mission is to "Discover, innovate, and transition Science and Technology (S&T) to ensure dominant strategic land power". To accomplish its mission, ARL executes fundamental research to address enduring S&T challenges identified by the Assistant Secretary of the Army for Acquisition, Logistics, and Technology [ASA(ALT)] and by priorities articulated by the Chief of Staff of the Army (CSA). In addition, the laboratory conducts research and analysis in emerging fields that may realize novel or vastly improved Army capabilities into the deep future..

The U.S. Army Artificial Intelligence Task Force (AITF) was created to allow the U.S. Army to better connect with the broader artificial intelligence community and focus their efforts in this dynamic field. AITF seeks to leverage and engage universities and companies from across the nation to support AI research and its applications.

For ease of reference and clarity, the ARL research funding opportunities are organized into two separate funding opportunity announcements: the ARL Broad Agency Announcement (BAA) and the Army Research Office (ARO) BAA.

The ARL BAA identifies topics of interest to the ARL Directorates (Computational and Information Sciences Directorate, Human Research and Engineering Directorate, Sensors and Electron Devices Directorate, and Weapons and Materials Research Directorate) and to the Army Artificial Intelligence Task Force. The Directorates focus on executing in-house research programs, with a significant emphasis on collaborative research with other organizations. The Directorates fund a modest amount of extramural research in certain specific areas, and those areas are described in this BAA.

The ARL BAA seeks proposals from institutions of higher education, nonprofit organizations, state and local governments, foreign organizations, foreign public entities, and for-profit organizations (i.e. large and small businesses) for research based on the following S&T campaigns: Computational Sciences, Materials Research, Sciences for Maneuver, Information Sciences, Sciences for Lethality and Protection, Human Sciences, and Assessment and Analysis. Further details are described in the ARL Technical Strategy and in the ARL S&T Campaigns located at www.arl.army.mil. These documents are subject to periodic refinements which may result in taxonomy inconsistencies. These inconsistencies should not affect the efficacy of the BAA to present a complete portfolio of essential ARL research.

The ARL BAA generally conforms to the portfolio structured around mission, enemy, Key Campaign Initiatives (KCIs) and Core Campaign Enablers (CCEs). KCIs are substantive, long-lived, primarily in-house technical programs focused on pursuing scientific discoveries, innovations, and knowledge product transitions that are expected to lead to greatly enhanced capabilities for the operational Army of 2030 and beyond. KCIs reflect a robust yet aggressive

approach, and are delineated by near-term, mid-term, and long-term trajectories. CCEs are enduring technical thrusts dedicated to a fundamental understanding of new concepts and the maturation of foundational technologies and methodologies. The essence of the ARL technical portfolio is captured in the ARL Technical Strategy and by the ARL S&T Campaign Plans.

Proposals are sought for cutting-edge innovative research that could produce discoveries with a significant impact to enable new and improved Army technologies and related operational capabilities and related technologies. The specific research areas and topics of interest described in this document should be viewed as suggestive, rather than limiting.

Prospective applicants contemplating submission of a whitepaper or proposal are strongly encouraged to contact the appropriate Technical Point of Contact (TPOC). The TPOCs' names, telephone numbers, and email addresses are listed immediately after each research area of interest. If requested by the TPOC, a whitepaper should be prepared in accordance with the instructions contained in this BAA. Upon receipt, a whitepaper will be evaluated and the applicant will be advised of the results. Applicants whose whitepapers receive a favorable evaluation may be encouraged to prepare a proposal in accordance with instructions contained in this BAA. The costs of whitepapers and/or proposals in response to this BAA are not considered an allowable direct charge to any award resulting from this BAA or any other award. It may be an allowable expense to the normal bid and proposal indirect costs specified in FAR 31.205-18. Proposals may be submitted at any time during the announcement period.

The Army has a long history of advocating and supporting research at Historically Black Colleges and Universities and Minority-Serving Institutions (HBCU/MSI). ARL welcomes proposals from HBCUs and MSIs in full competition with all applicants who may submit proposals under this BAA. ARL also encourages the inclusion of HBCUs and/or MSIs as part of a consortium proposal or as sub-recipients to prime recipients.

In accordance with federal statutes, regulations, and Department of Defense (DoD) and Army policies, no person on grounds of race, color, age, sex, national origin, or disability shall be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving financial assistance from the Army.

Applicants submitting proposals are cautioned that only a Contracting or Grants Officer can obligate the Government to any legal instrument involving expenditure of Government funds. This BAA is also used to solicit research proposals for submission to the DEVCOM International Technology Centers.

All administrative inquiries regarding this BAA shall be submitted via email to: usarmy.rtp.devcom-arl.mbx.baa@army.mil Scientific and technical questions should be referred to the TPOCs shown following each research area of interest. Interested parties are encouraged to periodically check any of the following websites for updates and amendments to this BAA: www.grants.gov, www.fbo.gov, and the ARL website, www.arl.army.mil/.

Dr. Patrick Baker
Director,

U.S. Army Research Laboratory
AFC/DEVCOM/ARL

(End of Section)

A. Required Overview Content

1. Agency Name:
U.S. Army Research Laboratory

Issuing Acquisition Office:
U.S. Army Contracting Command-Aberdeen Proving Ground, Research Triangle Park (ACCAPG-RTP) Division

2. Research Opportunity Title:
ARL Broad Agency Announcement (BAA) for Basic and Applied Scientific Research for 01 April 2017 – 30 September 2022

3. Announcement Type: Amended Announcement

4. Research Opportunity Number: W911NF-17-S-0003

5. Catalog of Federal Domestic Assistance (CFDA) Number and Title:
12.431 – Basic Scientific Research

6. Response Dates:
This BAA is a continuously open announcement valid throughout the period from the date of issuance through 30 September 2022, unless anno ced otherwise. This announcement succeeds ARL BAA W911NF-12-R-0011 (including all amendments) dated 15 May 2012.

(End of Section)

B. Additional Overview Information

This BAA sets forth research areas of interest to the ARL. This BAA is issued under paragraph 6.102(d)(2) of the Federal Acquisition Regulation (FAR), which provides for the competitive selection of basic and applied research proposals, and 10 U.S.C. 2358, 10 U.S.C. 2371, and 10 U.S.C. 2371b, which provide the authorities for issuing awards under this announcement for basic and applied research. The definitions of basic and applied research may be found at 32 Code of Federal Regulations (CFR) 22.105.

Proposals submitted in response to this BAA and selected for award are considered to be the result of full and open competition and in full compliance with the provision of Public Law 98369, "The Competition in Contracting Act of 1984" and subsequent amendments.

The DoD agencies involved in this program reserve the right to select for award all, some, or none of the proposals submitted in response to this announcement. Due to Government budget uncertainties, no specific dollars have been reserved for awards under this BAA. The participating DoD agencies will provide no funding for direct reimbursement of whitepaper or proposal development costs.

Whitepapers and technical and cost proposals (or any other material) submitted in response to this BAA will not be returned to the applicant. Unless noted in an applicant's proposal to the contrary, unsuccessful proposals will be retained for six (6) months from declination and then properly destroyed. It is the policy of participating DoD agencies to treat all proposals as sensitive, competitive information and to disclose their contents only for the purposes of evaluation.

An applicant may withdraw a proposal at any time before award by written notice or by email sent to the government point of contact identified in Section G of this BAA.

(End of Section)

II. DETAILED INFORMATION ABOUT THE FUNDING OPPORTUNITY

A. Program Description

1. COMPUTATIONAL SCIENCES (CS) CAMPAIGN

The CS Campaign focuses on advancing the fundamentals of predictive simulation sciences, data intensive sciences, computing sciences, and emerging computing architectures to transform the future of complex Army applications. Gains made through these underpinning multidisciplinary research efforts and exploiting emerging advanced computing systems will lead to scientific breakthroughs that are expected to have significant impact on Army materiel systems. Technologies resulting from this multidisciplinary research collaboratively with other ARL S&T campaign innovations will have a significant impact on Power Projection Superiority, Information Supremacy, Lethality and Protection Superiority, and Soldier Performance Augmentation for the Army of 2030.

Represented in this BAA for the CS Campaign are one KCI and five CS-related topics that are integrated to form a robust advanced computing foundation to understand and overcome complex fundamental challenges simultaneous to improving approaches of importance to the Army, including weapon systems design; materials-by-design; information dominated and networked battle command applications; system-of-systems analyses; human performance modeling; platform maneuverability; and tactical supercomputers. The campaign heavily relies on ARL's research expertise and facilities devoted to emerging advanced computing architectures, mobile High Performance Computing (HPC), multi-scale and interdisciplinary predictive simulation sciences, multi-dimensional distributed data analytics, and computing sciences. Discoveries and innovations made in this area will exert a significant impact on the Army of the future. There are natural synergies among the challenges facing ARL's CS Campaign and ARL's other S&T campaigns. Synergistic advances across all campaigns are expected to enable next generation scientific breakthroughs.

a. KCI-CS-1: Tactical High Performance Computing (HPC)

This KCI concentrates on understanding and exploiting the fundamental aspects of hardware and associated system software for emergent and future computing architectures for mobile, scientific, and data intensive applications. Computing systems include both mobile and fixed/virtual architectures optimized for fast communications, low power consumption, large hierarchical memory, novel and robust algorithms, high resiliency, and HPC networking.

i. Tactical HPC integrates four primary research areas, including 1) advanced computing research to facilitate the efficient use of emerging architectures; new algorithm design and analysis approaches must be developed to boost the computing capacity of fixed and deployed devices; 2) research in provisioning these systems within a distributed computing architecture; this work includes novel concepts to schedule computing tasks over friendly networked

processors to limit network hop to appropriate resources; 3) dynamic binary translation to limit software re-writes and facilitate optimization in a runtime environment to achieve maximum performance; and 4) power- and architecture-aware computing for enhanced intelligence of provisioning systems to design systems that have greater awareness of their computing capacity and mission appropriateness. The critical, mobile ad hoc networks that will form the connections in tactical cloudlets to the large-scale databases and complex applications that will be performed by these resources make this research uniquely military and Army in nature. Numerous applications are envisioned for this system in the future and include artificial intelligence aids for decision making, processing large-scale datasets (text, video), and navigation systems for autonomous vehicles (HPC-enabled autonomous vehicles providing on-demand processing).

ii. Emergent Computing Architectures research focuses on light weight architectures, large scale on-chip parallelism, and exascale performance to support petascale computing with multicore processors. These research efforts are also dedicated to developing novel algorithms and application formulations that facilitate the input and output rates required for petascale computing; and application development and performance optimization for next generation computing architectures.

iii. Tactical Computing research is focused on better understanding algorithms and applications which facilitate seamless reach back to large-scale HPC systems and help to supply information to the Soldier at the tactical edge. Research in this area is dedicated to moving beyond optimizing devices in isolation, and embraces the challenges of cross-environment co-design to address the needs of emerging tactical applications.

iv. Next Generation Computing Architectures research is focused on non-traditional computing systems and envisioned to provide disruptive technologies for the Army. Cognitive computing, neuro-synaptic computing, and DNA computing are some emerging concepts.

TPOC: Song Park, (410) 278-5444, song.j.park.civ@army.mil

Computational Sciences (CS) Related Topics:

b. Real-Time, Scalable Data Analytics for the Army

This topic focuses on understanding and exploiting the fundamental aspects of large-scale, real time, multi-variate data analytics. Experiments, observations, and numerical simulations are on the verge of generating extreme quantities of data at ever increasing rates that must be processed for understanding and consumption. These massive amounts of data are distributed across disparate locations and pose a challenge in providing real-time analytics that support U.S. military operations.

i. Brain-inspired computing research addresses the fundamental question of how our understanding of neuroscience, brain structure, and function inform the development of computing architectures to address Army research challenges. For instance, current models underlying existing machine learning are based on a 40 year old understanding of the structure and organization of animal brains. This research focuses on the design of neural network structures informed by our current understanding of the repeating micro-structure circuits neuroscience has discovered in brains. The benefits of this research may be the discovery of computing structures that are more powerful and learn more generally than the structures currently used.

ii. Science of Large Data research is focused on pursuing theoretical developments and innovations to provide immersion in high dimensional data and very large-scale sets. These efforts are dedicated to discovering, evolving, and maturing analytic algorithms that efficiently scale to facilitate rapid analyses of massive data sets. The primary goal of this research area is to realize Army-relevant, high accuracy, predictive models based on massive data sets, which take advantage of emerging computing architectures. Additional areas of relevant research interest is maturation of methodologies to reduce data set dimensionality prior to modeling, thereby greatly shortening computational time.

iii. Computational Methods for Large-scale data analytics research is focused on identifying, evolving, and maturing innovative computational algorithms and methodologies to describe, model, simulate, solve, explore, and optimize control and coordination of computational systems impacted through physical events. Dynamic discrete event systems are data intensive and exist in many technological applications relevant to the Army, from communications to system-of-systems, to quantum sciences.

iv. Data Intensive Computing Methods include the creation of scalable mathematical algorithms, predictive computational methods, real-time data analytics, model order reduction, human cognition based mathematical approaches, neuro- and biologically-inspired methods, science analyzing large-scale data from wearable electronics/technologies, large-scale data sensing/compression methodologies, large-scale visual analytics, live-virtual methods for training, data mining/learning mathematical algorithms for distributed heterogeneous computing systems. Computational scalable algorithmic research in cognitive behavior, artificial intelligence, human-machine interactions, and autonomous networks is also integral to this work. Novel methods to create systems capable of computing in memory and accommodating large amounts of unstructured data storage are critical to far-term success.

v. Machine Learning and Artificial Intelligence research focuses on the development of new methods and algorithms, and how to optimally implement these approaches on emerging and specialized processors. The focus is to allow for novel discovery methods using machine learning and artificial intelligence approaches, and also optimized processing speeds to allow for satisfaction of fixed-time response requirements found in applications such as autonomous maneuver.

TPOC: Manuel Vindiola, (410) 278-9151, manuel.m.vindiola.civ@army.mil.

c. Computational Modeling of Complex Systems

The subject topic concentrates on the fundamental aspects of CS to enable multi-disciplinary and multi-scale modeling and simulation (M&S) to predict, quantify, assess, and optimize the performance and response of complex systems, and system of systems, enabling rapid design, development, and transition particularly in cases where laboratory experimental approaches are costly and difficult to conduct, and/or are not feasible. Proposals are requested for the following areas:

i. Computational Mathematics and Algorithms research encompasses a range of disciplines seeking computational methods to solve fundamental equations. Solutions may be sought for existing equations, or new equations may be developed expressly for the purpose of treating problems of interest to the Army. Problems in which the equations can be expressed in the form of partial differential equations stem from the basic science and engineering disciplines spanning characteristic length scales from sub-atomic to continuum, neural signals, stochastic variables, and design theory. Broad classes of problems may also require considerable specialization of solutions based on the platform used to obtain them.

ii. Scientific Computing Research seeks understanding of phenomena that pertain to the scientific pursuits in and across traditional scientific disciplines that lack relevant computational capabilities. The problems are interdisciplinary, multi-physics with disparate intrinsic length and time scales. The equations, algorithms, and conceptual representation can change with respect to multi-dimensions (including space and time traversing scales or crossing the boundaries between scientific disciplines). Simulations bridging multi-scale domains are instrumental in discovering and revealing mechanisms and physics-based predictions (e.g., in materials, chemical and biological dispersion; micro-systems; biological ecosystems; and computer and human networks). High fidelity computations at the individual relevant scales, as well as research into mathematics and computational algorithms bridging these scales through innovative and scalable methodologies, including finite element methods, particle methods, and meshless methods applied to Computational Mechanics, Computational Fluid Dynamics (CFD), Computational Structural Mechanics (CSM), Computational Electromagnetics and Acoustics (CEA), and Computational Chemistry and Materials (CCM), are required.

iii. Applied Computer Modeling and Analysis is focused on using predictive and reliable computational capabilities and tools to impact the design and deployment of critical Army systems and devices. CS-based enabling tools are required to perform large-scale system analysis from complex model development to detailed analytics. This includes innovative and scalable methods for Discrete Event Simulation (DES) that can be useful to a wide variety of performance and optimization problems in complex Army systems.

iv. Uncertainty Quantification (UQ) research is focused on determining and quantifying simulations performance as intended, considering the range of conditions where models and simulations reproduce observed behavior within acceptable tolerances and established confidence levels. UQ research is concerned with novel and efficient concepts and methodologies for high-fidelity assessment on the level of agreement in sets of models relative to input and output data, as well as the variations in interdependent models due to various physics, mathematical, and numerical assumptions. UQ methodologies, integrated with data sciences and machine learning will enable tools for: (1) identifying deficiencies in simulations; (2) setting guidelines for adequacy of computational results; (3) exploring the impact of known variability and uncertainty of input; and (4) control of adaptive algorithms to achieve specified levels of accuracy to aid decisions from design to operational planning.

v. Multi-scale Modeling focuses on the development of new systems and models of complex phenomena by significantly reducing development time and evaluation costs. This goal can be achieved with: 1) high-fidelity physical models at multiple scales; and 2) computational methodologies (numerical methods and associated algorithms) to enable rapid creation of new high-fidelity multi-scale computer models of complex systems capable of utilizing modern extreme-scale computing.

The success of multi-scale modeling hinges on the ability to combine at-scale models into a multi-scale model. However, few numerical methodologies and associated algorithms have been developed so far to enable such scale-bridging. Moreover, many at-scale models are extremely demanding computationally and render any multi-scale model utilizing them unsuitable for practical applications. While surrogate modeling allows reduction of this computational cost, most methodologies for surrogate modeling are global, and thus are characterized by a relatively high cost. New adaptive, non-local surrogate modeling methodologies are needed, which can bring the computational cost to tractable levels. Finally, at-scale models are frequently endowed with uncertainty due to various sources, such as natural fluctuations, model parameters, or model form. This uncertainty and natural variability must be consistently incorporated into multi-scale computer models in order to enable computational design.

(1) Four main areas will be the focus of the effort in multi-scale CS:

(a) Hierarchical Multi-scale Framework
(b) Discrete Dislocation Dynamics
(c) Phonon and Electron Transport
(d) Density Functional Theory

(2) The strategic approach to these focus areas include:

(a) Shortened development time and evaluation costs of novel energetic materials by allowing macro-scale response to be accurately predicted directly from composition and chemical reactivity at the molecular level.

(b) Development of novel materials for battery applications through expedited computational evaluation of potential compositions.

(c) Advanced Soldier protective equipment and vehicle occupant protection through accurate multi-scale prediction of skeletal fracture in comprehensive analysis and design simulations.

(d) Accelerated material development for Army applications enabled by high-fidelity multi-scale simulation methodologies (Materials by Design).

vi. Interdisciplinary Sciences research includes the development of fully validated, large-scale parallel software, which will simulate multi-scale, complex systems in multiple technology areas. This software will integrate diverse temporal and spatial scale models, some running concurrently for highly coupled system components, and others sequentially, as dictated by the system functionality. The highly coupled model components may be separate executables, running at different time scales and potentially on different computational platforms. Some of the components may be commercial or third-party software packages where only the executable is available. The data exchange and particulars of the execution would be transparent to the user. Multi-scale analysis and material by design are supported through this scalable computational methodologies and software. The system software would be integrated with optimization algorithms and capabilities for determining design sensitivity and UQ. Use of reduced order models will provide varying levels of computational speed and fidelity for different needs, and will facilitate coupling through reduced data sets across distinct physical representations of system components.

TPOC: Ernest Chin, (410) 306-1988, ernest.s.chin.civ@army.mil, and Jarek Knap, (410) 2780420, jaroslaw.knap.civ@army.mil.

d. Computing Sciences for Advanced and Unconventional Computing Architectures

Focuses on understanding and exploiting the fundamental aspects of hardware and associated system software for emergent and future computing architectures for mobile, scientific, and data intensive applications. Computing systems include both mobile and fixed/virtual architectures optimized for fast communications, low power consumption, large hierarchical memory, novel and robust algorithms, high resiliency, and HPC networking. Computing science is focused on developing the understanding, tools, techniques, and methodologies to fully exploit emerging computing architectures through realization efficient parallel task algorithms and take advantage of memory hierarchies. These efforts are expected to greatly reduce the time required to re-state algorithms in parallel form and with correct implementation faults and bugs.

i. Programming Languages and Processes research is focused on exploring research activities on adaptable operating system, behavioral programming languages, domain specific

languages (DSL), and novel libraries. DSL's will raise the level of abstraction of the codes that programmers write, both to maintain portability across increasingly diverse hardware and to give the language implementation more scope for choosing the best route to map a program on to the most appropriate computing hardware.

ii. Programming Environments (PE) research is focused on simplifying HPC processes associated with application analysis and software development. Application enabling and data sharing environments are focused on assisting scientific software developers, scientists and engineers, and software users with ease of using evolving computing systems for data intensive applications. Disparate data from scientific simulations, experimental, sensors, and observations pose research challenges in making seamless integration with evolving computing systems.

iii. Software integration is focused on using components of different application software, and integrating software modules to achieve a different functionality. One approach to achieve better software, more quickly and at lower cost, is to adopt a design process that is based on systematic software reuse. The evolution of computing infrastructure is creating new challenges, ranging from energy-aware software development to software for massively parallel and distributed systems.

iv. Distributed Computing-Based Algorithms for Quantum Networks and Quantum Control addresses one of the key roles of HPC for the Army: rapid processing of data that is obtained from sources distributed over different platforms and locations. Exploiting quantum phenomena has the potential to harness distributed information in powerful new ways, and may also allow distributed processing of such information well beyond present capabilities. The goal of this effort is to:

(1) Understand how to design and control quantum networks to harness and process information from distributed sources, and how to do so securely and efficiently.

(2) Explore how quantum networks may gain an advantage over traditional parallel processing by applying distributed operations to distributed information. An important enabler for this research is the ability to model and simulate quantum networks. A significant part of this effort is therefore devoted to developing efficient methods for modeling and simulating open quantum systems and networks of these systems.

v. Co-Design of Algorithms and Hardware for Unconventional Computing Architectures research addresses the issues associated with advanced computing architectures that are becoming more complex with memory hierarchies, which are laid out as parallel processors with multiple processing cores. To harness the computational capability of these advanced computing architectures, new algorithms and software development paradigms are needed, especially for the future Army S&T campaigns. In addition to petascale and beyond capability, there is a need for new architectures and algorithms, such as non-von Neumann systems like neuromorphic and quantum computing. Key goals include the development of algorithms and

techniques to address power, performance, portability, and efficiency through the construction of domain specific architectures, scalable algorithms, and programming models. Representative thrust areas include:

(1) Threaded message passing to allow for massive on-core RISC (reduced instruction set computer) -based architecture parallelism.

(2) Compiler-based software deployment, on neuromorphic architectures, focusing on a single control flow construct as a baseline.

(3) 3D rendering coupled with 3D printing of scientific visualization and modeling predictions of experimentation for verification, validation, and uncertainty quantification

TPOC: Dale Shires, (410) 278-5006, dale.r.shires.civ@army.mil, James Ross, (410) 278-9556, james.a.ross176.civ@army.mil

e. Supercomputing Technologies

Focuses on delivering world-class HPC capabilities to the DoD S&T and Test and Evaluation (T&E) communities. These capabilities provide DOD scientists and engineers with the resources necessary to solve the most demanding computational problems. The capabilities include large scale HPC systems, high speed networks, multi-terabyte archival mass storage systems, data analysis and assessment, and computational software expertise.

TPOC: Howard Kash, (410) 278-6507, howard.m.kash.civ@army.mil.

f. Distributed Simulation, Integration, and Interoperability

Existing simulation systems can be characterized as black boxes that interface externally allowing internal computations to be non-standard between models representing phenomena, which introduces fair fight issues and additional inconsistencies. Moreover, the desired contemporary uses of simulation often call for the ability to access simulation capabilities at the point of need. In parallel, computer science and computing technology continue to evolve providing unique opportunities for innovation in simulation.

The Distributed Simulation, Integration and Interoperability CCE researches and develops methods and means to enable a simulation architecture that is truly based on composable models and services as opposed to the traditional method of various simulations interoperating. It aims to enable robust Army simulation capabilities with composable synthetic representations delivered where they're needed in the form in which they're needed.

ARL is interested in research studies, demonstrations and development involving areas such as:

(1) Methods and means that enable a single simulation architecture capable of supporting complex real-time and non-real-time uses

(2) M&S as a service across geographically distributed areas

(3) Application of advances in computing to the simulation domain

(4) Novel encapsulation of military representations, models and data

(5) Exploration of Digital Engineering, Model-Based Systems Engineering and other trade space analysis methodologies in the context of simulation environments

Research activities should be demonstrated through uses cases relevant to the six Army M&S Communities (Acquisition, Analysis, Experimentation, Intelligence, T&E and Training).

TPOC: Christopher McGroarty, (407) 208-3323, christopher.j.mcgroarty.civ@army.mil.

2. MATERIALS RESEARCH (MR) CAMPAIGN

The MR Campaign focuses on fundamental research to provide superior materials and devices needed to achieve lasting strategic land power dominance. MR cross-cuts ARL's four focused S&T campaigns by providing materials with superior properties to address emerging requirements and capabilities for all Army platforms. The Army of 2030 will require materials with unprecedented capabilities that can be rapidly grown or synthesized, and processed cost-effectively to enable Army platforms that are highly mobile, information reliant, lethal, and protected.

The MR Campaign has developed six KCIs, three CCEs, and four MR-related topics that are designed to address the future Army's need to rapidly respond to emerging threats and to eliminate tactical surprise – caused by the proliferation of advanced technology by our adversaries – by creating a materials by-design and on-demand enterprise; and a manufacturing science engine to ensure rapid progression from materials discovery to delivery, with the goal of producing materials in greatly reduced timeframes and at a fraction of the cost compared to today.

a. KCI-MR-1: Materials for Soldier and Platform Power Systems

Design of Soldier and platform power as a system is required to enable indefinite power for tactical units and significantly reduces the logistics tail for power resupply. To accomplish this requires significant materials and device advancement in the areas of alternative energy, advanced energy storage, and energy conversion. This KCI focuses on increasing power supply in the three focus areas: (i) Alternative energy; (ii) Advanced energy storage; and (iii) Energy conversion technologies.

The Alternative Energy area focuses on developing ultraenergetic materials and radioisotope power sources. Radioactive isotopes represent the greatest possible energy density, about 10^8 Wh/kg, achievable without the use of nuclear reactors – at more than 100,000 times the intrinsic energy density of chemicals, radioisotopes are truly ultra-energetic materials. Isotopes and isomers of greatest interest are those with half-lives exceeding 10 years, while their corresponding ground states may be stable or, in many cases, unstable. A research objective in support of the application of this technology is to understand the physics underlying radiation hard materials, and to measure efficiencies for related power sources. As a separate technology, wireless power is focused to enable truly wireless distribution in which loads and sources are free to move while maintaining power levels and efficiency.

The Advanced Energy Storage area focuses on developing new materials and components for very high energy density and high power density batteries as well as novel energy storage technologies for Army capabilities. Battery research is focused on developing new materials for high voltage, high temperature, extended cycle life, and high power energy storage for military environments and applications. Development of embedded, flexible, multifunctional structures that provide the required structural and power/energy performance under combined load without compromising the safety or integrity of the target platform are being sought.

The Energy Conversion Technologies area focuses on mechanical and thermal conversion systems, used to generate electrical energy from Soldier power systems to base level power generators or to generate mechanical energy for ground and air vehicles. Efforts are focused on compact thermal sources that generate thermal energy efficiently from transportable fuels. A primary goal is to integrate the thermal source with thermal-to-electric energy converters for Soldier and Soldier system power sources capable of 1000 Wh/kg energy densities. Fuel cells as energy conversion devices offer improvements in energy density; however, miniaturization and cost reductions are necessary. Acid-alkaline hybrid fuel cell stack designs can help meet these needs and motivate the development of anion exchange membranes (AEMs). The JP-8 reformation research and development (R&D) program is directed at reformation of JP-8 fuel into a hydrogen rich alternative fuel for downstream power generation. Essential will be the development of liquid phase desulfurization process and Pd-composite membrane for hydrogen separation.

i. Electrochemical Power Production and Energy Storage areas of interest are:

(1) Active and Reserve Primary Batteries for Munitions Applications: Research of new battery chemistries, materials, and battery designs for improved thermal and liquid electrolyte reserve batteries capable of supplying power densities from 20 to 400 Watts/liter after 10 or more years of storage. Primary areas of interest are: thin-film thermal battery chemistries, materials, components, or production methodologies for batteries with faster activation, higher power, smaller volume, more-flexible form-factor, greater mechanical robustness, or better production efficiency; and new forms of heat sources that would be compatible with the thin-

film thermal battery technology. Storage and operation are required over the full military temperature range.

(2) Primary Lithium Batteries: Research in battery chemistries for cells and stacks of cells for man-portable applications using environmentally-friendly materials capable of providing better service than the Army's present general-purpose Li/SO2 and Li/MnO2 batteries. Emphasis is on modification of commercial chemistries to permit all-weather storage and use. This may include Li/air, Li/S and Li/CFx formulations. The development of manufacturing technology for these batteries is an area of interest.

(3) Rechargeable Li (Li-Ion) Batteries: Research in electrode and electrolyte materials for cells and stacks of cells using liquid or polymeric electrolytes capable of providing, at the packaged cell level, specific energies greater than 250 Wh/kg, specific power greater than 50 W/kg continuous, and greater than 10 kW/kg pulse power over the full military temperature range. Hybrid energy storage technology that provides both high power and extended cycle life, beyond conventional Li-ion, at a moderate energy density. The development of manufacturing technology for these batteries is an area of interest.

(4) Advanced battery chemistries to include multivalent materials such as magnesium and aluminum. Research of components, especially electrolytes and cathodes to allow stable operation. Research in Aqueous Li-ion to provide high energy and safe li-ion batteries for Soldier carried applications. Investigation in Lithium rechargeable batteries including Li-S and Li-Air as well as development of new cathodes and electrolytes for rechargeable lithium batteries that reduce or eliminate dendrite formation. Advanced solid electrolytes for all solid state batteries and molten salt batteries including advanced processing of solid electrolytes into dense robust membranes required for cell manufacture.

(5) Batteries for grid storage applications that include molten salt batteries, dual intercalation batteries, and aqueous electrolyte storage batteries.

(6) Fuel Cells: R&D of improved low temperature alkaline and acid based polymer electrolyte membrane fuel cells and components including catalysts for use with alcohol and solid fuels. Use M&S to solve and improve fuel cells performance. The development of hydrocarbon fuel reformers and reformer components, including desulfurizers and sulfur tolerant reformer catalysts to provide hydrogen for fuel cells are areas of interest. The development of medium and high temperature fuel cells and components for the direct utilization of hydrocarbon fuels or impure hydrogen is also an area of interest.

(7) Fast Discharge Pulse Power Capacitors: Research of film capacitor technology including the development of high energy density dielectric films, impregnants, metallization and manufacturing technology for capacitors that can provide energy densities > 2.0 J/cc with a DC life over 2000 hours, and discharge time is the microseconds range.

(8) High Temperature Capacitors for Power Electronics: R&D of high temperature polymeric dielectrics including process development for high temperature thin film manufacturing. The capacitors made of such thin film dielectric should be operable at temperatures over 125oC, preferably over 150 degrees C. The capacitors shall have the following characteristics: a dissipation factor below 0.5 percent, insulation resistance greater than 105 ohm-farad at 125oC, operational life of greater than 10,000 hours at frequency greater than 20 kHz and rms current greater than 1.0 A/microfarad.

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ii. Ultra-Energetic Materials and Energy Storage areas of interest include, but are not limited to, the following:

(1) Radioisotopes and Nuclear Isomers: Develop and study approaches to the control of nuclear emission and/or nuclear decay rates. Investigate nuclear structure of isomeric nuclei, particularly focused on long-lived isomers from which gamma or charged particle emission could be utilized for power sources.

(2) Radioisotope/Nuclear Isomer Energy Conversion: Develop and study improved concepts for conversion of nuclear decays into usable electrical power. Techniques using liquids or novel materials are of interest for long-lived micro-power sources.

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iii. Topological materials for energy efficient electronics operating at or near room temperature. Research interest includes, but is not restricted to, the following:

(1) Molecular beam epitaxy (MBE) growth and characterization of thin layers of topological materials (topological insulators, Dirac and Weyl semimetals, topological superconductors).

(2) Theoretical and experimental investigation of the magnetotransport properties of topological surface states of three dimensional topological insulators, and the magnetotransport characteristics of two-dimensional topological insulators.

(3) Topologically enabled devices and technology based on active heteroepitaxial interfaces between topological materials and ferroic materials, as well as topological materials and high temperature superconductors.

(4) Investigations of proximity-induced superconductivity in topological materials.

(5) Magneto-terahertz investigations of topological surface states of three dimensional topological materials.

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b. KCI-MR-2: Energy Efficient Electronics and Photonics

ARL aims to discover, design and develop future electronic devices, circuits, materials, microelectromechanical systems (MEMS), on-chip energetic materials, and heterogeneous integration techniques that enable order of magnitude reductions in the power-draw of systems for Soldier and small platforms while maintaining or increasing functionality. Novel circuit topologies combined via heterogeneous integration with emerging electronic and photonic devices on conventional substrates such as silicon will enable new energy efficient front ends that result in longer mission lifetime for Army systems. Advanced wideband gap devices will be critical for smart power management as well as highly efficient radio frequency power amplifiers for assured communications and electronic warfare (EW) applications. Advanced electronic materials work may comprise: two dimensional materials; active heterogeneous interfaces; photonics sources and detectors and topological phases of matter to reduce the power demand of future electronic and photonic systems. MEMS offer alternative ways to enhance electronic devices and extend their capabilities to offer novel power management approaches, no or lower-power overall power solutions for electronics devices, and enable energy efficient system level approaches for highly adaptable, tunable, and reconfigurable electronics. On-chip energetics offer a way to generate energy at the chip level reducing overall system size, weight, and power requirements as well as adding new functionality not available via traditional electronics. Ultimately, the heterogeneous integration of novel electronic and photonic materials with conventional substrates such as silicon will open up a new paradigm for Army systems.

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c. KCI-MR-3: Agile Expedient Manufacturing

i. Novel Synthesis and Processing Methods

(1) The objective of the Agile Expedient Manufacturing KCI is to enable adaptive, rapid, and low cost fabrication of replaceable parts that are certified for service through the development of novel synthesis and processing methods. The subject KCI's objectives includes 2D and 3D hybrid electronics assembly and packaging concepts for sensors and systems. Manufacturing capabilities developed through this effort are expected to enable 3D additive approaches that facilitate alloying-by-design concurrent with (near-) net-shape fabrication with reduced time from raw material to finished component. Research contributing to this goal includes the system thermodynamics and kinetics within a meta-stable environment of rapid heating, material melting, alloy mixing, cooling and solidification, and solid state transformation throughout the entire 3D additive manufacturing process. Materials (commercial off-the-shelf (COTS), bio-derived, indigenous, and specialty materials) of varying length-scale and morphology (nano, multi-phase, 2D/3D composites, and coatings) and various material classes (metallics, ceramics, glasses, polymers, and composites) are the basis from which property datasets are

established for component design. Designing and producing the precursor materials is a key component of this effort. Further, this work is focused on developing a better understanding of the preconditioning, and tailoring of precursor materials for thermomechanical processing to achieve the designed properties and performance. The 2D and 3D hybrid electronics shall support the development of additive processes for flexible electronics and 3D hybrid electronics and research in components sensors that include, but are not limited to, Soldier health monitoring, asset monitoring, communications, antennas and navigation, and soft robotics. Related topics that engage education and workforce development are also of interest.

(2) A second objective of the Agile Expedient Manufacturing KCI is to develop multi-material 2D/3D small-scale fabrication of polymer/ceramic/metallic composite prototypes tailored for light weight and rapid field deployment. These devices can incorporate a combination of features to include electronic, mechanical, or material/coatings with tailored electromagnetic spectrum (EMS) characteristics, that when fabricated via AM can produce defined responses replicating military targets of interest across a variety of tactical sensor systems. This includes the ability to also reproduce and re-design commercial components integrated with new and novel EMS materials/capabilities at a wide range of scales (mm to meters).

(3) A third objective of the Agile Expedient Manufacturing KCI is to develop a multi-material 2D/3D composites capability for fabrication, characterization, and printing of polymer/ceramic composite electromagnetic and conductive materials for antennas and other radio frequency devices. Increased versatility of additive manufacturing (AM) in the RF design space requires high dielectric substrates. AM filaments with dielectric constants greater than 6 are not commercially available. Research investigating methods for extruding high dielectric AM filaments through a robust and repeatable method that allows for the printing of AM substrates with a given value of dielectric constant is paramount. Furthermore, characterization of complex dielectric constant from ultra-high frequency (UHF) through Ka-band will be required. A final need for 2D/3D composites is research in the area of conductive inks. Conductive inks can achieve conductivity of five to ten times less than bulk copper, but require sintering at temperatures above 175 degrees Celsius. 2D/3D composites printed from polymer-based filaments will melt at these temperatures, preventing the goal of hybrid 3D printing of RF components and antennas. Alternative methods, such as localized laser sintering or flash annealing are examples of research methods hoping to achieve high conductivity in the presence of 3D printed polymer substrates.

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ii. Convergent Manufacturing

Development of transformational materials for Army modernization requires materials that

can operate in extreme conditions. Transformational supermaterials and high-performance interfaces that will take advantage of emerging advanced manufacturing processes to embed integrated functionalities with complex geometrical structures, achieve novel ballistic, thermal, and mechanical response. As such, advanced manufacturing is critical to developing innovative materiel for the Department of Defense (DoD's) modernization efforts and for enabling point of need manufacturing for warfighter readiness. Additive manufactured (AM) products produced at point-of-need can enable US Army transformational overmatch of adversarial capabilities. However, most additive processes produce materials that are inferior to bulk manufactured parts; there is limited ability to utilize multiple materials that are significantly different from each other. Also, most additive processes still require separate subtractive (e.g., removing build plate and other milling, cutting, and sometimes drilling steps) and transformative (e.g., annealing, hot isostatic press, post-curing) processes to manufacture the final part.

Current manufacturing is in separate silos according to manufacturing method and material. Convergent manufacturing (CM) is the next generation of manufacturing that will bring together disparate manufacturing strategies and classes of materials leading to transformational capabilities and enhanced capabilities at point of need at a speed faster than additive processes. Convergent manufacturing combines virtual manufacturing, manufacturing processes including bulk, additive, subtractive, transformative, process monitoring and control, heterogeneous materials in one connected platform to yield functional devices and components.

To fully exploit CM as a tool for the warfighter, requires additional research and development (R&D) to foster improvements and combinations in the CM processes and applicable materials. These include design for convergent manufacturing, integrated computational materials engineering (ICME) for CM, digital twin for CM, in situ monitoring of CM, manufacturing at multiple scales, co-manufacturing of multiple classes of materials, and layer-by layer transformative manufacturing according to a recent study by the National Academies. The focus of 6.1 efforts are: 1) Convergent Manufacturing of Dissimilar Materials and 2) Hybrid Manufacturing Advancements for Manufacturing at Multiple Scales. Proposals should focus on 1-3 of the sub-goals defined below (i.e., Focusing on all of these goals below is too broad for one particular project). Projects should address the corresponding priority science questions (PSQ) within each focal sub-goal.

(1) Convergent Manufacturing of Dissimilar Materials - The goal of this aspect of the work is to be able to converge manufacturing from separate silos based on material class into a common manufacturing cell using multiple classes of materials and produce useful materials with enhanced performance in one or more ways. Gradient materials represent an excellent way to achieve higher performance (e.g. thermal, shear) at a surface while maintaining reduced cost of improved bulk strength. Layer-by layer designs of compliant and stiff materials may provide excellent energy absorbers. In all, modeling of such designs to be able to identify potentially beneficial designs using ICME for CM is an important goal, but cannot be the major focus of this manufacturing SoN. Potential additional detail, challenges, and knowledge gaps, on these sub-areas are indicated below:

(a) Advances in Digital Build Mapping - Develop computational methods validated by experiment that create a digital twin of builds prior to manufacturing that enable complete control of the material composition at each voxel. Improve the resolution of existing methods to enable more precise and fine deposition of specific material classes in a multi-material build. PSQ: What methods can we develop to we accurately predict a build's structure and performance under static, dynamic, and thermal loading so that qualification and performance standards can be developed for components produced by convergent methods?

(b) In-Situ Processing Optimization and Control - Acquire and utilize data from in-situ monitoring of convergent manufacturing processes (see 2 below) in artificial intelligence (AI) and machine learning (ML) efforts to identify conditions and indicators linked to processing defects. Develop in-situ methods to identify potential defect formation and adjust manufacturing parameters to mitigate or eliminate them. PSQ: What are the indicators and causes of processing defects, how can they be detected in process, and how can the manufacturing process be adjusted on the spot to avoid or mitigate said defects to ensure high quality of the manufactured part?

(c) Understanding and Enabling Multi-Material Builds - Projects proposed can focus on composites of any two types of material class (polymers, ceramics, and metals). Develop manufacturing solutions that enable to conjoining of dissimilar material classes (ceramics, polymers, and metals) and their effective integration into a single build. Study the phases and chemistry of interfaces in order to enable diffuse bonds that are mechanically strong. Enable selective sintering or consolidation of a specific material class in the composite, without the degradation of the other material classes. Create feedstocks capable of enabling multi-material designs. PSQ: How do you design and manufacture high performance interfaces between multiple material classes using advanced manufacturing?

(2) Convergent Manufacturing Advancements for Manufacturing at Multiple Scales - The goal is to use convergent manufacturing platform to enable bulk, additive, subtractive, and transformative manufacturing. The use of additive and subtractive together to achieve high fidelity geometries than cannot be achieved with additive alone is important. In addition, methodologies for more rapid manufacturing using hybrid/convergent techniques must be developed. Current manufacturing approaches either uses capital-intensive bulk manufacturing or AM with one manufacturing length scale. More flexible approaches integrating bulk and finer processing methods are needed to enable more rapid manufacturing. Potential additional detail, challenges, and knowledge gaps on these sub-areas are indicated below:

(a) Convergent Manufacturing Methods for High Performance Builds - Novel methodologies to achieve high performance materiel through additional processes that change the properties of the material. Novel voxel-by-voxel or layer by layer transformative manufacturing, in addition to additive and subtractive manufacturing

are strongly encouraged. Novel methods for implementing additive and subtractive manufacturing methods onto existing parts to be able to achieve different surface performance than the bulk are of significant interest, but must be coupled with other basic research work. PSQ: How do you effectively transform materials to achieve desired chemistry, morphology, properties, and performance during manufacturing to achieve improved performance through convergent manufacturing?

(b) Multi-scale Manufacturing Approaches - Advance the speed of hybrid manufacturing processes by integrating rapid, but low fidelity manufacturing techniques with slower and higher fidelity methods. (e.g., laser milling layer by layer on a cast part to achieve small feature sizes, additive and subtractive manufacturing on the surface of a rough build to achieve different properties and dimensional tolerances.) ICME and other methodologies that integrate a multi-scale approach to creating a realistic digital twin that can be utilized for developing a manufacturing procedure should be developed. These methodologies should incorporate different material processes, identify the processes most suitable for different aspects of the build, and develop a precise and time optimized hybrid manufacturing approach for fabrication. PSQ: Which length scales are critical to achieving multi-material designs?

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d. KCI-MR-4: Quantum Sciences

Over the past century, the quantum principles of superposition, electronic structure, and uncertainty relations gave us tremendous advances in a number of applications relevant to the military, including atomic clocks, magnetometry, PNT, and gravimetry. While these areas can still be improved through technological advances, next generation gains in sensing and in secure communications will occur through the concept of quantum entanglement.

An ideal approach to investigating entanglement is through exploration of a quantum network, in which quantum information and processing can be stored in quantum memories at multiple nodes. Great advances have been made to increase the fidelity of critical quantum components needed to establish a resilient network of quantum entangled resources in various atomic and solid-state systems. Although several research groups have demonstrated point-to-point quantum teleportation, entanglement distribution, quantum error correction, and quantum memory, no scalable, integrated, modular architecture exists by which one can connect three or more quantum nodes and through which quantum information may be processed.

A particularly critical requirement is the establishment of efficient light-matter interfaces, which enable photons to be written into and read from a quantum system. The in-house Quantum Sciences effort working cooperatively with academia and industry will investigate this aspect of an entanglement-based distributed quantum network. Specifically, we will explore both ensemble quantum systems (neutral atom gases and rare-earth stoichiometric crystals) and single qubit systems (ion traps and solid state defects). Examples of approaches to enhanced light-matter interactions are cavity QED and nanophotonic integration. Additional efforts within this program are to explore Army-relevant applications for such distributed entanglement; identify performance limitations of a distributed heterogeneous quantum network that must be overcome or are fundamental. Specific material components include quantum memories, quantum registers, quantum processors, quantum switches, quantum frequency conversion devices, entangled photon sources, single-photon detectors, matter-photon interfaces, quantum sensors, as well as other technologies enabling the realization of integrated, chip-scale and/or modular components for robust, mobile distributed quantum information networks.

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e. KCI-MR-5: Energy Coupled to Matter (ECM) for Responsive Materials

ECM is an emerging technology that goes beyond the traditional process optimization factors of scale, composition, temperature, and pressure. The research focuses on the understanding that energy transfer is non-linear. Design of Experiments (DoE) methodologies are coupled with modeling as one approach to understanding the physics of energy transfer in the synthesis and processing of materials under high and multi-physics fields (e.g. electric, magnetic, acoustic, microwave, radiation, and others). This work pursues innovative physics-based approaches for controlling the thermodynamic behavior of metals, intermetallics, polymers, ceramics and hybrid composite systems. Manipulating transformation pathways in favor of new non-equilibrium alloys, aligned phases, controlled nanoscale architectures, and producing materials with revolutionary, on-demand, permanent or temporary material properties or shape changes will provide an unparalleled opportunity for advanced materials. Additionally, materials developed using ECM principles will have been designed and transitioned for application to enable adaptive ”on-command” protection technologies by diverting, bending, and fracturing ballistic threat projectiles with greater efficiency, thus reducing system weight and volume. Further, higher strength projectiles fabricated through ECM MR will be used as a foundation to design lethal effects for defeating future enemy protection systems.

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f. KCI-MR-6: Lightweight Materials

This area seeks lightweight materials of all classes on-demand (flexible and affordable manufacturing innovations) and by-design (from atoms to properties) in order to develop and achieve concurrent materials and system design with significant weight reduction. This

initiative develops and exploits computational materials models, guided and validated by experiments. These models include realistic materials physics, executed at the appropriate length and time scales, to accurately model material composition, (micro)structure, mechanical and physical properties and system performance. This is expected to enable the discovery, design and synthesis of material systems in concert with fabrication and system design not possible today. The material's performance in the system is not only based on materials properties, but also includes the component's functional design as part of the system. Specific research emphasis for discovering new lightweight materials and to quantify their performance in system designs include: a) property-processing-microstructure relationships in lightweight metals (magnesium, aluminum, titanium and high strength-to-weight alloys) within the chemistry, nano-engineering, solidification and thermomechanical processing design space; b) high rate toughening of lightweight armor ceramics that can support vehicular structural loads; and c) common efficient load transfer in hybrid lightweight composites via polymer and hybrid fiber interfacial engineering.

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g. CCE-MR-1: Designing Materials

The MR CCEs in Designing Materials is a sustained effort to systematically build a science and engineering-based capability to design materials and related devices. Whether this be for electron, photon, phonon, mechanical, chemical, or living matter behavior, it relies on predicting and advancing the physics, chemistry, biology, and related engineering between microstructure and performance to enable the design of model materials and devices for Army relevant applications.

Microstructure is the detailed description of materials from the atomistic to the relevant bulk scale for functional and performance purposes. Performance is the material system constitutive behavior in its passive or responsive state detailed by the combined intrinsic and extrinsic physical, biological, and chemical properties. Examples of materials and device performance goals are those identified in MR KCIs in Quantum Science, Energy Efficient Electronics and Photonics, Materials for Soldier and Platform Power Systems, Lightweight Materials, ECM and Responsive Materials, and Agile Expedient Manufacturing. To achieve the ability to design materials, the fundamental scientific requirement is the ability to effectively characterize the material state (microstructure) at the relevant length scales, and accurately predict through physics-based models and mechanisms the resultant properties of the material and even the final component based upon that knowledge alone. The objective of this MR CCE is to achieve the knowledge necessary to provide model materials and devices designed and optimized for predetermined Army-centric performance requirements.

i. The MR CCE on Designing Materials investigates and advances mechanisms in organic, inorganic and living material microstructures relevant to three performance challenges:

(1) Materials and devices to resist and perform under extreme dynamic, thermal, mechanical, chemical, biological environments; this effort considers all material classes.

(2) Materials and devices to absorb, divert, convert, emit, detect, and direct the electromagnetic space. These include photonic, spintronic, and electronic devices, as well as electrochemical energy devices and biology enabled/enhanced devices.

(3) Materials and devices to store and control rate-release of energy including device design work-such as on-chip pyrotechnic devices. These include battery materials; fuel cells; and other components.

ii. The strategic approach to these focuses include:

(1) Application of multi-scale M&S tools for articulation and virtual exploration of scientific mechanisms, bridging the material length and time scales, for a predictive design tool. Integrated materials by design capabilities for structural, electronic, electromagnetic, power and energetic materials for ARL KCIs and Army relevant material challenges.

(2) Bio-inspired materials from living matter and systems/synthetic biology to design materials at a high degree of fidelity and unparalleled control.

The integrated CCEs in Designing Materials, Materials Synthesis and Processing, and Materials Characterization and Discovery will be the foundation to leap ahead from Integrated Computational Materials Science and Engineering, to Ab Initio Design of materials and devices, to Production for Performance.

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h. CCE-MR-2: Materials Synthesis and Processing

The purpose of this MR CCE in Materials Synthesis and Processing is to advance the fundamental sciences in synthesis and processing enabling fabrication of Army relevant materials and devices. New approaches and innovation in material synthesis and processing are necessitated by emerging requirements to explore new material systems, optimize materials for Army applications, and develop new processing methods to realize and transition materials to Army relevant applications. The desired synthesis and processing science will enable fabrication from atomistic-design to engineering bulk material and devices. This knowledge based research will seed synthesis and processing innovations in manipulating organic and inorganic matter to build materials with precision placement of atoms or with biological building blocks from design.

In creating and broadening an opportunistic environment in synthesis and processing science for materials by design, three research foci will be emphasized:

i. Synthesize, refine and tailor precursor materials' chemistry and microstructure and subsequent processing methods to achieve the designed material specification as well as using biological systems leading to biologically inspired and/or derived synthesis of materials and devices.

ii. Layer and construct materials, including 1 dimensional seeding, 2 dimensional surfaces, up to 3 dimensional bulk or layered element-by-element deposition methods, controlling the progressive material structure and properties systematically.

iii. New methods for characterizing material properties for device-level modeling and selectively etching, depositing, and patterning synthesized and deposited materials to realize functional devices.

This MR CCE in Synthesis and Processing will provide the underpinning sciences and engineering to deliver tangible materials from model material by design to support all the KCIs where materials are needed on-demand.

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i. CCE-MR-3: Materials Characterization and Discovery

The R&D of technology that can fully detail atoms-to-meters of materials will enable not just validation of what was predicted, but also discovery of the unexpected and the unknown. This MR CCE in Material Characterization and Discovery, in conjunction with the Materials Design and the Synthesis and Processing MR CCEs, is foundational and the door to future disruptive and un-planned discoveries enabling the MR KCIs in Quantum Science, Efficient Electronics and Photonics, Power for Soldier and Platforms, Lightweight Materials, ECM, and Agile Expedient Manufacturing.

Contemporary methods to interrogating materials include a suite of spectroscopy, microscopy, and experimental characterization. Within each of these methods are extensive research and efforts to attain higher fidelity, better resolution, better consistencies, and in less time. The ARL continues to focus on advancing these techniques to explore materials enabling disruptive technologies for the Army.

The MR CCE on Materials Characterization and Discovery is grounded on:

(1) Designing and developing mechanistic-focused experimentation,

(2) Enhancing and developing novel spectroscopic, microscopic and experimental techniques in conjunction with the other MR CCEs to enable the MR KCIs, and

(3) Developing real-time full spectral probing, sensing, analytics and informatics to enable discovery of the unexpected.

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Materials Research (MR) Related Topics:

j. Photonics

i. Novel Solid State Lasers and Laser Materials: The Army is interested in research on innovative gain media, for example laser-quality ceramics with emphasis on engineerable doping and index profile (e.g., gradient doping, sharp-step wave-guiding structures with sub-10-micrometer diffusion zone); solid-state materials for high-gain stimulated Brillouin scattering (SBS) and stimulated Raman scattering (SRS); specialty fibers and fiber lasers suitable for high average powers and power scaling (e.g., with compositions for ultra-high SBS threshold; fully crystalline double-clad, i.e., crystalline core/crystalline cladding fibers; non-circular, high aspect ratio, fiber designs with well-developed mode selection mechanisms or self-mode selection); and advanced laser materials for diode-pumped eye-safe lasers (e.g., based on high and ultra-high thermal conductivity hosts, environmentally stable low-phonon hosts, or exceptionally high emission/absorption cross-section laser materials).

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ii. Techniques for Power Scaling of Diode-Pumped Solid State Lasers: The Army also has interest in innovative highly efficient pump-coupling techniques; innovative pump diode and active medium cooling techniques (e.g., cooling via optically transparent highly thermo-conductive materials); passive and active laser beam/aperture combining methods; laser wavelength shifting techniques for achieving high average powers with optimum eye-safety; active and passive wave-front distortion compensating/OPD reducing techniques.

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iii. Semiconductor Modeling: ARL has identified a strategic need to foster and accelerate collaborative research related to the modeling of advanced electro-optic semiconductor materials and devices. This Modeling Center will act as a repository of a broad base of modeling knowledge to be shared across the community in order to foster the development of new materials as well as to reduce the timeline between "discovery" and manufacturing. Specific areas of modeling collaboration interest include:

(1) Fundamental materials modeling related to semiconductor growth via molecular beam epitaxy (MBE), metal organic chemical vapor deposition (MOCVD), and atomic layer deposition (ALD). Interests lie in probing the parameter space related to developing new or exotic semiconductor alloy materials and structures encompassing II-VI, III-V, and III-VI systems with applications in the UV, IR, and topological and quantum regimes.

(2) Electrical properties, including carrier transport and dynamics within semiconductor materials and across interfaces; carrier injection, and device performance metrics such as modulation transfer function (MTF) and noise.

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iv. Semiconductor Materials and Device Characterization: ARL has an interest in understanding fundamental materials and device properties of a host of semiconductor based alloy systems that encompass IR, UV, plasmonic, and topological applications. Interest lies in performing structural, electrical, optical, and chemical characterization and relating results back to models developed with the goal of significantly enhancing, or creating completely new capabilities. Some specific areas of interest include, time-resolved photoluminescence, pump-probe measurements, angle resolved photoemission spectroscopy, magneto-transport, and g-factor measurements of topological materials.

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iv. Fast optical switching: The Materials Campaign requires research in transparent nonlinear optical (NLO) materials, electro-optical (EO) materials, metamaterials, and in related components and devices that can reduce their optical transmission across the visible, NIR, SWIR, MWIR, and/or LWIR wavelength range passively, or actively when subjected to an incident laser beam within that wavelength range. Orders of magnitude of reduction of transmission are desired. Materials and devices must be highly transmissive in the initial state. Technical areas of interest include, but are not limited to, the following:

(1) Development of optical materials with large nonlinearities and a broad wavelength and/or pulse-width response. This can include molecular modeling, material synthesis, and characterization of nonlinear parameters as well as nonlinear transmission studies to determine structure-property relationships to improve performance.

(2) Modeling efforts to relate nonlinear material properties to their ability to effectively reduce transmission. Modeling effort should include details on how the nonlinear materials affect the propagation of incoming laser beams.

(3) Development of active broadly tunable metamaterial structures and devices including modeling studies and characterization efforts.

(4) Novel experimental techniques for characterization of nonlinearities, lifetimes, switching speeds, etc.

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vi. Photonic and Integrated Photonics Devices and Modules: Research is encouraged pertaining to active and passive devices as well as fiber based technology for sensing, analog RF signal generation/processing, communication, data and optical signal processing. Active device research includes the development of bulk and integrated sources, modulators, detectors and waveguides, and the development of technologies for their integration into processor architectures. Active interface devices include semiconductor light emitting diodes (LED), lasers, photo detectors, solar cells, modulators, amplifiers and waveguides, with operation in the UV to IR spectral region, as well as integrated drivers and receivers. Also of interests are novel high-bandwidth (10s GHz) photonic devices, components, modules, and subsystems which incorporate $\boldsymbol{\varepsilon}$ & $\boldsymbol{\mu}$ near zero, or negative, metamaterials, high-contrast metastructures, photonic crystals, and/or other novel material concepts. Finally, there is strong interest in integrated photonic research to include on-chip processing, layout, mounting, and device cooling for one, two and three dimensional photonic integrated circuits (PICs) for the following applications: chemical specific sensing, laser ranging and imaging, free space optical communications and radio-frequency photonics.

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vii. Advanced Concepts for Chemical Specific Sensing Applications: ARL is exploring new and enabling detection technologies for human performance and hazardous material sensing applications. The ultimate goal of our research efforts is to develop low SWAP-C point sensors for these field applications. Desirable features of sensor systems include: high specificity in analyte identification, small in size for field portability, low power requirements, low cost, and stability for long periods of time under various environmental conditions. The several key sensor research thrust areas are integrated photonic transduction techniques, direct spectroscopic methodologies, recognition elements (e.g. Molecularly Imprinted Polymers), and health monitoring bio-marker identification. Our current research interests includes development of point and wearable embodiments using mainly optical techniques and technology, including photonic integrated circuits. The desired sensor technologies are not limited to these methods, but may use mechanical or other novel detection methods. Optical technologies include, but are not limited to, new optical sources and detectors for sensors, waveguide structures, optical resonantors, non-linear optics, Raman techniques, and fluorescence with specific emphasis on photonics devices in PIC platforms.

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k. Position, Navigation, and Timing (PNT)

Precision Measurements and Control for Constrained Systems and Contested Environments: Research areas include methods, electronics and algorithms to enable robust state-estimation and control from distributed, heterogeneous, omnipresent, multi-aspect sensors; miniature navigation-grade inertial measurement units (IMUs) leveraging MEMS fabrication; sensor fusion architectures for distributed sensing with IMUs with alternative sensing modalities (e.g.,

vision) or other signals of opportunity; flexible and distributed anti-jam antenna solutions; and non-RF long range transmission of secure timing solutions. Also of interest are free-space time transfer via optical links, or RF links, chip-scale photonic based precision long-holding oscillator/clocks that may incorporate micro-resonators, integrated optical frequency comb, environmental insensitive cavities, as well as quantum/atomic based devices. The goal is to enable innovative solutions providing precision state-estimation, PNT solutions for GPS-denied and contested environments and extremely size, weight, power, and processing constrained systems to generate leap-ahead technologies by pursuing non-traditional materials, integration methods, and system architectures.

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l. Energy and Power

i. Wide Band-Gap Power Devices. ARL is seeking proposals for research of wide band gap devices in the following areas:

(1) Device design and fabrication of monolithic and hybrid voltage-controlled SiC or GaN high-temperature high-field power devices.

(2) High-temperature high-field insulator materials for use as gate dielectric and field passivation layers for application to SiC and/or GaN power devices.

(3) Advanced Technology Computer-Aided Design (TCAD) modeling methods, techniques and/or material models that advance computational efficiency or accuracy.

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ii. Heat Transfer and Thermal Management. Research and modeling in materials and techniques to remove high heat fluxes from power electronics, cool sensor components, improve efficiency of small energy converters, recuperate & repurpose waste heat energy, improve thermal system packaging, improve environmental control units, and understand multi-phase heat transfer fundamental mechanisms.

TPOC: Bruce Geil, (301) 394-3190, bruce.r.geil.civ@army.mil.

iii. Microsystems power components and conversion: research in high power density, multifunctional components and sub-systems for capturing, transforming, converting and delivering power to compact systems or wearable technologies.

TPOC: C. Mike Waits, (301) 938-6404; christopher.m.waits.civ@army.mil.

iv. Energy Science: R&D of novel materials and routes to energy. These could include development of alternative routes to fuel such as direct photoelectrolytic routes to hydrogen or energy, photovoltaic devices that have very high efficiency for development of devices suitable for portable power, can also include metamaterials that could be used in catalysis, high efficiency solar or waste heat to energy. Other routes for waste heat to energy include thermoelectric, pyroelectric, and thermo-photovoltaic devices.

TPOC: C. Mike Waits, (301) 938-6404; christopher.m.waits.civ@army.mil.

v. Nuclear Detection and Sensors: Develop and study approaches that include compact sensors that can be arrayed for large area survey and data fusion. Investigate sensor element architectures that enhance system energy efficiency supporting 100 microwatt power level sources and increased performance of compact devices.

TPOC: Marc S. Litz, (301) 394-5556, marc.s.litz.civ@army.mil, and James Carroll, (301) 3941411, james.j.carroll99.civ@army.mil.

m. Biologically Derived Sensor, Power, Device and Materials Research (MR)

This effort is characterized by three main core competencies: the study of biological systems, synthetic biomaterials and biotic/abiotic interface science. These areas are used to build future technologies designed to increase situational awareness, reduce logistic loads and provide new capabilities in extreme operational environments. Goals include the development of revolutionary biological, photonic, electronic and organic- electronic hybrid devices and sensors. In an effort to capitalize on these advances, targeted investigations will be conducted in the following areas:

i. Biosensors to either sense biology or sense with biology.

ii. Synthetic recognition discovery tools including engineered biomolecular scaffolds through low cost cell sorting technologies.

iii. Natural and synthetic metabolic network analysis including metabolomics, regulation, tools for building synthetic networks and predictive modeling.

iv. Photonic and electronic devices that utilize or harness biology to function.

v. Biologically derived power generation and storage.

vi. Biological waste-to-energy / waste-to-commodity chemical conversion.

vii. Biological / Bio-Hybrid / Bio-electronic materials that are built from biological structures or assembled/enabled by biological structures.

viii. Bio/Abio Interface Science: Developing integrated bio-/abio materials and systems for organism / hardware interactions.

ix. Computational Biology: Fundamental understanding of atomic and molecular properties and interactions (as bioinformatics and computational systems biology) enabling biological, bio-hybrid, and bio-mimetic materials and devices.

x. Synthetic Biology: Engineer and construct modified biological systems to achieve unprecedented function and performance. This includes an effort in Living Materials to explore the novel concept of responsive materials imparting living functions for operation in Army relevant environments thus enabling disruptive capabilities, such as self-healing, adaptation, protection, and situational awareness. Interests include research to enable design and synthesis of materials both enabled by and including biological entities to provide these living functions.

TPOC: James J. Sumner, (301) 394-0252, james.j.sumner4.civ@army.mil.

n. RF-to-THz Devices and Integrated Circuit Technology

ARL is interested in research on innovative electronic substrate and epitaxial materials, devices, and monolithic circuits; and integration techniques for digital, mixed-signal, and RF, millimeter-wave to Terahertz (THz) applications, including radar, communications, EW, and sensor systems. Research should involve materials, devices, integrated circuits, and subsystems, built upon advanced Si-based, III–V, III-nitride, and II-VI materials, ultra-wide bandgap (i.e. diamond), novel device structures, nano-technology innovative circuit topology, and multi-level, and/or heterogeneous integration technology. The research may also include related device, circuit, subsystem, and system level CAD modeling and analysis to achieve optimal performance.

TPOC: Ali Darwish, (301) 394-2532, Tony Ivanov, (301) 394-3568, tony.g.ivanov.civ@army.mil, and Ed Viveiros, (301) 394-0930, edward.a.viveiros2.civ@army.mil.

3. SCIENCES FOR MANEUVER (ScMVR) CAMPAIGN

The ScMVR Campaign focuses on gaining a greater fundamental understanding of advanced mobility technologies that enable innovative vehicles configurations and subsystems architectures – critical to the future Army's movement, sustainment, and maneuverability. Knowledge gained through these research efforts will lead to technologies for the design, fabrication, integration, control, and platforms support that will significantly improve Army power projection superiority.

The ScMVR Campaign has developed three KCIs, four CCEs, and one ScMVR-related topic that are integrated to form a robust foundation to understand and overcome complex fundamental challenges associated with Energy and Propulsion; Platform Mechanics; Vehicle Intelligence; and Logistics and Sustainability. The campaign builds on fundamental pillars of science and engineering to conduct research in manned and unmanned Army air and ground vehicles. Discoveries and innovations made in this area will exert a significant impact on the Army of the future.

a. KCI-ScMVR-1: Force Projection and Augmentation through Intelligent Vehicles

ARL research is focused on developing fundamental understanding through greatly improved vehicle perceptual, learning, reasoning, communication and physical capabilities that will enable future unmanned vehicle systems operating in the air, on the ground, or in maritime environments. ARL's goal is to facilitate effective intelligent vehicle interactions with Soldiers and the local populace that engender trust essential to forming efficient teams. Technological advances are envisioned to create the potential for affordable, interoperable autonomous and semi-autonomous systems that improve the effectiveness of Soldiers and units. Intelligent vehicles are expected to deploy as force multipliers at all echelons from squads to brigade combat teams. Future intelligent vehicles are expected to augment Soldiers and increase unit capabilities, situational awareness, mobility, and speed of action. ARL research is creating machine cognition as well as reasoning, learning and communication behaviors that can, in certain scenarios, replace the operator (driver or pilot) for future unmanned vehicles. Robust capabilities to analyze and assess research developments are also critical to inform research.

ARL seeks proposals to further its technical goals which include, but are not limited to:

i. Cognition architecture and supporting technologies to model the world in semantic terms, permit reasoning based on abstractions, and allow interactive communication with Soldiers using structural language;

ii. Semantic labeling of an increasingly larger vocabulary of objects and behaviors to permit a richer, more detailed description of the environment (including determination of critical scene elements, actions and relationships to be remembered for future use in machine planning, learning and reasoning; recognition of changes in the physical and tactical environment as a cue to significant activity requiring reaction; and incorporation of contextual information and life-long learning into reasoning;

iii. Capabilities to infer purpose from the relationships among objects in the environment and behaviors (activities) exhibited by people (teammates, adversaries, and non-combatants) and place objects and behaviors into context;

iv. Enhanced capabilities to generalize and rapidly learn from a limited number of exemplars: monitor execution, identify conditions requiring reconsideration of plans and modifications of behaviors, and autonomously initiate re-planning processes;

v. Enable machines to explain knowledge, actions and predicted outcomes to enable rapid redistribution of tasks between Soldier and robot, enhancing transparency and engendering trust by human collaborators;

vi. Interactions with the physical world applicable to a broad range of scales, from Microsystems through larger tactical vehicles, which includes the ability to pick up and move objects, either upon semantic direction or their own initiative, and to maneuver in three dimensional space/terrain while negotiating obstacles in spaces that Soldiers cannot travel; and

vii. Representative test-bed vehicles, both air and ground, on which to integrate, exercise and explore integrated component technologies at appropriate scales in relevant, reconfigurable environments.

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b. KCI-ScMVR-2: Advanced, Electrical Power Technologies and Components

With the demand for higher efficiency and performance, the Army has traditionally migrated from mechanical systems to electronic systems. In the future, this evolution will be even more attractive and necessary as networked power management holds the promise of enabling additional capabilities, benefits and cost savings. The Advanced, Electrical Power Technologies and Components effort addresses the development of a broad spectrum of materiel and devices that will be required by Army systems developers in the coming years. Of special focus are high-voltage components that will accelerate the realization of compact, high energy (sub-) systems.

This research effort is expected to have the following Army impacts:

- Improving mission effectiveness of Army platforms through the development of necessary energy and power underpinning devices and circuits that are required to enable electric-based component technologies.

- Reducing logistics burdens through the development of more efficient electrical power generation, distribution, and conversion components and systems.

This research effort will focus on pursuing advanced, electrical power technologies and components to enable efficient Army platforms. The goals of this work are to overcome barriers to realization of intelligent, solid-state alternatives to selected electromechanical components; components and techniques for improved thermal management of transient

heating events in electronic systems; high voltage components based on advanced wide bandgap semiconductors; intelligent power conditioning modules and interfaces for power conversion and inversion; and induction-based, electrical energy storage devices that approach 20 J/cc capacities.

Specific research areas include:

i. Power Conditioning. The Army is searching for innovative technologies and techniques for reducing the size, weight, cost, and logistics footprint of power conditioning systems across the full range of mobile and stationary Army applications incorporating energy networks. High efficiency and high temperature operation (for reduced cooling) are also critical requirements. Some specific areas of interest include:

(1) Novel power converters.

(2) Novel materials and designs for high-temperature power conditioning capacitors and inductors.

(3) High performance components such as switches and capacitors.

(4) Pulse-Forming Network (PFNs) and power conversion technology for lethality, survivability and directed energy capabilities and future high power and high voltage loads.

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ii. Energy Materials and Components. Tactical Energy Networks.

(1) Power lines sensing technologies are sought to determine types and specifications of loads and sources that cannot or do not provide the information directly Primary interest areas are sensors to collect information from a power line; techniques to analyze power line data; and methods to interrogate loads and sources through passive or active methods.

(2) Advanced cognitive techniques are desired to allow real time adaptive operation and longer term predictive modeling to provide energy-informed operation of energy networks. Primary interest areas are technologies to enable machine-based decisions for stationary energy networks that utilize heuristics and cognitive techniques. A key goal is to provide learned behavior with input from external sources such as operational data, weather, maintenance and other factors.

(3) Novel power conditioning components and control research in technologies are needed to allow efficient conversion of power between frequencies and voltages with the ability to scale system power levels based on needs.

(4) Research in tactical energy communications and control technologies is also desired to include layered architectures comprising physical, data, and communication; exploration of technologies that interact between the information, energy, and warfighter domains. Key areas to include interfaces for micro-grids; hardware and distribution boxes; and M&S of operation and performance in multiple domains.

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iii. Power Electronics Packaging.

(1) High performance packaging materials, methods and systems are needed that enable the full performance level of wide bandgap power electronics. This includes high temperature (Tj > 200° C), high voltage (> 10 kV), and high frequency (Mhz range) operation.

(2) Integrated design techniques and modeling are sought that utilize co-engineering and/or co-design to improve power packaging by understanding the trade-offs among power density, reliability, thermal performance, and electrical performance.

(3) Novel applications of standard additive manufacturing techniques as well as novel additive manufacturing techniques are desired to enable advanced and high performance power packaging. In addition, techniques and methods to functionalize structural, aerodynamic and/or other structures by integrating power electronics features are of interest.

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c. KCI-ScMVR-3: Discover and Advance Vertical Takeoff and Landing (VTOL) Innovations, Novel Concepts, and Ideas

Innovative capabilities are needed to achieve higher vehicle speeds, improved hover efficiency, greater vehicle ranges, increased payload, and reduced maintenance to achieve performance attributes for future VTOL platforms. ARL conducts foundational aeromechanics research to enable future Army rotorcraft with performance capabilities that are currently infeasible. In addition, analytical and experimental capabilities to support development of advanced numerical methods and computational codes for assessing aero-elastic, aeromechanical, and structural dynamics performance are of interest. Technologies are sought to enhance maneuverability in complex environments at higher operating speeds without degrading hover efficiency. Fundamental technology analysis capabilities are also needed to model vehicles and their components. Research tools are also needed for understanding and developing capabilities that couple physics-based analyses to examine performance in full-spectrum military operations.

ARL seeks proposals to (a) develop algorithms, methods, and tools for flight mechanics, dynamics predictions, performance assessment, and design space exploration of VTOL vehicles for sizes ranging from small unmanned aerial systems (UAS) to large vehicles; (b) develop new technologies to achieve revolutionary improvements in vehicle performance (such as active flow control and active structural shape control) to achieve revolutionary vehicle performance improvements across different flight regimes; and (c) explore innovative vehicle concepts for large VTOL platforms and micro/small autonomous air vehicles. Vehicle concepts may also exploit advances in the electric hybrid propulsion, multi-copter, and reconfigurable structure technologies. Novel proposal concepts from structural dynamics, aerodynamic performance, coupled fluids/structures, and/or nonlinear dynamics theoretic perspectives are relevant.

ARL also seeks proposals exploring advanced actuation to achieve locomotion and flight, including associated methods of control. Advancements for actuators, mechanism fabrication, and new/novel materials are of interest. Actuated structures using such advancements may explore highly complex systems employing energy efficient mobility techniques (such as impedance matched actuation, variably tuned compliance, and adaptive morphologies). Proposals focusing on complex networked and distributed actuation techniques integrated into structures that provide multiple functions such as mobility, actuation, dexterity, structure, kinetic energy (KE) dissipation, or redirection are also of interest. Lastly, increasing system complexity paired with dynamic environmental operating contexts requires a transformation in engineering design theory, methods, and tools. Existing design engineering approaches are often inadequate to detect interaction complexities early in design, as they assume that a system can be described as a sum of its parts.

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d. CCE-ScMVR-1: Advanced Switching and Control for Power Electronics

The ScMVR CCE in Advanced Switching and Control for Power Electronics offers the opportunity to develop electrical power systems that provide the Army efficient electrical switching technology with advanced capabilities. This effort will be supported by the analysis and characterization of devices, improved understanding of wide band gap device performance and reliability, and advances in circuit topologies and control algorithms. The ScMVR CCE on Advanced Switching and Control for Power Electronics Research will focus on four areas:

i. Advanced circuit simulation tools and methods that enable topology and device trade-off analyses for the design of extreme and/or novel power conversion and motor-control circuits in future Army applications.

ii. Highly efficient circuit design for power electronics applications at voltage, temperature and power extremes.

iii. Adaptive and predictive algorithms for motor control and power conversion.

iv. Exploitation of extreme and/or novel operating modes of advanced wide band gap devices that result in performance gains and/or new capabilities.

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e. CCE-ScMVR-2: High-Power-Density and Energy-Efficient Engine and Drivetrain Technologies

ARL advances fundamental sciences in engine and powertrain technologies to improve the performance, operational capabilities, and sustainment of Army vehicles. Power density and fuel efficiency are key engine parameters that directly influence vehicle capabilities in speed, range, and payload. Efficient and robust distribution of propulsive power enhances the mobility and survivability of military vehicles. ARL also investigates novel approaches for the efficient distribution of vehicle propulsive power routed from power plants to propulsive devices. Efforts under this core competency enabler include fundamental scientific research in combustion science, tribology and lubrication (including tribological surfaces/coatings, lubricants and manufacturing processes for improved power density and operation under starved lubrication in harsh environments); high temperature propulsion materials; multi-speed transmissions; innovative drive train technologies and concepts; and advanced engine technologies for ground and air applications.

i. Fuel Spray and Combustion Science. ARL seeks proposals on fuel spray and combustion science. The Army is interested in technologies to increase engine power density and efficiency, while operating on a single fuel. In order to realize these technologies, it is critical to understand the fundamental physics and chemistry in energy conversion from fuel to mechanical power. The areas of research interest include, but are not limited to, high-resolution optical and laser diagnostics, optically dense spray diagnostics, supercritical sprays, conventional and alternative fuels, and high-fidelity modeling.

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ii. Tribology and Lubrication in Power Transfer. ARL seeks research proposals in the area of high performance tribological interfaces transferring power from power-plants to thrust producing devices for Army ground and air vehicles. At the fundamental level, interface science probing nanoscale composition, properties and behavior of surfaces and solid interfaces in power transfer devices is of interest. Also of keen interest is power transfer tribology investigating solid, liquid, gas, and mixed phase lubrication and wear phenomena enabling high performance, robust, and reliable mechanical component technologies. Research is sought in novel material systems and treatments applied to mechanical interfaces to provide enhanced life and step-function changes in power density and resistance to damage.

TPOC: Stephen Berkebile, (410) 278-9547, stephen.p.berkebile.civ@army.mil.

iii. High Temperature Propulsion MR. ARL seeks research proposals on high-temperature materials and structures for advanced propulsion concepts that will improve engine performance and reliability while reducing weight and cost. Technical challenges include the development of engine and power conversion materials to enable unprecedented maneuver capabilities in degraded environments. Operating conditions for combustion engines include high temperatures (3000^0F or above) as well as thermomechanical fatigue and creep resistant materials operating in sandy or salt-fog environments. Development of theoretical, physics based models, and methods to assess process-structure-property relationships for complex materials (such as ceramic matrix composites, fatigue resistant fiber/metal laminates, and engineered metal alloys) are needed to achieve Army goals. The Army thrust for damage tolerant structures requires high fidelity material state awareness. Research capabilities to detail mechanical, thermal, and chemical behaviors of propulsion materials at high-transient elevated temperatures and harsh environments are in their infancy. High temperature sensors, thermal and chemical damage quantification, and life cycle analyses (including accurate and reliable material life prediction) are lacking. Research efforts toward design, manufacturing and insertion of materials-by-design for high-temperature turbomachinery are sought.

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iv. Turbomachinery Science. ARL seeks proposals for adaptive turbomachinery component concepts that will enable high efficiency, high power density gas turbine engines for Army rotorcraft. Concepts are also sought for Unmanned Air Vehicle propulsion systems relying on VTOL. Research on smart materials based articulating or adaptive turbomachinery components that can enable improved engine stall stability margin and higher aero-thermodynamic efficiency under off-design conditions is also of interest to the Army.

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v. Drivetrain Research. ARL seeks proposals for innovative concepts for the distribution and transfer of propulsive power in Army vehicles such as helicopters, ground vehicles, and unconventional or unmanned small aircraft. Improved distribution of shaft work may be accomplished through novel technologies applied to bearings, gears, seals, shafts, splines, couplings, clutches, etc. Also, proposals are desired for hybrid drivetrains, lightweight electric machines and similar approaches that reduce mechanical interfaces for aircraft in power classes and configurations where commercial technology does not currently exist.

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vi. Innovative Engine Technologies. ARL seeks proposals on innovative engine technologies to enable higher power density, higher efficiency, reduced signatures, multi-fuel capable, reduced cooling capacity, and more durable and reliable air and ground engines. Areas of research interest include, but are not limited to, advanced engine cycles, innovative new engine concepts, innovative component technologies, alternative fuels combustion, and engine analysis tools and modeling to advance the state-of-the-art technologies.

TPOC: Kenneth Kim, (410) 278-9525, kenneth.s.kim11.civ@army.mil.

vii. Rotorcraft Propulsion. Proposals are sought to improve propulsion for helicopters and other rotorcraft, including advanced gas turbine engine and mechanical power transfer system technologies and concepts. Improved performance and reliability must be simultaneously achieved with reduced weight and cost. Research interests include basic adaptive technologies that can enable variable speed/torque engine and drivetrain capabilities, and adaptive thermodynamic cycles that create new design space for revolutionary propulsion systems for the Army. Analysis code and algorithm development (including nanoscale material modeling, nonlinear structural dynamics, fluid structure interaction, conjugate heat transfer, and related propulsion multi-physics modeling) is needed with along with experimental validation of analysis predictions.

TPOC: Waldo Acosta, (216) 433-3393, waldo.a.acosta.civ@army.mil.

f. CCE-ScMVR-3: Virtual Risk-Informed Agile Maneuver Sustainment (VRAMS)
VRAMS is focused on discovery, innovation and transition of integrated health monitoring and maneuver capabilities to support the Army's vision for zero-maintenance platforms. ARL goals are to automatically detect changes in functional states; advance design methodologies and methods for structures; analyze and characterize novel durable and damage tolerant materials and structures; and assess functionality in the context of upcoming or ongoing missions. Functional changes in structural components or sub-systems may include effects from structural fatigue, wear, damage, or age. The long-term goal is to integrate detected functional changes with data from on/off board systems for mission planning, maintenance schedules, and operations to compare readiness to mission demands. Additionally, system responses are envisioned to inform vehicle operations in real time on vehicle health and capabilities, and recommend operator control adjustments to subsystem responses to balance performance and integrity limits.

Currently, the primary structural damage indicator is crack size. Damage detection technologies based on crack measurements provide accurate service life predictions towards the last 20% of remaining useful life for structures and components. Given detectable fatigue cracks appear relatively late in service life, it is often too late to perform remedial maintenance to prevent failures. Structural damage is known to also affect material mechanical properties such as stiffness or compliance, hardness, damping, residual stresses, acoustics, electrical and magnetic properties (such as resistivity, permeability and dielectric constants). ARL seeks

research proposals that will investigate, identify, quantify, or correlate more reliable methods to detect damage much earlier in service life. Proposals are also sought to design and develop advanced structural materials (such as self-healing or stress strengthening materials) and concepts to advance extremely lightweight, adaptive, durable, and damage tolerant structures. While fault detection sensing capabilities and tailored signal processing algorithms have advanced, challenges also remain to efficiently detect damage when platforms are not in operation as well as real time when platforms are under complex operational loads. Research proposals in these areas are also of interest.

ARL seeks proposals to reliably detect damage earlier, advance vehicle materials and structures, and develop health and usage monitoring system (HUMS) technologies. Fundamental understanding and models for damage progression are needed to reliably detect damage early and predict progression in complex multi-axial/multi-scale environments. Vehicle structure improvements are needed to reduce size and weight; improve reliability and affordability; reduce maintenance burdens; and sense early structural damage. As structural damage indicator research advances, concepts will also be sought to mitigate damage progression via real-time HUMS, risk assessments, and vehicle adaptive maneuvers.

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g. CCE-ScMVR-4: Mechanics and Dynamics of Complex Systems

ARL seeks proposals exploring directions for the mechanics and dynamics of complex ground and air systems scaled from microsystems to manned and optionally manned platforms. Primary areas of interest include fluid structure dynamics, mechanisms and actuation, and platform concepts.

To achieve technology developments, research in fluid structure dynamics is critical to understand aero-elastic stability characteristics of advanced rotor structures. Modeling, simulation, and experimentation can be applied to understand fundamental aspects necessary to further develop, advance, and evaluate passive and active technologies for stability augmentation. ARL seeks proposals for understanding and predicting aero-elasticity of advanced platforms, and for developing passive and active technologies for improved platform aero-elasticity stability performance. From a dynamics perspective, research will advance mathematical treatments and decomposition techniques of complex fluid and coupled fluid structure phenomena that go beyond energy based methods. Approaches will enable theoretical, numerical, and experimental modeling and control research in fluids and fluid structure interaction problems that limit maneuver capabilities.

Rotor blade-mounted aerodynamic actuators provide a means for individual blade control and have potential to reduce vibratory loads, reduce noise and improve performance for vertical flight vehicles. Blade-mounted actuation methods include both mechanical devices (such as

circulation control and servo-flaps) and electrical control devices (such as piezo-electric or smart materials) which provide sufficient control authority under various operating conditions and environments. ARL seeks proposals to develop actuation mechanisms to achieve swashplate-less rotor systems as an enabler for high-speed vertical lift platforms. Additionally, proposals are also desired for M&S methods to evaluate such technologies are desired.

ARL also seeks proposals that provide underpinning S&T that will allow the Army to detect, diagnosis, visualize, and model interactions from the component level up to the system-of systems level for complex mobility systems being developed for the future. ARL anticipates that data informed design and decision making environment will be fully collaborative, multidisciplinary, real-time, and immersive by 2030. Capabilities stemming from proposals in this area are expected to allow technology developers, in interactive and tactile environments, to see how their technology integrates with a system, the effects of internal and external interactions on the system during operation, and probabilistic impacts on measures of effectiveness--all before any components of the system are manufactured. Research under this core capability enabler is also expected to enable the Army to determine where gaps exist in its technology development portfolio and help inform decisions and investments.

Proposals addressing novel mathematical treatments of nonlinear dynamics and complex systems are also of interest to ARL. Proposed research is expected to be inherently interdisciplinary and should not be application driven. Theoretical underpinnings are particularly emphasized here rather than development of numerical methods. Examples of current areas of interest include spectral operator based approaches to reduced order modeling of multi-scale dynamical systems and fractional calculus perspectives on complex systems with emphasis on physical interpretations. Applicants need not be limited to these two examples. Furthermore, combined experimental and theoretical mechanics advances are encouraged in a variety of areas ranging from non-equilibrium phenomena and active matter, nanocomposites with engineered interfaces, self-assemblies, as well as novel solutions for overcoming pervasive challenges in aeromechanics (such as flow control or structural damping).

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Sciences for Maneuver (ScMVR) Related Topic:

h. Maneuver System Trade Space Methodology and Tools

ARL seeks proposals to model and examine the maneuver trade space of novel and evolving technologies for Army air and ground vehicles, both manned and unmanned. Quantitative approaches are sought to assess the benefits of emerging and existing technologies to inform strategic research directions. Proposals are needed to provide scientific understanding and technical foundation to develop maneuver concepts to achieve next generation capabilities. Proposals are sought in these areas:

i. Methods to create and explore technology development trade space, including, but not limited to, manufacture, materials, integration, maneuverability, reliability, sustainment needs, and maintenance costs.

ii. Methods to explore the design space and visualize multidimensional tradeoffs, beyond two-dimensional Pareto front and three-dimensional Pareto surface.

iii. Methods to increase confidence that technology trade spaces are sufficiently bounded and populated.

iv. Methods to estimate robust and reliable subsystem- and system-level optima based on technology uncertainties at the component level.

v. Methods to predict long-term technology reliability and maintainability that component-level reliability improvements can have at subsystems, systems and fleets.

vi. Methods to analyze the sensitivity of system capabilities to changes in design variables, requirements, and technologies.

vii. Removal or reduction in subjectivity associated with weightings on measures of performance and effectiveness, as well as assessments of the sensitivity of stakeholder desires to system capability.

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4. INFORMATION SCIENCES (IS) CAMPAIGN

The IS Campaign focuses on gaining a greater understanding of emerging technology opportunities that support intelligent information systems that perform acquisition, analysis, reasoning, decision-making, collaborative communication, and assurance of information and knowledge. Understanding gained through these research efforts will lead to technological developments that make it possible to manage and utilize information flows in the battlespace. Technologies resulting from these efforts will have a direct impact on the Information Supremacy of the Army of 2030.

The IS Campaign has developed four KCIs, five CCEs, and one related IS topic that are integrated to form a robust foundation to understand and overcome complex fundamental challenges associated with Sensing and Effecting; Systems Intelligence and Intelligent Systems; Human and Information Interaction; Networks and Communications; and Cyber Security. The campaign builds on fundamental pillars of networks; advanced decision support aids; M&S of complex environments; and HPC to conduct research in areas including Intelligent Agents; Enhanced Tactical Networks; Effective Decision Support Aids; Knowledge

Exploitation; and Cyber Defense and Forensics. Discoveries and innovations made in this area will exert a significant impact on the Army of the future.

a. KCI-IS-1: Cyber Fire and Maneuver in Tactical Battle

This research effort will focus on developing the models, methods, and understanding to overcome existing barriers to realization of effective cyber fires and maneuvers in a tactical environment. The goals of this work are to pursue near-autonomous detection and identification of malicious activity directed at friendly networks; methods to rapidly respond to adversarial activities; predictive characterization of network vulnerabilities; and a robust framework to assess networks. In addition, this research program will focus on realization of methodologies for the reliable reconfiguration of friendly cyber assets to evade or recover from attack; covert means for collection and predictive analysis of enemy actions; and methodologies to degrade or destroy adversarial cyber assets with high certainty and predictable probabilities of kill.

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b. KCI-IS-2: Taming the Flash-Floods of Networked Battlefield Information

This research effort will focus on developing the models and methods to overcome existing barriers to realization of analytical approaches to better understand the dynamics that characterize complex, multi-genre networks and the data generated by these networks. The goals of this work are to pursue quantitative models of information semantics trust and quality; methodologies to creating coherent information networks from distributed information sources; approaches to partially centralized and semi-autonomous control of large complex networks; and approaches to autonomously recognizing, modeling, and anticipating dynamic changes in network processes.

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c. KCI-IS-3: Acting Intelligently in a Dynamic Battlefield of Information, Agents, and Humans

This research effort will focus on developing the models, methods, and understanding to overcome existing barriers for the realization of robust and reliable teams of intelligent agents and Soldiers in a squad. The goals of this work are to pursue concepts for processing large-scale text and speech of low-resource languages; concepts for determining visual saliency in large scale imagery and video data sets; militarily-relevant pattern recognition and mapping methodologies; techniques to enable real-time decision-making; approaches to develop new world-models of recently encountered spaces; algorithms to infer relationships between disparate elements and events; and approaches to autonomously recognize, model, and anticipate dynamic changes in information processes.

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d. KCI-IS-4: Sensing and Information Fusion for Advanced Indications and Warnings

This research effort will focus on developing the ability to shift the burden of technological complexity away from the user by relying heavily on making information sources such as sensors, social media, and communications more capable, easily assessable and interconnected. Fusion of multiple information sources, not only sensors, is essential and much of the program will be focused on foundational work aimed at facilitating the correlation of relevant information for display to the user. Fundamental research in the physical phenomenology of acoustic, electro-optic, electromagnetic, and seismic wave propagation is critical since it will lead to new sensing opportunities and sources of information, enable full exploitation of sensor data, and lead to realization of new sensors which can provide more robust input to fusion algorithms.

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e. CCE-IS-1: Networking and Communications in Contested and Austere Environments

The IS CCE on Networking and Communications in Contested and Austere Environments addresses the increasingly complex battlefields, in which the Army must be able to communicate; a highly dynamic, wireless, mobile networking environment populated by hundreds to thousands of networked nodes. Often, these environments are austere in terms of availability of resources for supporting and servicing the networking equipment. They are highly congested by multiple conflicting demands on bandwidth, and severely contested by a capable adversary. Research in networking and communications will address these multiple and complex challenges by pursuing the following overarching goals:

i. Diverse, effective channels – traditional and non-traditional – will be available for creating heterogeneous networks rapidly, predictably, and in a manner optimized for specific requirements and constraints of mission and environment, adapting intelligently to challenges of terrain, atmospheric conditions, local bandwidth congestion, and ensuring high performance along with energy efficiency and minimized probability of detection and interception by the adversary.

ii. The networks will be driven, largely autonomously, but with appropriate degree of human control, by protocols and algorithms for control and processing of signal and information, as well as for self-organization of the network, that ensure persistent high performance of the network, consistent with dynamically changing missions, supportive of rapid reorganization and mobility of friendly forces, and highly robust against strong disruptions.

iii. Survivability and defensive properties will be integral to the future network, making it inherently secure and survivable against disruptions by adversarial attacks such as jamming and other forms of interference, in part by minimizing probability of the communications and networks detection, interception, penetration and information exfiltration, as well as by responding to adversary actions by agile maneuver and recovery.

The IS CCE on Networking and Communications in Contested and Austere Environments will provide underpinning technology for KCIs where it is critical to ensure communications remain reliable, robust and resilient in the face of disruptive effects such as task reorganization, mobility of friendly forces, and adversarial attacks on friendly networks in future tactical environments.

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f. CCE-IS-2: Natural Language Processing (NLP) and Multi-Lingual Computing

The IS CCE on NLP and Multi-Lingual Computing objective is to provide foundational understanding and applied theoretical methods to enable the rapid and precise automated translation and IE from documents regardless of language, dialect, or medium. Research in this area will address the issues such as: (1) Should one translate Arabic dialects to English directly or pivot through Modern Standard Arabic? (2) Is it easier to differentiate between Arabic dialects if they are written in Roman script or Arabic script? (3) Can crowd-sourced workers produce accurate dependency parse annotations with minimal training? (4) When building statistical machine translation (MT) systems for polysynthetic languages what degree of decomposition of words into morphemes is most effective? (5) To what extent do IE algorithms developed for English require fundamental changes to be successfully applied to Arabic due to inherent differences in language structure? (6) How do we develop an event ontology that will aid in detecting higher-order event-event relations? (7) How can we overcome the noise and special features of social media data without over-fitting our approaches to a particular media source (e.g., Twitter)? The strategic approach to these focuses include:

i. MT of polysynthetic languages (e.g., Inuktitut) into English, Information Extraction (IE) algorithms for Arabic temporal expressions, events, and relations, protest domain ontology based on language of Twitter and adaptation of traditional IE software to language of social media.

ii. Temporal and spatial linguistic cues and modified dialog management systems to support natural language communication between human and robots in a collaborative task. Event ontologies and NLP components to incorporate social media artifacts and document summarization for situational awareness.

iii. A common multilingual semantic representation of a 3,000 word subset of spoken language frequently used by Soldiers in cross-lingual, cross-cultural encounters while enabling

Soldiers and robots to collaborate effectively with spoken natural language communications comprising 80% of their interactions.

NLP and Multilingual Computing supports KCIs by addressing underpinning science for information gathering and management, human-intelligent system interactions and intelligence and mission support tools.

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g. CCE-IS-3: Text and Video Analytics

The IS CCE on Text and Video Analytics addresses how traditional video analytic methods is improved by introducing semantic cues using textual class-based attributes. This research addresses a large gap, namely how can text-based information be combined with video analysis. We propose to develop a new approach that incorporates textual class-based attributes to impact the accuracy of methods when traditional low-level video features do not perform as well as expected, as in action recognition. The convergence of text and video from a range of sources holds promise for allowing warfighters to exploit the incredibly large and growing sources of information streaming in, an understanding of which can be critical to decision making, and therefore safety and mission success. This exploratory research will make use of an event ontology to structure relationships between attributes, actions, events, and larger sequences of events. Three research foci will be emphasized:

i. Leverage text within video for object recognition.

ii. Transition these findings into the activity recognition.

iii. Expand into highly complex sequences of actions to be able to infer implicit information which may not be explicit.

The IS CCE on Text and Video Analytics will support KCIs by creating a path towards developing a deeper semantic representation of unstructured data, including reasoning for improved scene understanding using real-world knowledge that can make it easy for human analysts to quickly recognize important factors and relationships.

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h. CCE-IS-4: Atmospheric Boundary Layer Exploitation

The purpose of the IS CCE on Atmospheric Boundary Layer Exploitation is to advance the ability to accurately sense and forecast weather events that can significantly deviate from

expected climatic norms, and to assess and mitigate their effects on Army personnel, systems, and operations. The following goals address this critical requirement:

i. Establish capability to characterize near-surface heat, moisture, and momentum fluxes in rugged, complex terrain. Essential atmospheric data will be quickly, accurately, and automatically collected from a wide variety of ground- and air-based platforms. These data will be incorporated as new parameterizations into fine-scale Numerical Weather Prediction (NWP) models to provide high-resolution temporal and spatial predictions.

ii. Characterize interactions of hazardous aerosols with naturally-occurring atmospheric constituents. Develop low SWaP (Size, Weight, and Power) LiDAR/RADAR prototype systems capable of remotely-characterizing atmospheric parameters (i.e., wind, temperature, moisture, etc.) and aerosol composition.

iii. Ingest atmospheric data seamlessly via "machine to machine" (M2M) interfaces into advanced modeling systems hosted on powerful, tactical-sized, high performance computer systems, even down to the smallest of mobile, Soldier-hosted hand-held devices. These models will be fully validated with quantified metrics to assess their accuracy. Apply Machine Learning techniques to fully exploit/data mine large atmospheric data sets.

iv. Translate weather forecasts from NWP models into highly-intuitive decision support guidance products tailored to meet a variety of mission requirements, depicting weather impacts on personnel, operations, and systems.

The Atmospheric Boundary Layer Exploitation CCE provides information and intelligence tools to be used as a force multiplier in intelligence and mission command decision support tools, artillery accuracy, Soldier health and performance, communications, sensing and imaging, and intelligent systems' maneuvers. The underpinning science supports KCIs by providing environmentally context-aware, mission-relevant information. Friendly forces leveraging this technology will have vastly superior knowledge, when compared to our enemies, of the current and future atmospheric state, as well as its potential effects on personnel, systems, and operations. This work will provide strategic and tactical information for the Army of the future by providing Army-scale atmospheric predictions in complex, dynamic terrain and "megacity" dense-urban environments. This information will guide mission planning and execution in the field and inform intelligent systems, including smart energy systems, autonomous systems (ground and air), smart routing, and others, for real-time adjustments and maneuver capability.

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i. CCE-IS-5: Sensors, Sensor Phenomenology, and Algorithms

This CCE seeks to develop underpinning technologies that will provide the Army with a high degree of situational understanding against ground and airborne threats while operating in

complex environments against adaptive enemy forces. The main objectives are to develop the necessary models, signal processing, prototype sensors and subsystems to support the next generation of situational awareness, air defense, and tactical sensing RADAR technologies. Research areas include:

i. Forward looking synthetic aperture radar (SAR) for degraded visual environments (DVE). Research will develop laboratory-grade hardware, RADAR signal processing algorithms and physics-based computational models to demonstrate technologies associated with forward looking SAR concepts at the millimeter wave band for helicopters operating in DVE conditions to ensure situational understanding, navigation, and safe landing.

ii. Affordable COTS-based RADARs for Degraded Visual Environment (DVE): Research uses an affordable COTS framework to perform field measurements and analysis in order to define appropriate metrics for the multifunction DVE helicopter mission. The warfighter will benefit with situational awareness in environments obscured by weather (brownout and whiteout conditions) and other nearby obstacles.

iii. Multi-band air defense RADAR: Research will focus on designing, developing, and assessing cognitive and adaptive RADAR architectures and components for Air Defense and Counter-Rockets, Artillery, and Mortar (C-RAM) missions. Other major applications include detecting small UAS using Doppler and micro-Doppler signature-based techniques.

iv. Cognitive RADAR: Research will investigate various hardware and algorithmic approaches to develop techniques that enable continued RADAR operations in congested RF environments. Spectrum sensing, waveform design, machine learning, artificial intelligence, and agile and adaptive hardware solutions across multiple frequency bands are key research areas.

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Information Sciences (IS) Related Topics:

j. Electric and Magnetic Field Sensor Technology

Research proposals are desired that are related to small, rugged, low-power electric- and magnetic-field sensors that can be deployed on a battlefield using artillery-based delivery systems, or scattered from air or ground vehicles, or emplaced by individual soldiers. These sensors should be passive or semi-active (i.e., with no local field-generating element), and may operate at low frequencies in the quasi-static zone (or "near field"), where the electric and magnetic fields are not coupled. These sensors should be characterized by exceptionally low power, size, weight, and cost, and/or by exceptionally high sensitivity and low noise (i.e., with performance limited by the background environment). Sensor bandwidth generally falls between DC and ~1 MHz, but may be further limited for specific applications: e.g., 0.001-10

Hz for anomaly detection; 30-3000 Hz for electric-power sensing; 3-30 kHz for very low frequency (VLF) sensing.

Sensors should operate in an unattended mode, and should be able to detect, classify, identify, localize, and/or track tactically-significant targets, including ground vehicles (tanks and other tracked vehicles, and wheeled vehicles), air vehicles (fixed-wing, rotary-wing, unmanned aerial vehicles (UAV) / manned aerial vehicles (MAV), etc.), and/or other targets and events at tactically-useful distances. These other targets include, but are not limited to, armed individual soldiers, underground facilities, power and telephone lines, RF transmitters; other events including gunshots, mortar and artillery launches, and explosions.

These sensors may be used individually or as part of a wide-area sensor array for surveillance, target acquisition, and/or engagement. While individual sensors may or may not have exceptional individual performance, their low size, power, weight, and cost should permit them to be used on the battlefield in ways not previously contemplated. Moreover, arrays and/or networks of such sensors are expected to provide new sensing capabilities and levels of performance simply not available today.

Unattended surveillance sensors may be stationary or mounted on robotic platforms; these sensors will be integrated with local and networked signal processing and communications capabilities. They should operate unattended for weeks or months after deployment, and indefinitely with energy harvesting. The sensor output should be quantitative: e.g., analog voltage level(s) or digital word(s); it should contain target information, and possibly a confidence level, suitable for low-bandwidth transmission and/or inter-sensor fusion.

Proposals will be accepted in seven areas:

i. Research on novel electric- and magnetic-field sensor concepts leading to quantification of detection distance(s), classification, identification, localization, and/or tracking of various classes of targets. High-performance sensors should have exceptional sensitivity (limited by environmental noise), frequency and phase response, dynamic range (60 to 120+ dB), linearity, total harmonic distortion, hysteresis, cross-axis sensitivity, cross-modality sensitivity, etc. Arrays of sensors should be characterized by exceptional performance matching. Low-SWaP-C sensing elements (field transducers), processors, and communication elements should each be chip-scale, use 1 nW to ~1 mW of power, and cost on the order of a few dollars.

ii. Research directed at environmental and/or platform noise reduction, and/or reduction of sensor front-end noise (particularly 1/f noise).

iii. Research related to filtering and/or signal processing techniques, which are expected to improve the detectability of targets in a battlefield environment. Array processing, in-situ "imaging", and multi-modal processing are of particular interest.

iv. Computer-based modeling of targets and sensors that can provide a capability to perform trade-off analyses of sensor concepts during prototype design.

v. Algorithms that can provide improved detection, classification, and/or identification of targets of interest in real-world environments. Proposed algorithms should be low-SWaP-C, portable to the Internet of Battlefield Things (IoBT), and usable in the Future Army Network.

vi. Resilient processing with performance that gracefully degrades in the presence of intermittent power, intermittent and/or unreliable networking, information assurance attacks, memory failures, and cosmic rays, etc.

vii. Proof-of-concept prototype design(s) of individual electric and magnetic-field sensors suitable for detecting tactically significant targets in battlefield environment.

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k. Artificial Intelligence and Machine Learning

The Government currently collects more data than it can meaningfully process. This includes image and video data, structured data sets for a variety of combat and non-combat missions (e.g. health, maintenance, logistics, and operations), and various, stove-piped, unstructured, massive data sets that exist primarily in the form of text documents. The vast scale of data collection challenges human-driven/human-only solutions to collection and processing.

The goals of this work are to increase the government's capacity to process that data by assisting and augmenting analysts through the application of artificial intelligence (AI) and machine learning (ML) algorithms, to include deep learning algorithms. Research will focus on experimental investigation and prototype development of AI/ML algorithms and capabilities. In addition, this research program will focus on helping analysts perceive and understand dynamic and unknown environments. Another research focus area includes the creation comprehensive models of real-world environments in which AI/ML entities facilitate course of action development by displaying intuition and improvisation characteristics in real-time, dynamic scenarios.

Elements of this research effort include new frameworks and tools for the creation of algorithms; tailored algorithms to perform discrete tasks, particularly in the fields of computer vision and language; innovative AI/ML computational environments; new labeling techniques to generate massive scale annotated data for supervised deep learning techniques; new methods of edge computation to bring deep learning algorithms to constrained computational environments; methods to evaluate and determine the effectiveness of algorithmic approaches; interfaces for the display, search, and interaction with algorithmically derived metadata and tabular structured algorithmic output; new techniques, hardware, software, and tools for the training, testing, and validating of algorithms; and storage and indexing capabilities for local algorithmically-produced data.

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l. Technologies for Spectrum Analysis and Control

ARL is interested in technologies that enable the use of electromagnetic (EM) energy to control the EM spectrum or attack the adversary while protecting our own EM systems against interference. Embedded in this goal are technologies that include EM spectrum sensing to enable situational understanding. ARL is accepting proposals addressing one or more of the following research areas:

i. Cognitive/adaptive: Technologies that enable EM capabilities or techniques to outpace an adversary's tactical options, placing ourselves at a strategic position in the "observe, orient, decide, and act" (OODA) loop.
ii. Distributed/coordinated: Technologies that enable spatially and temporally diverse awareness, action, and response, leveraging the Army's large number of low-cost and/or small platforms.
iii. Pre-emptive/proactive: Technologies that prevent or disrupt the adversary's ability to engage our forces, by decisively impeding the "find, fix, track, target, engage, assess" process.
iv. Broadband/multispectral: Technologies including ultra-wideband and multi-band radio frequency front-ends, back-ends, antennas, receivers, and transmitters to enable agnostic detection and prosecution of adversary transceivers.
v. Interoperable/compatible: Technologies based on software-defined, standardized, non-proprietary interfaces, including waveforms, spectrum management, and protocols.
vi. Electronic protection: Technologies that ensure blue force protection from jamming and EM interference with minimal impact on system performance, or technologies that enhance system performance in complex congested and contested EM environments.

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5. SCIENCES FOR LETHALITY AND PROTECTION (ScL/P) CAMPAIGN

The ScL/P Campaign focuses on gaining a greater understanding and discovery of mechanisms and on generating concepts and emerging technologies that support lethality and protection systems, and the mechanisms of injury affecting the warfighter. Knowledge and concepts gained through these research efforts will lead to technologies that enable a broad array of discriminate lethality systems as well as resilient protection systems and reduced incidents and severity of combat casualties. Campaign competencies and knowledge can support the Army through 2025, and the new technologies are essential for Lethality and Protection Superiority of the Army of 2030 and beyond.

The ScL/P Campaign has developed five KCIs and two CCEs that are integrated to form a robust foundation to understand and overcome complex fundamental challenges associated with Ballistics and Blast; EW; and Battlefield Injury Mechanisms. Through this campaign,

combinations of existing and new innovative technologies will be brought together through partnerships to realize disruptive system advances. These advances are driven by overcoming key learning and technical challenges required to further enable the Army of 2030 and beyond.

a. KCI-ScL/P-1: Scalable Lethal Adaptable Weapons Concepts

These efforts will provide continued lethal overmatch across the full range of weapons for both direct and indirect fires. Systems will be employed in expanding roles such as light and heavy armor with increased range and fire power as well as new lightweight manned and unmanned combat vehicles/systems and dismounts. New types of gun and missile technologies will be enabled with new launch mechanisms to deliver increased muzzle energies and new lethal mechanisms capable of defeating the toughest targets at reduced energy, reduced caliber, or reduced missile size while working with other research areas to provide necessary standoff range. Futuristic lethal mechanisms will be pursued and validated to provide a range of incapacitation effects against personnel and combat vehicles/systems. Disruptive energetic and propulsive materials will be investigated and tested to provide the Army with weapons with orders of magnitude enhancement in performance.

This program will lead to unprecedented enhancements in lethality for the mounted and dismounted soldier against a spectrum of personnel and manned and unmanned ground and aerial combat systems.

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b. KCI-ScL/P-2: Desired Lethal Effects at Standoff Ranges in Constrained Environments

The expected impact that this research will have on the operational Army's capabilities in the 2030 timeframe is significant enhancements in assured delivery of the lethal payload. Assured delivery implies that munitions will be brought to bear on the battlefield more precisely (lower collateral damage, reduced logistics burden), with more mission space (extended range, moving targets, defilade targets, smaller caliber weapons for lighter platforms), in a more complex environment (GPS denied, countermeasures) at low cost.

Assured delivery of the lethal payload is underpinned by ballistic launch and flight sciences. Guided delivery is composed of two enabling technologies: maneuverability and navigation. Navigation provides information to understand the dynamic states relating the target and the munition and maneuverability is necessary to deliver the payload to the target. Goals are defined with these sciences and enabling technologies in mind.

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c. KCI-ScL/P-3: Soldier Lethality and Protection

Research will enhance our understanding of battlefield injury mechanisms, such as those due to blast (e.g., injuries caused by shock waves, including accelerative loading and traumatic brain injury (TBI)), ballistic (e.g., impact of bullets, fragments and spall), and directed energy (e.g., injuries caused by laser and microwave sources). Research efforts in each of these mechanistic areas will yield scientific understanding and lead to new Army concepts. The long-term approach is to obtain a fundamental understanding of human injury and vulnerability de-convolved from the current Army solutions.

The goal of this research is to provide a mechanism-based understanding of the human response to ballistic and blast insults that can lead to advances in protection sciences and weapons development, thereby increasing Army capabilities.

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d. KCI-ScL/P-4: Adaptive and Cooperative Protection

The operational threat environment that our troops face continues to grow in both capability and complexity. From near-peer adversaries to terrorist groups, the landscape is constantly evolving. The ability of our troops to exercise freedom of maneuver under these contested conditions will dictate mission success or failure. Developing a suite of technologies that provide the highest level of protection, in austere conditions, is the goal of this research. These efforts will result in transformational protection capabilities for Army platforms (ground, air, Soldier, and maritime) focused on increased levels of protection and the ability to rapidly adapt to new and unforeseen changes in threat environment at a reduced weight burden.

This research effort combines technologies from across numerous disciplines to include technical intelligence, environmental sensing, dynamic threat characteristics, high speed signal processing, signature modification, and counter-measures in addition to conventional armor. All of these elements and combinations are linked through an intelligent agent to provide a real-time response decision that can proactively adapt. This methodology is capable of learning and applying new approaches as it evolves. An optimized combination of hard and soft protection techniques will provide a robust and redundant solution that will reduce inherent susceptibilities of current active protection systems to a variety of counter measures. It will also allow new techniques and responses to be deployed in real-time as dynamic software upgrades. This approach is seen as the only feasible means to maintain pace as the rate of threat evolution and proliferation is accelerated by globally available technologies such as digital design and additive manufacturing. The resulting advantages of this approach include; reduced weight when compared to current methodologies, increased reliability, ability to counter new threats in real-time and the ability to learn, adapt and improve.

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e. KCI-ScL/P-5: Disruptive Energetic Materials

Improved models, concepts, and new energetic materials for propulsion are expected to provide enhanced range, speed of engagement, and maneuverability while maintaining weapons safety and surety. Additionally, game-changing energetic concepts with an order of magnitude more potential than conventional energetics are being pursued and are expected to enable new approaches to lethality, particularly when partnered with emerging accuracy and precision advances.

These efforts will focus on the exploration and maturation of novel energetic and propulsive materials which are expected to provide revolutionary performance capabilities that are unachievable today. Research in this area seeks to understand very high energy density storage and release on desired timescales, methods to balance various parameters in energetic formulations, and prediction of formulation ingredient compatibility.

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f. CCE-ScL/P-2: Terminal Ballistics and Blast Effects

The CCE in Terminal Ballistics and Blast Effects is a sustained effort to advance the science base for mechanics and physics of weapon-target interactions. These technical areas include but are not limited to: shock physics and solid dynamics; fracture and failure of materials; interaction of solids with blast, electrical, and magnetic stimuli; detonation physics; and directed energy. To apply the greater understanding of fundamental sciences, which underpin weapon-target interaction, this CCE will develop coupled mesoscale poly-crystal model(s) with inter- and intra-granular mechanisms; develop and incorporate advanced diagnostic methods for relevant penetration experiments; develop and implement algorithms that provide electrical conductivities of low density gases using multiscale methods; apply formal Verification and Validation (V&V) methods and complete Uncertainty Quantification (UQ) assessment on tera/peta-scale simulation methods routinely used for protection technology development; develop and implement new analytical and computational methods for problems involving localization; assess coupling of structural and magnetic fields to protection relevant shock loading; implement robust methods for Modeling and Simulation (M&S) of energetic materials in response to shock stimuli; quantify relationships between structure, properties, and ballistic performance of armor ceramics.

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6. HUMAN SCIENCES (HS) CAMPAIGN

The HS Campaign focuses on identifying, creating, and transitioning scientific discoveries and technological innovations underlying Human Behavior; Human Capabilities Enhancement; and Human-System Integration that are critical to the U.S. Army's future technological superiority. This campaign concentrates on high-risk and high-payoff transformational basic research; critically-focused, promising applied research; and selective advanced technology development

that are expected to have revolutionary impacts on the Army's warfighting capabilities. In addition to significantly improving the Army's existing warfighting capabilities, it creates disruptive and game changing Soldier-centric technologies for the Army, while also preventing technological surprises from potential adversaries.

The HS Campaign has developed three KCIs and four CCEs that are integrated to form a robust foundation to understand and overcome complex fundamental challenges. The campaign builds on fundamental pillars of science and engineering to conduct R&D in human behavior understanding; human performance augmentation; and manned and unmanned teaming. Discoveries and innovations made in this area will exert a significant impact on the Army of the future.

a. KCI-HS-1: Robust Human and Machine Hybridization

Strengthening the Reciprocal Coupling of Man and Machines integrates empirical and theoretical efforts to understand dynamic, complex human-system interactions and apply that knowledge towards the conceptualization of unique and novel human-system integration technologies. The research has three thrusts 1) examining closed-loop human adaptation to uncertainty with specific goals to develop descriptive, mechanistic, and predictive models of human short- and long-term adaptation within system contexts; 2) investigating robust brain computer interaction technologies with an initial goal to uncover methods and analytic capabilities that enable long-term, sustained performance while minimizing calibration and training requirements; and 3) conceiving of novel human-system interface technologies that increase the flow of information and meaning from intelligent agents system and Soldiers in complex socio-technical environments with an initial focus on novel multimodal interface technologies that enable greater understanding with less effort and training The critical challenge for human-system integration in future technologies will be the design of solutions that adapt their capabilities to maximize the human potential of the future Soldier. This effort seeks to identify general systems principles that operate across levels of analysis, providing a conceptual and modeling framework that captures human adaptation in ways that current models cannot.

New methodological and analytical approaches will provide the core for technologies that revolutionize the direct interaction between Soldier and technology; increasing the bandwidth and effectiveness of information transfer, and shared understanding.

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b. KCI-HS-2: Multi-Faceted Assessment of Soldier Variability

The goal of this research is to provide the foundational elements for future Army systems to generate high-resolution, moment-to-moment, predictions of individual Soldier's internal and external behavioral and performance variability in mixed agent team and social settings across training and operational environments through the use of multi-faceted sensing systems. This capability will provide the foundation for future Army systems to adapt to the individual Soldier's states, behaviors, and intentions in real-time, which will provide our Soldier the most favorable conditions to train, engage in operations, and team with intelligent systems and personnel from the U.S. and other nations. Adaptive approaches will provide novel capabilities to decrease time-to-train, augment physical, cognitive, and social performance, and improve human-network interactions by providing robust predictions of Soldier state and intent to integrate with the network and are critical to the emergence of individualization of equipment and maximizing and sustaining both Soldier and unit peak performance during mission critical tasks. The research will focus on enabling high fidelity prediction that can account for continuous changes in Soldier's physical, cognitive, and social states, such as stress, fatigue, task difficulty, trust, and situational awareness. The goal is to exploit the array of sensors and information streams that will be present in the operational environment of 2030 to predict

Soldier variability with sufficient resolution and robustness to adapt systems in manners to directly enhance mission performance. The ultimate consumer of these technologies includes personnel across all three services both in the operational and medical domains. From U.S. Army Training and Doctrine Command (TRADOC) Pamphlet (PAM) 525-3-1: "Investments in maximizing human performance focus on achieving accelerated professional development; increasing cognitive and physical performance; developing Soldiers' social and interpersonal capabilities; improving the overall health and stamina of personnel; and improving talent management. These efforts will improve the adaptability and endurance of Soldiers operating in a complex environment across the range of military operations." This research is consistent with the following TRADOC Army Operating Concept for "Human performance" that improves the adaptability and endurance of Soldiers in a range of military operations. In addition, this research feeds several TRADOC Emerging Technology Focus areas:

- "Grow Adaptive Army Leaders, Optimize Human Performance" by using continuous Soldier assessment.
- "Maintain Overmatch" in the areas of protection, intelligence, and mission command.
- "Continuously Upgrade, Protect, and Simplify the Network" by incorporating human state information to enable high degree of situational understanding and greater interoperability.

Key research areas include:

i. Approaches and algorithms to assess and predict non-linear human states that vary on multiple time scales across training and operational environments.

ii. Techniques to leverage information about other individuals, sub-groups of individuals, and groups to improve prediction of an individual.

iii. Techniques and fusion algorithms to interpret and predict non-stationary, human actions and behaviors in complex, dynamic, artifact-rich environments.

This research will provide the foundational elements for future Army systems to generate high resolution, moment-to-moment, predictions of individual Soldier's internal and external behavioral and performance dynamics in mixed-agent team and social settings across training and operational environments through the use of multi-faceted systems.

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c. KCI-HS-3: Training Effectiveness Research

TRADOC/Army Capabilities Integration Center predicts (Strategic Trends Analysis, May 2014) predicts that by 2030 "the speed of events will unfold that will require the Army to rapidly respond (measured in hours and days vs. weeks and months) with an operationally significant force to protect vital national interests. Increased speed of information requires

more rapid and discriminate responses to crises. Future crises require increased multinational and whole-of-government approaches; however, partner and interagency capacities may not be sufficient. The environment will be increasingly transparent due to widespread information technology (IT). Mission command must be capable of handling big data. Future land forces will require the capability and capacity to gain situational understanding of complex megacity environments (physical, human, and information). As technology exponentially advances, the Army will need to replace systems more rapidly to equip the future force in an effective and timely manner. "This environment will require a real-time integration and adaptation to rapidly deployed technologies (personally worn exoskeletons, distributed unmanned systems, and cyberwarfare systems). To address these requirements, this research will demonstrate a ubiquitous, reconfigurable, fully adaptive, synthetic training environment that can quickly and accurately assess learning requirements, while reducing time required for Soldiers and their units to attain job domain competency; increasing the rate of knowledge and skill retention; increasing the rate of training transfer for mission readiness; increasing user acceptance; and reducing overall lifecycle sustainment costs.

The main goals of this research are to: 1) discover and delineate the relationships among training environment fidelity, level of training immersion, and Soldier/collective performance; 2) create models of efficient training evaluation for the Army driven by relationships between training technologies/methods and training effectiveness; 3) determine relationships between training technologies and transfer of acquired knowledge, skills, and abilities to operational contexts, 4) optimize training for autonomous, intelligent systems; 5) determine multidimensional measurement with feedback methods and strategies for individual / unit level simulation-based training; and 6) demonstrate automated individual to unit measurement and feedback tools and technologies.

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d. CCE-HS-1: Real World Behavior

Understanding human behavior in the real world is a core enabler to the HS Campaign. The Real World Behavior CCE is dedicated to translating laboratory-based research findings to real world contexts and environments. This is especially critical considering the extreme conditions under which Soldiers operate including extreme time pressure; physical stress; cognitive load; interacting individually or as a team with intelligent systems and agents; technical training; and mission preparation. These extremes are difficult, if not impossible, to replicate in a laboratory. Materiel and methodologies to measure and predict human behavior in real world environments will enable enhancements of human capability in real time during training or tactical operations. Understanding behavior in the real world will enable optimized human-system integration at scales from millisecond-level interactions that are dynamic and reciprocal to social-level interactions with robotic and intelligent systems or agents. Creating this understanding of behavior in the real world will accelerate transition of research findings to the field, thus speeding the delivery of technology, and ultimately, capability to the Army.

Core research areas include:

i. Real-world complexity in HS research: real-world perceptual and cognitive complexity in the laboratory as a function of the characteristics of simulations that give rise to the specific real world behaviors required for effective interaction across training, analytic, and operational domains for both individuals and teams.

ii. Assessing behavior in the real world via reliable and valid biological, neurological, and behavioral sensors that provide stable, computationally tractable data that are descriptive, diagnostic, and differentiating across the full-range of physical, cognitive, social, and organizational behaviors for application of augmentation and human-system integration approaches on multiple time scales.

Execution of the research in this CCE includes development of sensors that can reliably detect and capture nuanced actions, gross motor movements, and brain activity outside the laboratory. Fast and efficient computational approaches also must be in place to handle the massive amounts data that will be collected. Finally, the behavioral data must be correlated to the context and to the environment to enable a meaningful and differentiating association to higher-level and militarily-relevant effectiveness measures for training and operations.

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e. CCE-HS-2: Augmentation

Soldier cognition, perception, and physical performance can be augmented, aided, or protected by technology, or technology can impair Soldier performance if it is not designed, developed, and introduced in a way that is consistent with fundamental human capabilities and capacities. The goal is to augment Soldier capabilities such that they can surpass the baseline limits of performance. Through augmentation, a Soldier's sensing and perceptual abilities can be greatly enhanced, thereby enabling the warfighter to sense and perceive the environment faster, more accurately, and more comprehensively. Augmenting cognitive capabilities that are matched to individual capabilities and tuned to the operational environment will enable greater resilience to the extremes of warfighting and support the attainment and sustainment of situation awareness and ultimately, agile, knowledgeable decision making. Innovations are also expected to enhance warfighter physical capabilities by balancing load, improving protection, and enhancing performance.
Core research areas include:

i. Perceptual Augmentation: the characterization and augmentation of the perceptual requirements of visual, auditory, and tactile signals in complex, dynamic, militarily-relevant environments derived from laboratory and field studies and forming the basis of guidance principles for the system development community.

ii. Physical Augmentation: focus on ‘skin-out’ technology that may augment physical performance, and focus on advanced technology designed to increase the physical strength of the Soldier or increase their endurance.

The objectives of this research are to understand and augment fundamental human capabilities across both short and long time scales. Under this CCE, research will be conducted to develop and assess the effects of augmentation technologies or approaches on Soldier performance through the evaluation of performance metrics and prediction of operational benefit for mission tasks ranging from marksmanship and load carriage to communications tasks, driving and navigating, and distributed decision making. Many augmentation technologies constitute a direct approach such as an exoskeleton, but other approaches may be via indirect means such as insertion or manipulation of imagery, symbology, or virtual characters by means of augmented reality techniques.

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f. CCE-HS-3: Training

The research in this CCE is vital to the investigation, demonstration, and advancement of a broad range of simulation technologies to enhance Army training, and the instantiation of learning methods to enable effective, efficient, and adaptive/tailored instruction at the point of need.

This CCE includes a broad-based program of fundamental research and advanced technology development to achieve significant advances in Soldier training and, ultimately, mission effectiveness. The development of future training technologies requires advances in learning sciences, HS, human-system interaction, computer science, engineering and M&S. Execution of the training technology program is intended to produce high-payoff achievements in learning, retention, and transfer of knowledge and skills from the training environment to the operational environment. The end goal is to discover and innovate powerful new tools, technologies, and methods that can accelerate learning, can be applied at the point of need at any time and are affordable.

Core research areas include:

i. Intelligent and adaptive tutoring systems: Intelligent and adaptive tutoring systems for individuals and units that promote learning of structured and unstructured militarily-relevant domains and contexts. The goal of this research is to enhance the realism, adaptability and decision-making skills of artificially-intelligent computer-based tutors and virtual humans to support one-to-one and one-to-many training experiences, where human support is limited, impractical, or completely unavailable. Technical challenges include: (1) the development and application of intelligent agents that can adapt in complex, (2) ill-defined domains; (3) understanding natural language in multi-sided conversations with trainees; (4) rapid authoring of effective computer-based tutors for individuals and teams, and (5) realistic virtual humans.

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ii. Authoring tools: Simulation technology relies on the underlying scenarios and content to deliver training objectives. In order to generate new scenarios, content, and simulations, authoring tools are needed. Ideally, these tools enable rapid, tailored, and effective training at point-of-need. Key areas of research focus on authoring tools that are: (1) low-cost, (2) usable by non-technical personnel, and (3) capable of enhancing extensibility of training systems.

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iii. Immersive Learning: Immersive learning includes but is not limited to, games and virtual worlds for learning as well as immersive collaboration environments and traditional simulations (otherwise described as virtual environments). We seek advances in virtual environment research that improves the sense of presence and engagement in a virtual environment, improves the realism of a virtual environment and the ability to visualize information, improves the user's experience and within the environment, and provides the ability for multiple users to edit the environment on-the-fly a user should be able to easily replicate a concept within their mind without platform limitations). Potential display environments include traditional screens, head-mounted displays, large-scale displays, and mobile devices. The user interface should not limit but rather should augment the virtual experience by providing realistic feedback from experiences within the virtual environment. The interface should provide subtle environmental effects to the user and improve the user's ability to navigate within the environment through natural means.

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iv. Virtual humans: Virtual humans allow for a highly realistic representation of a person-to-person interaction, in a risk-free virtual environment. ARL seeks virtual human capabilities that are tailored and effective for supporting a full range of human-simulation interactions, to include one-on-one social interactions, and culture-specific interactions. Specific areas of interest include: (1) high-fidelity avatars; (2) advanced NLP; (3) conversational agents; (4) low-cost tools for creating and authoring virtual patients.

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v. Live and Embedded Training (ET): ARL seeks research, development, and demonstration of live and ET technology to enhance training realism and effectiveness. Live training areas of interest include updated Non Line of Sight (NLOS) tactical engagement systems, MILES laser engagement systems, and improved indoor position, location, and tracking systems. ET is a capability designed into a Ground Combat System (GCS) and dismounted soldiers that enables the GCS and dismounted soldiers to provide necessary environmental and system feedback to train individuals, crews and units, and enhance operational readiness using the system's operational equipment. Having a training capability integrated within the system's operational equipment allows units to train anywhere and

anytime, including while deployed. The goal is to enable more cost-effective training and mission rehearsal and accelerate ET into the current force. Pacing technologies include, but are not limited to:

(1) Embedding training and mission rehearsal on current force vehicles,

(2) Innovative methods for image generation and stimulated weapon sensors,

(3) Methods to modify analog-based systems (brake, steering, direct view optics),

(4) Embedded visual and display systems, and

(5) Mounted/dismounted interoperable ET environments.

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vi. Medical Training: ARL has an interest in researching, developing, and demonstrating technologies, techniques, and strategies for immersing the military medical community into realistic, simulated military medical training environments for initial, transition, refresher, and sustainment training, including both individual and team training. Specific areas for consideration include:

(1) Technologies to reduce or eliminate the use of live tissue and cadavers in military medical training,

(2) Medical visualization and innovative display systems (e.g., autostereoscopic or holographic technologies),

(3) Virtual patients and novel interaction capabilities,

(4) Integration with existing warfighter simulations,

(5) Medical training technologies that realistically simulate human trauma,

(6) High-fidelity patient simulation technologies,

(7) Simulated tissue with properties that approach those of live human tissue,

(8) Olfactory and malodor simulation technologies,

(9) Simulated body fluids and hemostatic agent training technologies,

(10) Personal computer, game-based and mobile application training technologies, and

(11) Methodologies that improve cost effectiveness and increase test scores as well as skill levels.

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vii. Synthetic Environments: Army simulation and battle command systems are transforming into highly integrated, distributed/collaborative One World Terrain tool suites that depend on accurate, timely geospatial data. Providing representations of complex environments is a critical element of models and simulations, requiring interoperability of heterogeneous simulation systems. The research emphasis is to provide the capability to represent the synthetic environment as realistically as possible to support the Army mission. Areas of consideration focus on synthetic environments representation and include:

(1) Environment generation.

(2) Environment representation.

(3) Environment services.

(4) Dynamic environments.

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viii. Dismounted Soldier Research: The Army needs advanced technology to provide dismounted Soldiers with fully immersive, simulation based training environments. ARL has an interest in researching, developing and demonstrating technologies and techniques for virtual immersion as well as next generation Mixed Augmented Reality (MAR) environments for dismounted Soldiers. ARL seeks to explore methods of presenting 2D/3D virtual objects (representing various targets, fire and effects, vehicles, etc.) to the dismounted Soldier while operating both indoors and outdoors. Additionally, the trainee would be capable of interacting with virtual targets, personnel, vehicles, etc. as though real. Specific technologies of interest include, but are not limited to:

(1) Visual and display systems to include head mounted displays,

(2) Computer systems,

(3) Wireless tracking devices to include markerless tracking technologies,

(4) Natural locomotion,

(5) Wireless video/audio transmission,

(6) MAR systems to include optically aided video odometry,

(7) Accurate depth sensing and occlusion mapping,

(8) Visual landmark detection technology,

(9) Mission rehearsal,

(10) Distributed AAR systems, and

(11) Advanced synthetic natural environments.

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ix. Training Support Technologies: ARL is investigating innovative, license-free tools, and techniques to train and educate Soldiers and leaders in individual and team knowledge, skills, attributes, and abilities in order to execute full spectrum operations in an era of persistent conflict. Specific areas of interest include:

(1) Next-Generation Learning Management Systems,

(2) Authoring tools that are user friendly with minimum train-up time and support the rapid development of learning principle-based content across several platforms (e.g. game-based, mobile, virtual worlds),

(3) Content Management Systems that are data-driven and capable of taking doctrine, training requirements, historical records, and other user inputs,

(4) Social Media and Social Networks for Learning in and out of the classroom, and

(5) Other innovative learning technologies in support of the Army Learning Model.

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g. CCE-HS-4: Humans in Multi-Agent Systems

This CCE focuses on providing the critical technological breakthroughs needed for future Army multi-, mixed-agent teams across distributed network systems. These technologies must effectively merge human and agent capabilities for collaborative decision making and enhanced team performance; ensure that diverse teams of Soldiers comprehend new and critical information to maintain unprecedented situation awareness; and interact effectively with Soldiers and noncombatants to foster trust and gain community acceptance and influence across cultures and within complex, dynamic, politically sensitive environments. These complex multi-agent networked teams will enable faster and better informed decisions; reduce

Soldier workload; provide otherwise unachievable levels of situation understanding and management; and maintain strategic and tactical advantages in future operating environments requiring the integration of cyber-human-physical dimensions.

The objective of this research is to provide the critical technological breakthroughs needed to shape current and future networked operational environments consisting of Army multi-agent, mixed-agent (humans, robots, associate agents, and intelligent systems) in distributed network systems to: (1) effectively enable teaming among human, robotic, and mixed-agent capabilities for collaborative decision-making and enhanced team performance in dynamic, and complex socio-technical environments; (2) ensure that diverse teams of Soldiers comprehend new and critical information to achieve unprecedented situational awareness, while maintaining optimal information burden on individuals; and (3) interact effectively with Soldiers and noncombatants in civil military scenarios to foster trust and gain community acceptance across cultures, and within complex, dynamic, and politically sensitive environments; and visualize and understand the complex dense urban environment battlespace and the diverse socio-cultural dynamics in a dense urban environment to allow Soldiers to effectively execute mission plans, sustain military forces, predict population behavior, and provide humanitarian support to civil populations.

Core research areas include:

i. Human-Agent Teams: the establishment and calibration of trust, the processes required for deep collaboration, and dynamic and individualized interactions.

ii. Socio-Technical Systems: the networks required to support distributed, coordinated, and collaborative decision making across teams, with an emphasis on mission command and the cyber domain.

iii. Socio-Cultural Influences: captured in virtual agents for training and operational contexts, the influences on decision making.

This research results of this CCE will inform interface design for mission command, and distributed and collaborative decision making, and the cyber security domain, as well as informing organizational design. This research will examine and identify the reasonable limits of human processing of big data and multi-modal inputs. Efforts on human supervision of robotic assets will transition to fundamental research on teaming with remote and intelligent assets.

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7. ANALYSIS AND ASSESSMENT (AA) CAMPAIGN

ARL's Analysis and Assessment Campaign is focused on guiding the development and integration of technologies, substantially broadening the range of issues that can be addressed with analytical rigor, and improving the throughput and responsiveness of the analytical processes. This campaign builds on fundamental pillars of mathematics, statistics, physics, materials science, engineering, and chemistry to conduct SLV analyses in areas including Ballistic SLV, EW SLV, Cyber SLV, Personnel Survivability, Human-Systems Interface, and Complex Adaptive Systems. Efforts in these six analyses areas are the CCEs that provide the enduring technical thrusts to enable the analysis and assessment to be performed.

The AA Campaign also has three KCIs related to the development of tools, techniques and methodology to support complex, multi-domain analysis and interactive situational analytical techniques. Accomplishing these aims will empower the Army RDT&E community with solutions that will be demanded by technological and strategic realities of today and the future.

a. KCI-AA-1: Methodology for A&A of Complex Systems and Technologies Across Multiple Domains

The development of an A&A methodology for complex systems and technologies that addresses cyber and electromagnetic activities, swarming munitions, autonomous systems, and human-agent teaming, underpinned by a mathematical framework of complexity and emergence theory. The resultant methodology will integrate physics and engineering-based models with tactics, techniques, and procedures applicable to the assessment of systems of interest to understand the effects of specific technical parameters on mission outcome. The A&A methodology will also include advanced data analysis tools, which will generate the knowledge required by decision makers and others to fully assess the causes and implications of system performance within complex, multi-domain, and operationally relevant environments. The analysis tools will include appropriate measures of effectiveness and associated metrics of performance, as well as unique ways to visualize the results and intuitively appreciate their impacts. This advanced analytical capability will provide detailed insight for the design and development of systems and technologies, as well as their integration with the operational force to produce the most resilient system.

The goal of this technical program is to enable integrated coherent analysis of the behavior of complex adaptive systems across multiple domains in a tactically realistic environment that includes advanced intelligent autonomous threats within the three components of either a system or cyber autonomous intelligent agent: the human component (as a designer, programmer, and/or partner); the system component (including hardware, firmware/software, and interface realms); and the algorithm component (including programming/coding, decision trees/matrices design, and machine learning areas). The focus of this initiative is the development of analysis and assessment methodologies based on a mathematical framework of complexity to address: (i) CEMA in the tactical environment; (ii) swarming munitions; (iii) autonomous and semi-autonomous systems; and (iv) human-intelligent agent interaction.

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b. KCI-AA-2: Visual, Interactive, Situational Analysis and Assessment

The products of the Survivability, Lethality, and Vulnerability (SLV) analysis must be available in a timely manner, intuitively comprehensible, and demonstrably relevant to make them actionable. Implementing visual, interactive, situation-specific analysis will shorten development timelines, enable more informed acquisition decisions, improve operational training, and provide effective combatant decision aids. Collectively this will help insure dominance on the future battlefield. These tools will also help materiel designers, evaluators, and trainers to better equip and train the Soldier for this new challenge.

This includes the development of an approach for visual (easy to understand), interactive (quickly available), situational (in the current location and relevant to the task at hand) analysis results to be produced. The speed and visual presentation will allow understanding of the results and how they are derived. The latter is important for establishing credibility, relevance and confidence.

Through interaction, the user/operator can focus the simulation on relevant aspects to directly answer the questions being asked. This interaction focus naturally produces a "self-limiting" analysis process which eliminates unnecessary computation, yet produces detail where desirable. It allows broader questions to be addressed directly without sacrificing detail. This effort will create a goal oriented, cognition-driven analysis experience. This will provide Soldiers, materiel designers, evaluators and trainers with timely, comprehensible, relevant, and actionable information. It will make analysis products more accessible and valuable to the DoD community as a whole.

Analysis domains could include one or more of the following: ballistics SLV, non-kinetic damage, cyber SLV, EW SLV, personnel survivability, and human terrain analysis algorithms.

Meeting these various needs necessitates (1) Adoption of computational pipelines that take advantage of current computing hardware to execute needed analysis at interactive rates. (2) Coupling this with effective visual representations that facilitate cognitive understanding (3) Employment of computational steering techniques to allow simulations to be focused on the relevant aspects of the simulation. (4) Employment of a multi-disciplinary, collaborative approach to encourage participation by relevant experts in a variety of disciplines.

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c. KCI-AA-3: Analysis and Assessment Methodology for Congested and Contested Operational Environments

The subject KCI will develop the methodology for analyzing and assessing Army materiel in a contested and congested operational environment, and will identify the necessary capabilities to accomplish the aforementioned. The initiative will lay the groundwork for considering expanding complexity in the multi-domain battlespace and address emergent challenges associated with critical Office of the Secretary of Defense (OSD) priorities areas, such as hypersonics, directed-energy, artificial intelligence, and robotics. The effort will be further informed by participating in experimentation, prototype, and demonstration events critical to the success of the Army Futures Command. The future operational environments identified in TRADOC PAM 525-3-1, Win in a Complex World, includes operating in complex operational environments. Dense urban Environments (DuE) will be the most complex where cyber-physical-social complexity is most emergent.

Impacts on military operations will include limited or restricted lines of sight (LOS); congestion of structures, people, and traffic; constraints and bounds on electromagnetic effects and communications information (interconnectedness on a global scale); constraints on kinetic engagements, governance and control (including human sociocultural factors), target detection and acquisition, financial, and resource sourcing and allocation. These types of environments will induce unexpected synergistic effects and unanticipated emergence. Successful completion of this KCI will allow RDECOM to advance Survivability Lethality and Vulnerability Analysis and Assessment for congested and contested environments, thereby allowing the Army to be better advised in S&T, acquisition, and operational decisions.

The new methodologies will be used to assess systems slated for development in the Army Cross Functional Teams: Future Vertical Lift, Network C3 Intelligence, PNT, Synthetic Training Environment, Long Range Precision Fires, Next Generation Combat Vehicle, and Soldier Lethality. This KCI will involve the identification of specific phenomena, experimentation and data collection leading to development of relevant methodology for accelerating the production of requisite materiel that increases the lethality of our Soldiers. This KCI requires the participation of RDECOM support, and will require leveraging of products from all ARL Essential Research Programs, RDECOM acquisition programs, combat developers, the Army analyst community, and the Test and Evaluation community.

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d. CCE-AA-1: Ballistics Survivability, Lethality and Vulnerability (SLV)

The goal of the Ballistics SLV CCE is to leverage the science of threat-target interactions to identify and recommend techniques to reduce ballistic vulnerabilities, enhance system and complex target survivability, and ensure optimum effectiveness of the system in the full spectrum of battlefield environments and operations. Achieving the goal for this CCE enables a

focus on discovering and mitigating SLV challenges in emerging technologies and in system designs throughout the acquisition life-cycle. Success in this endeavor requires the development, application, and sustainment of robust, efficient and accurate methodologies, tools and models to enable innovative analyses. Innovative scientific methodologies and tools are foundational to advancing our ability to identify, understand, quantify, and model the potential effects of both emerging and future weapons against fielded and developmental systems.

Innovative methodologies, tools and analysis products that the AA Campaign develops will be transitioned, as appropriate, for use internally and to other DOD users who will be able to conduct complex analyses that meet their varied needs as new technologies mature and are applied to conceptual and developmental Army systems. The AA Campaign will provide subject matter expertise to perform early SLV analysis to "the left" for early SLV analysis and to "the right" for use in evaluation through the acquisition process as well as to operational users for mission planning purposes.

The Ballistics AA CCE focuses on the following objectives that support the development of:

i. Mature and scientifically rigorous products that enable ARL and other DoD users to interactively conduct complex SLV analysis throughout the acquisition timeline. This requires the development and application of computational techniques to deliver cutting-edge, modernized, faster, and higher resolution (in terms of both target geometry detail and the scale at which target-threat interactions are modelled) SLV analysis capabilities that will enhance core SLV models.

ii. Robust, efficient and accurate methodology including approaches using or based on fully integrated high-fidelity multi-physics software–for estimating vehicle and occupant vulnerability to under-body blast threats.

iii. Scientific tools, techniques and methods to enable lethality analyses of the effects from multiple ballistic impacts and from ballistic threats coupled with nontraditional directed-energy (DE) threat effects.

iv. Vulnerability reduction techniques that can be applied to future technologies.

v. Integrated ballistic SLV products and capabilities that provide a holistic understanding of the system or platform mission readiness.

vi. Analytical and scientific methods for subterranean and megacity (SbT/MgC) environments that enable characterization of the response of building designs and construction methods to ballistic response of a city/infrastructure to ballistic threats impacts.

vii. Integrated ballistic SLV products and capabilities that expand efforts to illuminate multi-domain effects and answer multi-domain questions (e.g., combined EW, cyber, CEMA, and/or ballistics) in the same analysis.

viii. New techniques/methods to better display V/L data to complement cell plots to provide clearer, intuitive, higher-value delivery mechanisms for analysts, evaluators and assessors.

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e. CCE-AA-2: Cyber Survivability, Lethality and Vulnerability (SLV)

Advancements in cloud computing and commercial-off-the-shelf technology and software increase the potential to add to or expand the number of unintended vulnerabilities in DoD systems and networks that adversaries can deny, disrupt, degrade or exploit. Advancements in nanotech computing, wireless, advanced robotics, autonomous, intelligent agent, cloud computing and other technologies as well as reliance on 3rd party commercial-off-the-shelf software will also increase the cyber-attack surface in DoD systems and networks.

The AA CCE in Cybersecurity focuses on researching, developing and sustaining methodologies and analytical tools to plan and conduct cybersecurity assessments on technologies, weapon systems, information systems and networks. This sustained effort will enable the design, development and integration of secure technologies developed for or integrated into U.S. Army warfighting systems. To keep pace with the rapid evolution of cyber threats, U.S. military defensive cyber operations rely on cybersecurity assessments and analyses on technologies, systems and network architectures throughout the acquisition process.

Continuous AA is critical to identifying and mitigating cyber vulnerabilities to ensure cyber resiliency across the acquisition enterprise. Cybersecurity is defined as the prevention of damage to, the protection of, and the restoration of computers, electronic communications systems, electronic communications services, wire communication, and electronic communication, including information contained therein, to ensure their availability, integrity, authentication, confidentiality, and nonrepudiation.

Nearly all defense systems incorporate IT in some form, and must be resilient from cyber adversaries. This means that cybersecurity applies to technologies used in weapons systems and platforms; Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) systems; and information systems and networks. Cybersecurity is a critical priority for the DoD, and is a vital aspect of maintaining United States technical superiority.
The AA CCE in Cybersecurity will focus on researching and developing cyber-attack techniques and tools to assess the security posture of emerging technologies; cyber vulnerability assessment and instrumentation tools leveraging advanced intelligent agents, data analytics, advanced visualization; malware reverse engineering and analysis; and security code analysis.

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f. CCE-AA-3: Electromagnetic Environment (EME) and Warfare

The CCE in EW SLV focuses on research and analysis efforts to enable the development of tools, techniques, and methodologies to assess and evaluate the negative effects of adversarial attacks on Army electronic systems. Utilizing readily available commercial and Government off-the-shelf technologies, EW SLV investigations look for inherent susceptibilities that these and similar technologies may have when directed toward existing or future Army systems.

The A&A CCE in EW SLV will conduct research to enable analytical efforts investigating the adverse effects and impacts on Army systems resulting from operations in a complex and dynamic battlefield Electromagnetic Environment (EME). Technological advancements in electronics, telecommunications, wireless technologies, sensors, lasers, and countermeasures that are commercially available are increasing unabated. The application of these technologies as both radio frequency electronic countermeasures (RFECM) and Electro-optical countermeasures (EOCM) to Army networks, communications, sensors, manned and unmanned platforms, and weapon systems is highly likely, given their advanced technical capabilities, general availability, and low costs compared to the Nation State sponsored technology developments in the past 30-40 years. Understanding how these technologies have the potential to adversely affect basic operation and mission effectiveness of Army systems will enable the Army to research, develop and apply mitigation strategies to counter these technologies and their associated effects. This research will enable the identification and mitigation of potential vulnerabilities to these technologies for both new and existing Army weapon, network, sensor, communication, and navigation systems. The A&A CCE in EW SLV enables the design and development of new, sophisticated, and cost effective analysis methods and tools for use during technology development, and throughout the acquisition life cycle, that can subject component, sub-system, and system level Army technologies to these stressing environments in systematic manner in order to detect and mitigate potential vulnerabilities. Utilizing advanced techniques in EME modeling, generation, and measurement (including both the inherent EME and intentional EA), in coordination with modeling and instrumentation of Army systems, and using laboratory, closed loop, hardware-in-the-loop (HWIL), anechoic chamber, and open-air range investigations; susceptibilities may be identified and mitigation techniques determined.

Strategic focus areas of the A&A CCE in EW include:

- Controlled environment (laboratory, HWIL, anechoic chamber) analysis development.
- Counter-countermeasure development and analysis (threat EA mitigation techniques).
- Effects of emerging threats on autonomous systems (both airborne and ground based).
- Effects of emerging RFCM and EOCM threats on sensors (RF and EO/IR), manned and unmanned platforms, and Army weapon systems.
- Effects of emerging threats on position, navigation, and timing.
- Threat and commercial EME generation capabilities, signatures, and predictors of presence (threat technique generation and identification).

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g. CCE-AA-4: Personnel Survivability

The Personnel Survivability CCE concentrates on the advancement of research and analysis to identify, understand, quantify, and model the effects of threat-target interactions on combat personnel, including injury assessment, performance, and operational effectiveness. Advances in research and experiments in the area of personnel survivability are foundational to the identification and development of scientific techniques to: 1) mitigate injury and enhance the survivability of Soldiers facing the wide range of battlefield threats, including ballistic, thermal, toxic substances, and less-than-lethal anti-personnel weapons; 2) enhance lethality of antipersonnel ballistic munitions; and 3) understand the effects of current and future weapons against personnel and protective systems. In addition to Soldier protection, Soldier survivability is assessed in terms of Soldier lethality, situational awareness, and the ability to effectively communicate and operate undetected when needed.

This AA CCE in Personnel Survivability describes a systematic plan of multidisciplinary research that addresses critical questions about the nature of human injury mechanisms and the interactions of the Soldier with enabling technologies that provide protection, lethality, mobility, information, communication and concealment. It addresses adaptive behavior on the battlefield to increase survivability in a hostile environment and the development of methodologies and models to address critical questions surrounding these interactions and implications on Soldier survivability.

ARL will apply these methodologies to identify the benefits and risks associated with new technologies prior to system design and integration supporting capabilities, such as Adaptive Soldier Architecture and trade space analysis of new individual Soldier and squad technologies. ARL will transition our products for use internally and to other DoD users to interactively conduct complex, credible analyses that meet their varied needs as these new technologies mature and are applied to conceptual and developmental Army systems. Using this approach we will extend our subject matter expertise in performing early SLV analysis to “the left” for early SLV analysis and to “the right” for use in evaluation through the acquisition process, as well as to operational users for mission planning purposes.

The AA CCE on Personnel Survivability investigates and advances understanding and modeling the Soldier as a system to look at personnel survivability. Personnel survivability is characterized in terms of injury, degraded Soldier performance and capability with and without injury, and risks to long-term quality of life given injury. Because personnel survivability depends on enabling capabilities provided by a number of technologies, personnel survivability is studied in the context of the Soldier as a system, where Soldier lethality and the Soldiers’ ability to sense, communicate, and to operate undetected are also taken into consideration.

The strategic approach includes:

i. Fundamental and applied research projects to understand and quantify human survivability and performance to develop human injury and performance models.

ii. Applied research to understand and characterize next-generation Soldier augmentation systems, protective systems, novel protective materials and future non-lethal and lethal systems that target precision, scalable effects and improved range, the ability to sense and communicate on the battlefield, and to operate undetected.
iii. Development, maintenance, and application of SLV analysis capability that is adaptable, interoperable, and interactive; enables analyses of complex interactions in a mission/capabilities context, exploits emerging computation capabilities and can be used within a collaborative simulation.

iv. Development, application, verification, validation, and transition of tools, techniques and methodologies for testing, analyzing, and evaluating Soldier performance and survivability.

TPOC: Gregory Dietrich, (410) 278-2284, gregory.k.dietrich.civ@army.mil.

h. CCE-AA-5: Human Systems Integration (HSI) Modeling and Analysis

The HSI Modeling and Analysis CCE focuses on developing and enhancing effective models and methodologies for predicting human, system of system, and mission capabilities throughout the acquisition cycle and supporting the Chief of Staff or the Army's modernization priorities. These efforts concentrate on identifying human capabilities and limitations within physical, perceptual, and cognitive areas to develop and inform methodologies; integrate the HSI domains; and develop technical, parametric system assessments.

The inclusion of physical, perceptual, and cognitive analyses to determine early, cost-effective insertion of HSI criteria, capabilities, requirements, and performance specifications within the acquisition process will optimize Soldier-System performance and reduce overall program cost at the system of systems level. It is important to continuously update relevant tools, techniques, and methodologies to maintain their verification, validation, and utility for the tri-service user community. Application of these HSI methodologies will provide insight into the Soldiers' capabilities and operation of systems, and will highlight issues and gaps that need to be addressed to achieve an overall balanced system design. The deployment and utilization of these tools, techniques, and methodologies must keep pace with increasingly advanced and shortened program acquisition schedules. Technologies for the development of rapid modeling tools and techniques, along with state-of-the-art immersive environments, will need to be pursued to accomplish these goals. Additionally, human performance data crucial to supporting development of acquisition requirements needed to assess future systems either do not exist, or are badly out of date and no longer apply to current system technologies. Studies and the resultant human performance data to support development of acquisition requirements, specifications, and early system analyses needs to be performed. Practical design and analysis tools need to be developed, deployed, and refined, so that HSI practitioners can make effective use of the human performance data to achieve the goal of optimizing Soldier-System performance and minimizing cost.

The Analysis & Assessment CCE on Human System Modeling and Analysis investigates and advances the sciences relevant to two performance challenges: 1) identifying Soldier performance trade-offs on mission demands, environment, human characteristics, equipment, and technology; and 2) understanding human factors that include sensing, perceptual and cognitive processes, ergonomics, biomechanics, and the tools and methodologies required to manage interaction within these areas and within the Soldiers' combat environment. In developing and updating models resulting from an integrated HSI Analytic Tool Suite and techniques capable of predicting human, system, and mission capabilities, four research focus areas will be emphasized:

1. Identify, develop, and apply human performance measures of effectiveness and human figure modeling tools.
2. Integrate human factors, mathematics, statistics, and system engineering, to generate complex and critical task combinations that provide the necessary analytical data to support physical, perceptual, and cognitive workload assessment.
3. Develop a virtual environment to represent the Soldier as a system while considering physical effects, cognitive load, and demographic influences in the context of Soldier Systems Integration.
4. Conduct research to support Capabilities Based Assessments, and develop requirements and performance specifications early on in the acquisition cycle to reduce cost.

In performing system design analyses with integrated complex human performance behavior, the A&A CCE in Human Systems Modeling and Analysis aims to shape technology development and system design for the Army modernization.

TPOC: Jock Grynovicki, (410) 278-5956, jock.o.grynovicki.civ@army.mil

i. CCE-AA-6: Complex Adaptive Systems Analysis

The Complex Adaptive Systems Analysis CCE focuses on the improvement, application, and sustainment of research and techniques to model the performance of complex, adaptive systems at the engineering level to support the full range of force operating capabilities. These methodologies are crucial to the assessment of technology and system tradeoffs to illuminate and evaluate survivability aspects of competing capability packages and technologies.

The Complex Adaptive Systems Analysis CCE will enable analyses of the effects and impacts of the Army's transformation in capabilities as a result of rapid, multi-faceted technological progress. Current Army analysis methodologies resulted from an era that contended with a much simpler set of analysis problems typically focused at the particular system or at the network levels. The Complex Adaptive Systems Analysis CCE will answer more complex questions, and thus provide the Army a significant leap forward in analysis techniques, methodologies, and mindsets by focusing at the area where all particular weapons, mission command, and other systems converge and merge their operations with the network levels, essentially at the larger combat formation echelons, company, battalion or brigade. For example, scientific advancements in information, computational, and human sciences have

resulted in revolutionary advances in information processing, human-agent teaming, artificial intelligence and machine learning, distributed and cooperative engagements, and increasingly autonomous ground and air vehicles. The Army must identify, articulate, and develop new and advanced analysis methods that can gauge how well the Army is taking advantage of new third offset capabilities, mitigating new threats posed by advancing adversary capabilities, and adapting to radically new contested environments. These methods will not be simplistic system-to-system comparisons, but must consider credible mission context and the environments in which the systems will operate with a complex, systems-of-systems environment. The proliferation of unmanned aerial systems, the challenges of dense urban environments, and the benefits and risks of manned-unmanned teaming all require enhanced analysis tools. Utilizing modern research in simulation, simulation languages, emerging mathematical techniques, and other advancements will improve capabilities to explore the continuum of military operations. The analysis methodologies will address the complexity inherent in interactions between systems, including humans and multiple, autonomous, and potentially intelligent learning machines. Analyses will also explore the rapid growth of adversary capabilities, in areas such as cyber and electronic warfare, due to advancing commercial technologies.

Strategic focus areas of the A&A CCE in Complex Adaptive Systems will incorporate:

1. Research from computational science and extramural basic research on advanced mathematical, statistical, and modeling and simulation techniques, such as predictive sciences, uncertainty quantification, advance computational algorithms, and data intensive techniques.
2. Research from human sciences to explore the human dimension of future conflict, including human/machine interfaces and cognitive decision making processes.
3. Research from the information sciences regarding communication, processing, storage, and retrieval of information, for example research on digital RF technology.

TPOC: Arturo Revilla, (575) 678-3435, arturo.revilla.civ@army.mil.

8. OTHER PROGRAMS: Visiting Scientist Program (VSP)

The VSP supports short-term travel opportunities for foreign/ international scientists to the United States and to international conferences to socialize new S&T ideas or findings with the Army that support advancing basic research through collaboration. For additional information, contact the RDECOM International Technology Center at usarmy.blenheimcrescent.rdecom.mbx.rfec-atlantic@mail.mil.

9. ARMY AI TASK FORCE RESEARCH INTERESTS - The Army AITF is seeking research and development solutions in support of new technologies and translational research-based approaches that support the identification, alignment, and exploitation of applied research and technology to enable the Army of 2028 to be ready to deploy, fight, and win decisively against any adversary, anytime, and anywhere, in a joint, multi-domain, high-intensity conflict, while simultaneously deterring others and maintaining its ability to conduct

irregular warfare. Solutions sought in conjunction with this effort consist of innovation-enabling technologies and approaches that will improve the Army's ability to rapidly and cost-effectively capitalize on global advances in the areas detailed below.

There are a number of technologies and approaches that touch more than one of the Army Modernization Priorities as well as other areas important to the Army. Advances in these areas may be highly disruptive since they could address multiple priorities or functions. Specialized capabilities and infrastructure needed to create, experiment with, validate and sustain long term research in these areas is of interest as well. Research areas of interest include, but are not limited to, the following:

a. **Autonomous platforms** – The Army is particularly interested in research in autonomous ground and air vehicles which must operate in open, urban and cluttered environments. Robotics and autonomous systems regardless of their missions require similar concepts and technologies including:

i. Ability to move in very cluttered, irregular, urban and underground terrains
ii. Ability to move effectively in contested environments and survive attacks
i. Technologies to enable low electronic and physical profiles
ii. Techniques to allow operators to be trained quickly even for complex tasks
iii. Architectures to enable reprogrammable platforms under dynamic conditions
iv. Sensors to detect obscured targets and to characterize terrain obstacles
v. Autonomous ground and air structures, propulsion, and mobility components
vi. Technologies to significantly reduce logistical burdens

b. **Artificial Intelligence and Machine Learning (AI/ML) -** The Army is interested in AI/ML research in areas which can reduce the load on humans and improve overall performance in many areas. AI/ML research is needed in areas such as:

i. Autonomous, intelligent maneuver and behaviors of autonomous ground and air vehicles - object recognition, threat warning, etc.
ii. Ability to analyze large, diverse data sets to predict enemy intent and behaviors
iii. Technologies to ensure robust, resilient and intelligent networking, cyber, electronic warfare and analysis of adversary signals
iv. Data analysis capabilities to engage with and exploit classified and unclassified sources in order to produce enhanced intelligence products
v. Techniques to fuse data from disparate sources to improve a particular mission

c. **Data visualization and synthetic environments** – The Army is interested in research in research into concepts enabling improved situational awareness and the visualization and navigation of large data sets and to enhance training. Research is needed in the visualization of data in following areas:

i. Sensor data
ii. Large data sets
iii. Complex multi-source mode data sets
iv. Novel visualization and synthetic environments approaches to enable improved training
v. Synthetic environments and networked instrumentation approaches for virtual-live validation of concepts and prototypes

d. **Assured Position, Navigation, and Timing (PNT)** – The Army is interested in researching novel new PNT technologies which could be key enablers for many capabilities including autonomous vehicles, communications, and land navigation. Solutions that enable robust PNT on vehicles, Soldiers, munitions might include research on:

i. PNT technologies which operate reliably in GPS-degraded or denied areas which cannot be exploited by others
ii. Enhancements to commercial technologies to enable them to meet Army needs
iii. Robust security techniques for PNT at all levels
iv. PNT-enabled guidance and control
v. Algorithms and techniques to fuse data from multiple PNT sources to provide robust capabilities

e. **Sensing** – The Army is interested in having a detailed understanding of the environment and activities in areas it operates in. Research is needed in the areas of sensors and associated processing in order to:

i. Detect people, equipment, weapons, and any other object or action of interest
ii. Detect all targets even when obscured
iii. Detect based upon, physical, behavioral, cyber or other signatures

f. **Communications & Networks** – It is critical the Army maintain secure, reliable communications for Soldiers, vehicles and at fixed locations even in austere environments with little or no fixed infrastructure. Research is needed in the areas related to following:

i. Concepts and methodologies to enable robust networks
ii. Protocols
iii. Network interoperability including multi-national partners
iv. High efficiency components

g. **Computation** – The Army has a growing need for high performance computational capabilities to exploit large data sets and to perform complex AI/ML algorithms for many applications. Research is needed to improve networks and communications in the following areas:

h. Throughput
ii. Power efficiency
iii. Edge computing

i. **Internet of Things (IOT)** – The Army needs to better integrate a wide range of capabilities and equipment and capitalize on commercial developments in the industrial IOT. The Army's interested is driven in part by the fact that the amount of usable communication bandwidth on the battlefield will be dynamic, and as such automated reallocation of communication resources and information sharing strategies are more challenging than commercial ones. Research is needed to improve Army IOT in the following areas:

i. New concepts, quantitative models and technical approaches enabling automated management of IoT.

ii. New machine learning techniques that accelerate decision making are needed to address the scale/volume of IoT information and advance the science.

iii. New approaches, low-complexity algorithms, and methods to enable IoT be secure, resilient, and to automatically manage and effect risk and uncertainty in a highly deceptive, mixed cooperative/adversarial, information-centric environment.

iv. Novel IoT approaches to enable improved training

v. Mesh and edge computing

j. **Underpinning Methodologies** - Methodologies, frameworks, tools, facilities, techniques, and experimentation concepts, which underpin and enable advanced research and development in all of the areas of the TRIAD concept are of interest including those which enhance the abilities to:

i. Collect, standardize, transform, and maintain data to focus research and validate concepts

ii. Rapid model, develop and assess technologies across widely distributed research teams

iii. Integrate innovative technology applications into current or future warfighting systems, applications, and analysis systems to assess the potential operational effectiveness of novel new technology elements

iv. Automated data analytics tools and approaches that enhance discovery, development and transition management of technologies that address Army capability gaps

POCs for all Army AITF Research Interests:
Ruben Cruz; (412) 268-2844; ruben.cruz22.civ@army.mil
Kim DeLong; (703) 571-3719; kimberly.l.delong.civ@army.mil

(End of Section)

B. Federal Award Information

The ACC-APG-RTP Division has the authority to award a variety of instruments on behalf of ARL. Anticipated awards will be made in the form of contracts, grants, cooperative agreements, technology investment agreements (TIAs), or other transactions for prototypes (OTAs). The ACC-APG-RTP Division reserves the right to select the type of instrument most appropriate for the effort proposed. Applicants should familiarize themselves with these instrument types and the applicable regulations before submitting a proposal. Following are brief descriptions of the possible award instruments:

1. Procurement Contract. A legal instrument, consistent with 31 U.S.C. 6303, which reflects a relationship between the Federal Government and a state government, a local government, or other entity/contractor when the principal purpose of the instrument is to acquire property or services for the direct benefit or use of the Federal Government.

Contracts are primarily governed by the following regulations:

a. Federal Acquisition Regulation (FAR)
b. Defense Federal Acquisition Regulation Supplement (DFARS)
c. Army Federal Acquisition Regulation Supplement (AFARS)

2. Grant. A legal instrument that, consistent with 31 U.S.C. 6304, is used to enter into a relationship:

   a. The principal purpose of which is to transfer a thing of value to the recipient to carry out a public purpose of support or stimulation authorized by a law or the United States, rather than to acquire property or services for the Federal Government's direct benefit or use.

   b. In which substantial involvement is not expected between the Federal Government and the recipient when carrying out the activity contemplated by the grant.

   c. No fee or profit is allowed.

3. Cooperative Agreement. A legal instrument which, consistent with 31 U.S.C. 6305, is used to enter into the same kind of relationship as a grant (see definition "grant"), except that substantial involvement is expected between the Federal Government and the recipient when carrying out the activity contemplated by the cooperative agreement. The term does not include "cooperative R&D agreements" as defined in 15 U.S.C. 3710a. No fee or profit is allowed.

4. Technology Investment Agreement (TIA). Assistance transaction other than a Grant or Cooperative Agreement (see 32 CFR Part 37). A legal instrument, consistent with 10 U.S.C. 2371, which may be used when the use of a contract, grant, or cooperative agreement is not feasible or appropriate for basic, applied, and advanced research projects. The research covered under a TIA shall not be duplicative of research being conducted under an existing DoD program. To the maximum extent practicable, TIA's shall provide for a 50/50 cost share between the government and the applicant. An applicant's cost share may take the form of cash, independent research and development (IR&D), foregone intellectual property rights, equipment, access to unique facilities, and/or other means. Due to the extent of cost share, and the fact that a TIA does not qualify as a "funding agreement" as defined at 37 CFR 401.2(a), the intellectual property provisions of a TIA can be negotiated to provide expanded protection to an applicant's intellectual property. No fee or profit is allowed on TIAs.

5. Other Transaction for Prototype (OTA). A legal instrument, consistent with 10 U.S.C. 237 1b., which may be used when the use of a contract, grant, or cooperative agreement is not feasible or appropriate for prototype projects directly relevant to enhancing the mission effectiveness of military personnel and the supporting platforms, systems, components, or

materials proposed to be acquired or developed by the DoD, or to improvement of platforms, systems, components, or materials in use by the armed forces. The effort covered under an OTA shall not be duplicative of effort being conducted under an existing DoD program (please refer to the "Other Transactions" OT Guide for Prototype Projects). This document, along with other OTA resources, may be accessed at the following link: https://www.dau.edu/training/career-development/logistics/blog/Other-Transaction-Authorities-(OTA)-Resources

6. Grants and cooperative agreements for institutions of higher education, nonprofit organizations, foreign organizations, and foreign public entities are primarily governed by the following:
   a. Federal statutes
   b. Federal regulations
   c. 2 CFR Part 200, as modified and supplemented by DoD's interim implementation found at 2 CFR Part 1103
   d. 32 CFR Parts 21, 22, 26, and 28
   e. DoD Research and Development General Terms and Conditions
   f. Agency-specific Research Terms and Conditions

7. Grants and cooperative agreements for for-profit and nonprofit organizations exempted from Subpart E—Cost Principles of 2 CFR Part 200, are primarily governed by the following:
   a. Federal statutes
   b. Federal regulations
   c. 32 CFR Part 34 - Administrative Requirements for Grants and Agreements with For-Profit Organizations
   d. 32 CFR Parts 21, 22, 26, and 28
   e. DoD Research and Development General Terms and Conditions
   f. Agency-specific Research Terms and Conditions

8. TIAs are primarily governed by the following:
   a. Federal statutes
   b. Federal regulations
   c. 32 CFR Part 37 – Technology Investment Agreements
   d. DoD Research and Development General Terms and Conditions
   e. Agency-specific Research Terms and Conditions

9. OTAs are primarily governed by the following:
   a. Federal statutes
   b. Federal regulations
   c. Office of Secretary of Defense implementation guidance titled Other Transactions (OT) Guide for Prototype Projects

10. The following websites may be accessed to obtain an electronic copy of the governing regulations and terms and conditions:

a. FAR, DFARS, and AFARS: http://acquisition.gov/
b. Code of Federal Regulations: http://www.ecfr.gov
c. DoD Research and Development General Terms and Conditions: https://www.onr.navy.mil/en/work-with-us/manage-your-award/manage-grant-award/grants-terms-conditions
d. Agency-specific Research Terms and Conditions: http://www.arl.army.mil/www/default.cfm?page=8

(End of Section)

C. Eligibility Information

1. Eligible Applicants

Eligible applicants under this BAA include institutions of higher education, nonprofit organizations, state and local governments, foreign organizations, foreign public entities, and for-profit organizations (i.e. large and small businesses) for scientific research in mechanical sciences, mathematical sciences, electronics, computing science, physics, chemistry, life sciences, materials science, network science, and environmental sciences. Whitepapers and proposals will be evaluated only if they are for fundamental scientific study and experimentation directed toward advancing the scientific state of the art or increasing basic knowledge and understanding. Whitepapers and proposals focused on specific devices or components are beyond the scope of this BAA.

For foreign public entities or foreign organizations, see Section II.C.3.a below for further information. There is no restriction on the place of performance for awards issued under this BAA.

2. Cost Sharing or Matching

Generally, there is no requirement for cost sharing, matching, or cost participation to be eligible for award under this BAA. Cost sharing and matching is not an evaluation factor used under this BAA. Exceptions may exist if the applicant is proposing the use of a TIA or an OTA as an award instrument. Cost-sharing requirements may be found at 32 CFR 37 for TIAs. Cost-sharing requirements for OTAs may be found at Section C2.16 COST SHARING in the January 2017 document titled “Other Transactions” OT Guide for Prototype Projects.

In addition, if cost sharing is proposed on a grant or cooperative agreement proposal submitted by a nonprofit or institution of higher education, the award will be subject to the restrictions at 2 CFR 200.306. If cost sharing is proposed on a contract proposal, the award will be subject to the restrictions at FAR 35.003.

3. Other

a. Foreign public entities or foreign organizations are advised that security restrictions may apply that could preclude their participation under this BAA.

b. Pursuant to the policy of FAR 35.017 and supplements, selected Federally Funded Research and Development Centers (FFRDC) may propose under this BAA as allowed by their sponsoring agency and in accordance with their sponsoring agency policy.

(End of Section)

D. Application and Submission Information

1. Address to View Broad Agency Announcement

This BAA may be accessed via the following websites:

a. Grants.gov (www.grants.gov)
b. System for Award Management (SAM.gov)
c. ARL website http://www.arl.army.mil/www/default.cfm?Action=6&Page=8.

Amendments to this BAA, if any, will be posted to these websites when they occur. Interested parties are encouraged to periodically check these websites for updates and amendments.

The following information is for those wishing to respond to the BAA:

2. Content and Form of Application Submission

a. General Information

i. Preliminary Inquiries: The ARL receives several hundred research proposals annually. Because of financial constraints, we are able to provide support for only a limited number of the proposals received. We realize the preparation of a research proposal often represents a substantial investment of time and effort by the applicant. Therefore, in an attempt to minimize this burden, we strongly encourage applicants interested in submitting proposals to make preliminary inquiries as to the general need for the type of research effort contemplated, before expending extensive effort in preparing a whitepaper and/or detailed proposal or submitting proprietary information. The TPOC names, telephone numbers, and email addresses are listed immediately after each research area of interest and they should be contacted, as appropriate, prior to the submission of whitepapers or proposals.

*NOTE: The Government will not be obligated by any discussion that arises out of preliminary inquiries.

ii. Classified Submissions: Classified proposals are not expected. However, in an unusual circumstance the applicant may be notified that access to classified information and/or controlled unclassified information will occur under the work proposed. In those instances where a contract is awarded requiring access to classified information and/or controlled unclassified information, clause FAR 52.204-2 shall be in effect, as well as a DD254, if issued. For questions regarding the potential for access to classified information and/or controlled unclassified information, please coordinate with the TPOC for that topic area prior to proposal submission.

iii. Use of Color in Proposals: All proposals received will be stored as electronic images. Electronic color images require a significantly larger amount of storage space than black-and white images. As a result, applicants' use of color in proposals should be minimal and used only when necessary for details. Do not use color if it is not necessary.

iv. Post-Employment Conflict of Interest: There are certain post-employment restrictions on former federal employees, including special government employees (18 U.S.C. 207). If a prospective applicant believes a conflict of interest may exist, the situation should be discussed with the TPOC listed in the BAA for their area of scientific research who will then coordinate with appropriate ARL legal counsel prior to the applicant expending time and effort in preparing a proposal.

v. Statement of Disclosure Preference: In accordance with Section II.D.2.e.iii of this BAA, Form 52 or 52A shall be completed stating your preference for release of information contained in your proposal. Copies of these forms may be downloaded from the ARO web site at: http://www.arl.army.mil/www/default.cfm?page=29, under "For the Researcher" (Forms, ARO BAA Forms).

NOTE: Proposals may be handled for administrative purposes by support contractors. These support contractors are prohibited from submitting proposals under this BAA and are bound by non-disclosure and/or conflict of interest requirements as deemed appropriate.

vi. Equipment (see instrument-specific regulations provided in Section II.B of this BAA): Normally, title to equipment or other tangible property purchased with Government funds vests with nonprofit institutions of higher education or with nonprofit organizations whose primary purpose is conducting scientific research if vesting will facilitate scientific research performed for the Government. For-profit organizations are expected to possess the necessary plant and equipment to conduct the proposed research. Deviations may be made on a case-by-case basis to allow for-profit organizations to purchase equipment, but regulatory disposition instructions must be followed.

b. The Application Process

The application process is in three stages as follows:

i. Stage 1- Verify the accuracy of your Unique Entity Identifier (formerly DUNS) at the Dun and Bradstreet (D&B) website http://fedgov.dnb.com/webform before registering with the System for Award Management System (SAM) at https://www.sam.gov. Prospective applicants must be registered in SAM prior to submitting an application or plan. The SAM obtains Legal Business Name, Doing Business Name (DBA), Physical Address, and Postal Code/ Zip+4 data fields from D&B. If corrections are required, registrants will not be able to enter/modify these fields in SAM; they will be pre-populated using D&B Unique Entity Identifier record data. When D&B confirms the correction has been made, the registrant must then re-visit sam.gov and click a "yes"' to D&B's changes. Only at this point will the D&B data be accepted into the SAM record. Allow a minimum of two (2) business days for D&B to send the modified data to SAM.

ii. Stage 2 - Prospective proposers are requested to submit whitepapers prior to the submission of a complete, more detailed proposal. The purpose of whitepapers is to minimize the labor and cost associated with the production of detailed proposals that have very little chance of being selected for funding. Based on assessment of the whitepapers, feedback will be provided to the proposers to encourage or discourage them from submitting proposals. Whitepapers should present the effort in sufficient detail to allow evaluation of the concept's scientific merit and its potential contributions of the effort to the Army mission.

iii. Stage 3 - Interested applicants are required to submit proposals. All proposals submitted under the terms and conditions cited in this BAA will be reviewed regardless of the feedback on, or lack of submission of, a whitepaper. If applicants have not submitted whitepapers, proposals may still be submitted for funding consideration. Proposals must be submitted in order for the applicant to be considered for funding.

All proposals for Assistance Instruments must be submitted electronically through Grants.gov using Workspace. Proposals for Contracts may be submitted via either Grants.gov or email to: usarmy.rtp.aro.mbx.baa@mail.mil. See Section II.D.f of this BAA for information on the proposal submission process.

Requests for waiver of electronic submission requirements may be submitted via email to: usarmy.rtp.aro.mbx.baa@mail.mil or regular mail:

Army Research Office
ATTN: RDRL-RO (Proposal Processing)
P.O. Box 12211
RTP, NC 27709-2211

All required forms for proposals may be downloaded from the ARO web site at: http://www.arl.army.mil/www/default.cfm?page=29, under "For the Researcher" (Forms, ARO BAA Forms).

c. Whitepaper Preparation

i. Whitepapers should focus on describing details of the proposed research, including how it is innovative, how it could substantially increase the scientific state of the art, Army relevance, and potential impact.

ii. Whitepapers are limited to seven (7) total pages; five (5) pages for whitepaper technical content, one (1) cover page and a one (1) page addendum as discussed below. Evaluators will only review the whitepaper cover page, up to five whitepaper technical content pages, and the one-page addendum.

Whitepapers must be in the following format but do not require any special forms:

- Page Size: 8 ½ x 11 inches
- Margins – 1 inch
- Spacing – single
- Font – Times New Roman, 12 point

iii. Combine all files and forms into a single PDF before submitting.

iv. Format and content of whitepapers:

(1) COVER PAGE (not to exceed one page):

The whitepaper cover page shall include at a minimum: Title of the whitepaper, name of the individual and organization submitting the whitepaper, the research area and number against which the whitepaper is submitted, and the TPOC name.

(2) TECHNICAL CONTENT (not to exceed five pages):

(a) A detailed discussion of the effort's scientific research objective, approach, relationship to similar research, and level of effort shall be submitted. Also include the nature and extent of the anticipated results and, if known, the manner in which the work will contribute to the accomplishment of the Army's mission and how this contribution would be demonstrated.

(b) The type of support, if any, the applicant requests of the Government, such as facilities, equipment, demonstration sites, test ranges, software, personnel or materials, shall be identified as government furnished equipment (GFE), government furnished information (GFI), government furnished property (GFP), or government furnished data (GFD). Applicants shall indicate any Government coordination that may be required for obtaining

equipment or facilities necessary to perform any simulations or exercises that would demonstrate the proposed capability.

(c) The cost portion of the whitepaper shall contain a brief cost estimate revealing all the component parts of the proposal, including research hours, burden, material costs, travel, etc.

(3) ADDENDUM (not to exceed one page):

Include biographical sketches of the key personnel who will perform the research, highlighting their qualifications and experience.

v. RESTRICTIVE MARKINGS ON WHITEPAPERS:

(1) Any proprietary data that the applicant intends to be used only by the Government for evaluation purposes must be clearly marked. The applicant must also identify any technical data or computer software contained in the whitepaper that is to be treated by the Government as limited rights in technical data and restricted rights in computer software. In the absence of such identification, the Government will conclude there are no limitations or restrictions on technical data or computer software included in the whitepaper. Records or data bearing a restrictive legend may be included in the whitepaper. It is the intent of the Army to treat all whitepapers as procurement sensitive before award and to disclose their contents only for the purpose of evaluation.

Care must be exercised to ensure that classified, sensitive, and critical technologies are not included in a whitepaper. If such information is required, appropriate restrictive markings and procedures should be applied prior to submission of the whitepaper.

(2) Applicants are cautioned, however, that portions of the whitepapers may be subject to release under terms of the Freedom of Information Act, 5 U.S.C. 552, as amended.

vi. EVALUATION AND DISPOSITION OF WHITEPAPERS:

(1) Evaluation Process: Applicants are advised that invitations for proposals will be made based on the whitepaper submission and the availability of funding. The whitepaper will be evaluated for the concept's scientific merit and potential contributions of the effort to the Army mission. Applicants whose whitepapers are evaluated as having significant scientific merit may be invited to submit a proposal. However, an applicant may submit a proposal despite not submitting a whitepaper or receiving a proposal invite from the Government.

(2) Disposition Process: The applicant will be notified in writing after completion of the evaluation. Whitepapers will not be returned to applicants.

d. Whitepaper Submission

All whitepapers must be emailed directly to the TPOC. In the email subject line, include the phrase “Whitepaper Submission,” the BAA number W911NF-17-S-0003, and the research topic number from Section II.A of this BAA. Whitepapers submitted via email must be in a single PDF formatted file as an email attachment.

e. Preparation of Proposals

i. COVER PAGE:

(1) A Cover Page is required. For contract proposals submitted by email, use ARO Form 51. For all Assistance instruments and contract proposals submitted via Grants.gov, use the Standard Form (SF) 424 (Research and Related (R&R)) Form. Proposals will not be processed without either: (1) a signed Cover Page, ARO Form 51, or (2) a SF 424 (R&R) Form.

(2) Should the project be carried out at a branch campus or other component of the applicant, that branch campus or component should be identified in the space provided (Block 11 on the ARO Form 51 and Block 12 on the SF 424 (R&R) Form).

(3) The title of the proposed project should be brief, scientifically representative, intelligible to a scientifically-literate reader, and suitable for use in the public domain.

(4) The proposed duration for which support is requested should be consistent with the nature and complexity of the proposed activity. Applicants shall discuss the preferred performance period with the TPOC.

(5) Specification of a desired starting date for the project is important and helpful; however, requested effective dates cannot be guaranteed.

(6) Pursuant to 31 U.S.C. 7701, as amended by the Debt Collection Improvement Act of 1996 [Section 31001(I)(1), Public Law 104-134] and implemented by 32 CFR 22.420(d), federal agencies shall obtain each awardees’ Taxpayer Identification Number (TIN). The TIN is being obtained for purposes of collecting and reporting on any delinquent amounts that may arise out of an awardees’ relationship with the Government.

(7) Applicants shall provide their organization's Unique Entity Identifier (formerly DUNS). This number is a nine-digit number assigned by D&B Information Services. See Section II.D.3 of this BAA for requirements pertaining to the Unique Entity Identifier.

(8) Applicants shall provide their assigned Commercial and Government Entity (CAGE) Code. The CAGE Code is a 5-character code assigned and maintained by the Defense Logistics Service Center (DLSC) to identify a commercial plant or establishment.

ii. TABLE OF CONTENTS:

Use the following format for the Table of Contents. Forms are available at http://www.arl.army.mil/www/default.cfm?page=29 under "For the Researcher" (Forms, ARO BAA Forms).

SECTION	PAGE NUMBER
Table of Contents	A-1
Statement of Disclosure Preference (Form 52 or 52A)	B-1
Research and Related Other Project Information	B-2
Project Abstract	C-1
Project Description (Technical Proposal)	D-1 - D-☐
Biographical Sketch	E-1 - E-☐
Bibliography	F-1 - F-☐
Current and Pending Support	G-1 - G-☐
Facilities, Equipment, and Other Resources	H-1 - H-☐
Proposal Budget	I-1 - I-☐
Contract Facilities Capital Cost of Money(FCCM) (DD Form 1861)	J-1
Appendices List Appendix Items: _____	K-☐

This format applies to all proposals submitted via email and via Grants.gov. Applicants' should show the location of each section of the proposal, as well as major subdivisions of the project description.

iii. STATEMENT OF DISCLOSURE PREFERENCE (FORM 52 OR 52A): Complete and sign ARO Form 52 (Industrial Contractors) or ARO Form 52A (Educational and Nonprofit Organizations).

iv. RESEARCH AND RELATED OTHER PROJECT INFORMATION: Must be completed and signed by all applicants.

v. PROJECT ABSTRACT:

(1) The project abstract shall be completed on the form entitled "Publicly Releasable Project Abstract" found at the following website: http://www.arl.army.mil/www/default.cfm?page=218.

(2) Unless otherwise instructed in this BAA, the project abstract shall include a concise statement of work and basic approaches to be used in the proposed effort. The abstract should include a statement of scientific objectives, methods to be employed, and the significance of the proposed effort to the advancement of scientific knowledge.

(3) The abstract should be no longer than one (1) page (maximum 4,000 characters).

(4) The project abstract shall be marked by the applicant as publically releasable. By submission of the project abstract, the applicant confirms that the abstract is releasable to the public. For a proposal that results in a grant award, the project abstract will be posted to a searchable website available to the general public to meet the requirements of Section 8123 of the DoD Appropriations Act, 2015. The website address is: https://dodgrantawards.dtic.mil/grants.

vi. PROJECT DESCRIPTION (TECHNICAL PROPOSAL): The technical portion of the proposal shall contain the following:

(1) A complete discussion stating the background and objectives of the proposed work, the scientific approaches to be considered, the relationship to competing or related research, and the level of effort to be employed. Include also the nature and extent of the anticipated results and how they will significantly advance the scientific state-of-the-art. Also, if known, include the manner in which the work will contribute to the accomplishment of the Army's mission. Ensure the proposal identifies any scientific uncertainties and describes specific approaches for the resolution or mitigation of the uncertainties.

(2) A brief description of your organization. If the applicant has extensive government contracting experience and has previously provided the information to the ARL, the information need not be provided again. A statement setting forth this condition should be made.

(3) The names of other federal, state, local agencies, or other parties receiving the proposal and/or funding the proposed effort. If none, state so. Concurrent or later submission of the proposal to other organizations will not prejudice its review by the ARL if we are kept informed of the situation.

(4) A statement regarding possible impact, if any, of the proposed effort on the environment, considering as a minimum its effect upon water, atmosphere, natural resources, human resources, and any other values.

(5) A statement regarding the use of Class I and Class II ozone- depleting substances. Ozone depleting substances are any substance designated as Class I by EPA, including but not limited to chlorofluorocarbons, halons, carbon tetrachloride, and methyl chloroform, and any substance designated as Class II by EPA, including but not limited to hydrochlorofluorocarbons. See 40 CFR Part 82 for detailed information. If Class I or II substances are to be utilized, a list shall be provided as part of the applicant's proposal. If none, state so.

(6) The type of support, if any, requested by the applicant (e.g., facilities, equipment, and materials).

vii. BIOGRAPHICAL SKETCH:

(1) This section shall contain the biographical sketches for key personnel only.

(a) Primary Principal Investigator (PI): The Primary PI provides a single or initial point of communication between the ARL and the awardee organization(s) about scientific matters. If not otherwise designated, the first PI listed will serve as the Primary PI. This individual can be changed with notification to ARL. ARL does not infer any additional scientific stature to this role among collaborating investigators.

(b) Co-Principal Investigators: The individual(s) a research organization designates as having an appropriate level of authority and responsibility for the proper conduct of the research and submission of required reports to ARL. When an organization designates more than one PI, it identifies them as individuals who share the authority and responsibility for leading and directing the research, intellectually and logistically. ARL does not infer any distinction among multiple PIs.

(2) The following information is required:

(a) Relevant experience and employment history including a description of any prior Federal employment within one year preceding the date of proposal submission.

(b) List of up to five publications most closely related to the proposed project and up to five other significant publications, including those being printed. Patents, copyrights, or software systems developed may be substituted for publications.

(c) List of persons, other than those cited in the publications list, who have collaborated on a project or a book, article, report or paper within the last four years. Include pending publications and submissions. Otherwise, state "None."

(d) Names of each investigator's own graduate or post-graduate advisors and advisees.

NOTE: The information provided in (c) and (d) is used to help identify potential conflicts or bias in the selection of reviewers.

(3) For the personnel categories of postdoctoral associates, other professionals, and students (research assistants), the proposal may include information on exceptional qualifications of these individuals that merit consideration in the evaluation of the proposal.

(4) The biographical sketches are limited to three (3) pages per investigator and other individuals that merit consideration.

viii. BIBLIOGRAPHY: A bibliography of pertinent literature is required. Citations must be complete (including full name of author(s), title, and location in the literature).

ix. CURRENT AND PENDING SUPPORT:

(1) All project support from whatever source must be listed. The list must include all projects requiring a portion of the PI's and other key personnel's time, even if they receive no salary support from the project(s).

(2) The information should include, as a minimum: (i) the project/proposal title and brief description, (ii) the name and location of the organization or agency presently funding the work or requested to fund such work, (iii) the award amount or annual dollar volume of the effort, (iv) the period of performance, and (v) a breakdown of the time required of the PI and/or other key personnel.

x. FACILITIES, EQUIPMENT, and OTHER RESOURCES: The applicant should include in the proposal a listing of facilities, equipment, and other resources already available to perform the research proposed.

xi. PROPOSAL BUDGET (including DD Form 1861):

(1) Each proposal must contain a budget for each year of support requested and a cumulative budget for the full term of requested support. Each budget year and the cumulative budget for the full term must be documented on ARO Form 99. ARO Form 99 may be reproduced, but you may not make substitutions in prescribed budget categories nor alter or rearrange the cost categories as they appear on the form. The proposal may request funds under any of the categories listed so long as the item is considered necessary to perform the proposed work and is not precluded by applicable cost principles. In addition to the forms, the budget proposal should include budget justification for each year.

(2) A signed summary budget page must be included. The documentation pages should be titled "Budget Explanation Page" and numbered chronologically starting with the budget form. The need for each item should be explained clearly.

(3) All cost data must be current and complete. Costs proposed must conform to the following principles and procedures:

Institutions of Higher Education: 2 CFR Part 200
Nonprofit Organizations: 2 CFR Part 200
For-Profit/Commercial Organizations: FAR Part 31, DFARS Part 231, FAR Subsection 15.403-5, and DFARS Subsection 215.403-5.

* For those nonprofit organizations specifically exempt from the provisions of Subpart E of 2 CFR Part 200 (see 2 CFR 200.401(c)), FAR Part 31 and DFARS Part 231 shall apply.

(4) Sample itemized budgets and the information they must include for a contract and for grants and cooperative agreements can be found at Section II.H of this BAA (Other Information). Before award of a cost-type contract or assistance instrument it must be established that an approved accounting system and financial management system exist.

xii. APPENDICES: Some situations require that special information and supporting documents be included in the proposal before funding can be approved. Such information and documentation should be included by appendix to the proposal.

(1) To evaluate compliance with Title IX of the Education Amendments of 1972 (20 U.S.C. A Section 1681 Et. Seq.), the Department of Defense is collecting certain demographic and career information to be able to assess the success rates of women who are proposed for key roles in applications in STEM disciplines. To enable this assessment, each application must include the following forms completed as indicated.

(A) Research and Related Senior/Key Person Profile (Expanded) form:

The Degree Type and Degree Year fields on the Research and Related Senior/Key Person Profile (Expanded) form will be used by DoD as the source for career information. In addition to the required fields on the form, applicants must complete these two fields for all individuals that are identified as having the project role of PD/PI or Co-PD/PI on the form. Additional senior/key persons can be added by selecting the “Next Person” button.

(B) Research and Related Personal Data form:

This form will be used by DoD as the source of demographic information, such as gender, race, ethnicity, and disability information for the Project Director/Principal Investigator and all other persons identified as Co-Project Director(s)/Co-Principal Investigator(s). Each application must include this form with the name fields of the Project Director/Principal Investigator or any Co-Project Director(s)/Co-Principal Investigator(s) completed; however, provision of the demographic information in the form is voluntary. If completing the form for multiple individuals, each Co-Project Director/Co-Principal Investigator can be added by selecting the “Next Person” button. The demographic information, if provided, will be used for statistical purposed only and will not be made available to merit reviewers. Applicants

who do not wish to provide some or all of the information should check or select the "Do not wish to provide" option.

f. Submission of Proposals

Proposals must be submitted by email (only when a contract is requested) or through Grants.gov. Proposals must be submitted through the applicant's organizational office having responsibility for Government business relations. All signatures must be that of an official authorized to commit the organization in business and financial affairs.

Proposal content requirements remain the same for both email and Grants.gov submission.

i. EMAIL SUBMISSION (only when a **Contract is the requested form of agreement**):

(1) Proposals requesting a Contract may be emailed directly to: usarmy.rtp.devcom-arl.mbx.baa@army.mil. Do not email full proposals to the TPOC. All emailed proposals must adhere to the format requirements and contain the information outlined in Section II.D.2.e of this BAA.

(2) The applicant must include with its proposal submission the representations required by Section II.F.2.a.i of this BAA. The representations must include applicant point of contact (POC) information and be signed by an authorized representative. Note: If the applicant's SAM Representations and Certifications include its response to the representations a hard copy representation is not required with proposal submission.

(3) All forms requiring signature must be completed, printed, signed, and scanned into a PDF document. All documents must be combined into a single PDF formatted file to be attached to the email.

(4) Proposal documents (excluding required forms) must use the following format:
- Page Size – 8 ½ x 11 inches
- Margins – 1 inch
- Spacing – single
- Font – Times New Roman, 12 point, single-sided pages

ii. GRANTS.GOV SUBMISSION (For **all** proposals requesting **Assistance**. Proposals requesting a Contract may be submitted either via Grants.gov or email)

(1) Grants.gov Registration (See Section II.D.2.g below) must be accomplished prior to application submission in Grants.gov.

NOTE: All web links referenced in this section are subject to change by Grants.gov and may not be updated here.

(2) Specific forms are required for submission of a proposal. The forms are contained in the Application Package available through the Grants.gov application process. To access these materials, go to http://www.grants.gov, select "Apply for Grants," and then select " Get Application Package." A Grant Application Package and Application Instructions are available through the Grants.Gov Apply portal under CFDA Number 12.431/Funding Opportunity Number W911NF-17-S-0003. Select "Apply" and then "Apply Now Using Workspace."

*NOTE: Effective 31 December 2017, the legacy PDF application package on Grants.gov will be retired and applicants must apply online at Grants.gov using the application Workspace. For access to complete instructions on how to apply for opportunities using Workspace refer to: https://www.grants.gov/web/grants/applicants/workspace-overview.html.

The following documents are mandatory: (1) Application for Federal Assistance (R&R) (SF 424 (R&R)), and (4) Attachments form.

(3) The SF 424 (R&R) form is to be used as the cover page for all proposals submitted via Grants.gov. The SF 424 (R&R) must be fully completed. Authorized Organization Representative (AOR) usernames and passwords serve as "electronic signatures" when your organization submits applications through Grants.gov. By using the SF 424 (R&R), proposers are providing the certification required by 32 CFR Part 28 regarding lobbying (see Section II.F.2.a.ii of this BAA). Block 11, "Descriptive Title of Applicant's Project," must reference the research topic area being addressed in the effort by identifying the specific paragraph from Section II.A of this BAA.

(4) The Attachments form must contain the documents outlined in Section II.D.2.e.ii entitled "Table of Contents". All documents must be combined into separate and single PDF formatted files using the Table of Contents names. Include "W911NF-17-S-0003" in the title so the proposal will be distinguished from other BAA submissions and upload each document to the mandatory Attachments form.

(5) The applicant must include with its proposal submission the representations required by Section II.F.2.a.ii of this BAA. The representations must include applicant POC information and be signed by an authorized representative. Attach the representations document to an available field within the Attachments form. Note: If the applicant's SAM Representations and Certifications include its response to the representations a hard copy representation is not required with proposal submission.

(6) The Grants.gov User Guide at: http://www.grants.gov/help/html/help/index.htm?callingApp=custom#t=Get_Started%2FGet_Sta rted.htm will assist AORs in the application process. Remember that you must open and complete the Application for Federal Assistance (R&R) (SF 424 (R&R)) first, as this form will automatically populate data fields in other forms. If you encounter any problems, contact customer support at 1-800-518-4726 or at support@grants.gov. If you forget your user name

or password, follow the instructions provided in the Credential Provider tutorial. Tutorials may be printed by right-clicking on the tutorial and selecting "Print".

(7) As it is possible for Grants.gov to reject the proposal during this process, it is strongly recommended that proposals be uploaded at least two days before any established deadline in the BAA so that they will not be received late and be ineligible for award consideration. It is also recommended to start uploading proposals at least two days before the deadline to plan ahead for any potential technical and/or input problems involving the applicant's own equipment.

g. Grants.gov Registration

i. Each organization that desires to submit applications via Grants.Gov must complete a one-time registration. There are several one-time actions your organization must complete in order to submit applications through Grants.gov (e.g., obtain a Unique Entity Identifier, register with the SAM, register with the credential provider, register with Grants.gov and obtain approval for an AOR to submit applications on behalf of the organization). To register please see: http://www.grants.gov/web/grants/applicants/organization-registration.html

ii. Please note the registration process for an Organization or an Individual can take between three to five business days or as long as four weeks if all steps are not completed in a timely manner.

iii. Questions relating to the registration process, system requirements, how an application form works, or the submittal process should be directed to Grants.gov at 1-800-518-4726 or support@grants.gov.

3. Unique Entity Identifier (UEI) and System for Award Management (SAM)

a. Each applicant (unless the applicant is an individual or Federal awarding agency that is exempt from those requirements under 2 CFR 25.110(b) or (c), or has an exemption approved by the Federal awarding agency under 2 CFR 25.110(d)) is required to:

i. Be registered in SAM prior to submitting its application; ii. Provide a valid unique entity identifier (formerly DUNS) in its application; and iii. Maintain an active SAM registration with current information at all times during which it has an active Federal award or an application or plan under consideration by a Federal awarding agency.

b. The Federal awarding agency may not make a Federal award to an applicant until the applicant has complied with all applicable unique entity identifier and SAM requirements. If an applicant has not fully complied with the requirements by the time the Federal awarding agency is ready to make a Federal award, the Federal awarding agency may determine that the applicant is not qualified to receive a Federal award and use that determination as a basis for making a Federal award to another applicant.

4. Submission Dates and Times

a. Proposals

Proposals will be considered until and including the closing date of this announcement (see cover page of this announcement for opening/closing dates), except for special programs identified in this BAA that may announce specific opening/closing dates. Proposals submitted after the closing date will not be considered by the Government.

b. Proposal Receipt Notices

i. Grants.gov: After a proposal is submitted to Grants.gov, the AOR will receive a series of three emails from Grants.gov. The first two emails will be received within 24 to 48 hours after submission. The first email will confirm time of receipt of the proposal by the Grants.gov system and the second will indicate that the proposal has either been successfully validated by the system prior to transmission to the grantor agency or has been rejected due to errors. A third email will be received once the grantor agency has confirmed receipt of the proposal. Reference the Grants.gov User Guide at: http://www.grants.gov/help/html/help/index.htm?callingApp=custom#t=Get_Started%2FGet_Star ted.htm for information on how to track your application package.

For the purposes of this BAA, an applicant's proposal is not considered received by ARL until the AOR receives email #3.

ii. Email Submission: After a proposal is submitted to usarmy.rtp.devcom-arl.mbx.baa@army.mil, the AOR will receive an email confirming time of receipt of the proposal by the grantor agency. For the purposes of this BAA, an applicant's proposal is not considered received by the grantor agency until the AOR receives the email confirming receipt of the proposal.

5. Intergovernmental Review

Not Applicable

6. Funding Restrictions

There are no specific funding restrictions associated with this BAA (e.g. direct costs, indirect costs, etc.).

7. Other Submission Requirements

a. Information to Be Requested from Successful Applicants: Applicants whose proposals are accepted for funding will be contacted before award to provide additional information required for award. The required information may include requests to clarifying budget explanations, representations, certifications, and some technical aspects.

b. For Contracts Only: Performance Work Statements (PWS). Prior to award the Contracting Officer may request that the contractor submit a PWS for the effort to be performed, which will be incorporated into the contract at the time of award.

8. Program security classification: Unclassified

a. Program Protection Plan. The government will address any critical program information (CPI) with a potential requirement for a program protection plan (PPP) generated as part of this effort as needed. The Government may require Operations Security (OPSEC) measures (when applicable) to protect sensitive unclassified information. If access to unclassified sensitive information (For Official Use Only - FOUO) is authorized, the awardee may access only the information related to the subject matter of their award.

b. Export Control: It is not anticipated that Export Control (International Traffic In Arms Regulation (ITAR) 22 CFR 120-131, or Export Administration Regulations (EAR) 15 CFR 710-774) will apply to most efforts under this BAA, although Export Control laws and regulations may apply to individual tasks depending on the nature of the research tasks. It is the awardee's responsibility to determine applicability with Export Control laws and regulations and ensure compliance.

c. Reporting: Awards may contain a requirement for awardee to report a violation of administrative security procedures or export control regulations that would subject critical unclassified information to possible compromise by foreign visitors or foreign national employees.

(End of Section)

E. Application Review Information

1. Criteria

Proposals submitted in response to this BAA will be evaluated using the factors listed below (in descending order of importance):

a. The overall scientific and/or technical merits of the proposal.

b. The potential contributions of the effort to the Army mission and the extent to which the research effort will contribute to balancing the overall ARL research program.

c. The applicant's capabilities, related experience, facilities, techniques, or unique combinations of these, which are integral factors for achieving the proposed objectives.

d. The qualifications, capabilities, and experience of the proposed PI, team leader, or other key personnel who are critical to achievement of the proposed objectives.

e. The applicant's record of past performance.

**NOTE: Cost sharing will not be considered in the evaluation.

2. Review and Selection Process

a. Upon receipt of a proposal, the ARL staff will perform an initial review of its scientific merit and potential contribution to the Army mission, and also determine if funds are expected to be available for the effort. Proposals not considered having sufficient scientific merit or relevance to the Army's needs, or those in areas for which funds are not expected to be available, may not receive further review.

b. All proposals are treated as procurement sensitive and are disclosed only for the purpose of evaluation. Proposals not declined as a result of an initial review will be subject to a peer review by highly qualified scientists. While the applicant may restrict the evaluation to scientists from within the Government, to do so may prevent review of the proposal by those most qualified in the field of research covered by the proposal. The applicant must indicate on the appropriate proposal form (Form 52 or 52A) any limitation to be placed on disclosure of information contained in the proposal.

c. Each proposal will be evaluated based on all the evaluation criteria in Section II.E.1 of this BAA rather than against other proposals for research in the same general area.

d. Upon completion of an evaluation against the criteria in Section II.E.1, a proposal selected for possible award will be analyzed for the realism and reasonableness of costs. Proposal costs must be determined reasonable and realistic before the Government can make an award.

3. Recipient Qualification

a. Grant, Cooperative Agreement, and TIA Proposals:

i. The Grants Officer is responsible for determining a recipient's qualification prior to award. In general, a Grants Officer will award grants or cooperative agreements only to qualified recipients that meet the standards at 32 CFR 22.415. To be qualified, a potential recipient must:

(1) Have the management capability and adequate financial and technical resources, given those that would be made available through the grant or cooperative agreement, to execute the program of activities envisioned under the grant or cooperative agreement;

(2) Have a satisfactory record of executing such programs or activities (if a prior recipient of an award);

(3) Have a satisfactory record of integrity and business ethics; and

(4) Be otherwise qualified and eligible to receive a grant or cooperative agreement under applicable laws and regulations.

Applicants are requested to provide information with proposal submissions to assist the Grants Officer's evaluation of recipient qualification.

ii. In accordance with Office of Management and Budget (OMB) guidance in parts 180 and 200 of Title 2, CFR, it is DoD policy that DoD Components must report and use integrity and performance information in the Federal Awardee Performance and Integrity Information System (FAPIIS), or any successor system designated by OMB, concerning grants, cooperative agreements, and TIAs as follows:

If the total Federal share will be greater than the simplified acquisition threshold on any Federal award under a notice of funding opportunity (see 2 CFR 200.88 Simplified Acquisition Threshold):

(1) The Federal awarding agency, prior to making a Federal award with a total amount of Federal share greater than the simplified acquisition threshold, will review and consider any information about the applicant that is in the designated integrity and performance system accessible through SAM (currently FAPIIS) (see 41 U.S.C. 2313);

(2) An applicant, at its option, may review information in the designated integrity and performance systems accessible through SAM and comment on any information about itself that a Federal awarding agency previously entered and is currently in the designated integrity and performance system accessible through SAM;

(3) The Federal awarding agency will consider any comments by the applicant, in

addition to the other information in the designated integrity and performance system, in making a judgment about the applicant's integrity, business ethics, and record of performance under Federal awards when completing the review of risk posed by applicants as described in 2 CFR 200.205 Federal awarding agency review of risk posed by applicants.

b. Contract Proposals:

i. Contracts shall be awarded to responsible prospective contractors only. See FAR 9.104-1 for a listing of the general standards against which an applicant will be assessed to determine responsibility.

Applicants are requested to provide information with proposal submission to assist the Contracting Officer's evaluation of responsibility.

ii. FAPIIS will be checked prior to making an award. The web address is: https://www.fapiis.gov/fapiis/. The applicant representing the entity may comment in this system on any information about the entity that a federal government official entered. The information in FAPIIS will be used in making a judgment about the entity's integrity, business ethics, and record of performance under Federal awards that may affect the official's determination that the applicant is qualified to receive an award.

(End of Section)

F. Award Administration Information

1. Award Notices

Applicants whose proposals are recommended for award may be contacted by a Contract/Grant Specialist to discuss additional information required for award. This may include representations and certifications, revised budgets or budget explanations, certificate of current cost or pricing data, subcontracting plan for small businesses, and/or other information as applicable to the proposed award. The anticipated start date will be determined at that time.

The notification email must not be regarded as an authorization to commit or expend funds. The Government is not obligated to provide any funding until a Government Contracting/ Grants Officer signs the award document.

The award document signed by the Government Contracting/Grants Officer is the official and authorizing award instrument. The authorizing award instrument, signed by the Contracting/ Grants Officer, will be emailed to the PI and AOR.

2. Administrative and National Policy Requirements

a. Required Representations and Certifications:

i. Contract Proposals:

(1) Representations and certifications shall be completed by successful applicants prior to award. FAR Online Representations and Certifications are to be completed through SAM at https://www.SAM.gov. As appropriate, DFARS and contract-specific certification packages will be provided to the contractor for completion prior to award.

(2) FAR 52.203-18, PROHIBITION ON CONTRACTING WITH ENTITIES THAT REQUIRE CERTAIN CONFIDENTIALITY AGREEMENTS OR STATEMENTS—REPRESENTATION (JAN 2017)

(a) Definition. As used in this provision--

"Internal confidentiality agreement or statement", "subcontract", and "subcontractor", are defined in the clause at 52.203-19, Prohibition on Requiring Certain Internal Confidentiality Agreements or Statements.

(b) In accordance with section 743 of Division E, Title VII, of the Consolidated and Further Continuing Appropriations Act, 2015 (Pub. L. 113-235) and its successor provisions in subsequent appropriations acts (and as extended in continuing resolutions), Government agencies are not permitted to use funds appropriated (or otherwise made available) for contracts with an entity that requires employees or subcontractors of such entity seeking to report waste, fraud, or abuse to sign internal confidentiality agreements or statements prohibiting or otherwise restricting such employees or subcontractors from lawfully reporting such waste, fraud, or abuse to a designated investigative or law enforcement representative of a Federal department or agency authorized to receive such information.

(c) The prohibition in paragraph (b) of this provision does not contravene requirements applicable to SF 312, (Classified Information Nondisclosure Agreement), Form 4414 (Sensitive Compartmented Information Nondisclosure Agreement), or any other form issued by a Federal department or agency governing the nondisclosure of classified information.

(d) Representation. By submission of its offer, the applicant represents that it will not require its employees or subcontractors to sign or comply with internal confidentiality agreements or statements prohibiting or otherwise restricting such employees or subcontractors from lawfully reporting waste, fraud, or abuse related to the performance of a Government contract to a designated investigative or law enforcement representative of a Federal department or agency authorized to receive such information (e.g., agency Office of the Inspector General).

(3) FAR 52.209-11, REPRESENTATION BY CORPORATIONS REGARDING DELINQUENT TAX LIABILITY OR A FELONY CONVICTION UNDER FEDERAL LAW (FEB 2016)

As required by sections 744 and 745 of Division E of the Consolidated and Further Continuing Appropriations Act, 2015 (Pub. L 113-235), and similar provisions, if contained in subsequent appropriations acts, the Government will not enter into a contract with any corporation that--

Has any unpaid Federal tax liability that has been assessed, for which all judicial and administrative remedies have been exhausted or have lapsed, and that is not being paid in a timely manner pursuant to an agreement with the authority responsible for collecting the tax liability, where the awarding agency is aware of the unpaid tax liability, unless an agency has considered suspension or debarment of the corporation and made a determination that suspension or debarment is not necessary to protect the interests of the Government; or

Was convicted of a felony criminal violation under any Federal law within the preceding 24 months, where the awarding agency is aware of the conviction, unless an agency has considered suspension or debarment of the corporation and made a determination that this action is not necessary to protect the interests of the Government.

The applicant represents that—

It is [ ] is not [ ] a corporation that has any unpaid Federal tax liability that has been assessed, for which all judicial and administrative remedies have been exhausted or have lapsed, and that is not being paid in a timely manner pursuant to an agreement with the authority responsible for collecting the tax liability; and

It is [ ] is not [ ] a corporation that was convicted of a felony criminal violation under a Federal law within the preceding 24 months.

ii. Grant and Cooperative Agreement Proposals:

(1) To apply for grants and other funding opportunities the applicant entity must be registered in the System for Award Management (SAM). Proposals will not be accepted through Grants.gov or other methods unless the entity is registered in SAM. Registration in SAM now includes the acceptance of Certifications and Assurances. SAM may be accessed at: https://sam.gov.

The Federal Assistance Certifications Report is an attestation that the entity will abide by the requirements of the various laws and regulations; therefore, as applicable, you are still required to submit any documentation, including the SF LLL Disclosure of Lobbying Activities (if applicable), and informing DoD of unpaid delinquent tax liability or a felony conviction under any Federal law.)

Below is the required certification:

CERTIFICATION AT APPENDIX A TO 32 CFR PART 28 REGARDING LOBBYING: Certification for Contracts, Grants, Loans, and Cooperative Agreements the undersigned certifies, to the best of his or her knowledge and belief, that:

(1) No Federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of an agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit SF-LLL, "Disclosure Form to Report Lobbying," in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all sub-awards at all tiers (including subcontracts, sub-grants, and contracts under grants, loans, and cooperative agreements) and that all sub-recipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by 31 U.S.C. 1352. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

(2) In accordance with Continuing Appropriations Act, 2017 (Pub. L. 114-223), or any other Act that extends to fiscal year (FY) 2017 funds the same prohibitions as contained in section 743, division E, title VII, of the Consolidated Appropriations Act, 2016 (Pub. L. 114-113), none of the funds appropriated or otherwise made available by that or any other Act may be made available for a grant or cooperative agreement with an entity that requires its employees or contractors seeking to report fraud, waste, or abuse to sign internal confidentiality agreements or statements prohibiting or otherwise restricting those employees or contractors from lawfully reporting that waste, fraud, or abuse to a designated investigative or law enforcement representative of a Federal department or agency authorized to receive the information.

PROHIBITION ON CONTRACTING WITH ENTITIES THAT REQUIRED CERTAIN INTERNAL CONFIDENTIALITY AGREEMENTS – REPRESENTATION

Agreement with the representation below will be affirmed by checking the “I agree” box in block 17 of the SF424 (R&R) as part of the electronic proposal submitted via Grants.gov. The representation reads as follows:

By submission of its proposal or application, the applicant represents that it does not require any of its employees, contractors, or sub-recipients seeking to report fraud, waste, or abuse to sign or comply with internal confidentiality agreements or statements prohibiting or otherwise restricting those employees, contractors, sub-recipients from lawfully reporting that waste, fraud, or abuse to a designated investigative or law enforcement representative of a Federal department or agency authorized to receive such information.

*Note that: Section 743 states that it does not contravene requirements applicable to SF 312, Form 4414, or any other form issued by a Federal department or agency governing the nondisclosure of classified information.

(3) Recipients are required to submit the following representation with the application package IAW the instructions at Section II.D.2.f.ii of this BAA:

REPRESENTATIONS UNDER DOD ASSISTANCE AGREEMENTS: APPROPRIATIONS PROVISIONS ON TAX DELINQUENCY AND FELONY CONVICTIONS

The applicant is ( ) is not ( ) a "Corporation" meaning any entity, including any institution of higher education, other nonprofit organization, or for-profit entity that has filed articles of incorporation.

If the applicant is a "Corporation" please complete the following representations:

(a) The applicant represents that it is ( ) is not ( ) a corporation that has any unpaid Federal tax liability that has been assessed, for which all judicial and administrative remedies have been exhausted or have lapsed, and that is not being paid in a timely manner pursuant to an agreement with the authority responsible for collecting the tax liability.

(b) The applicant represents that it is ( ) is not ( ) is not a corporation that was convicted of a criminal violation under any Federal law within the preceding 24 months.

NOTE: If an applicant responds in the affirmative to either of the above representations, the applicant is ineligible to receive an award unless the agency suspension and debarment official (SDO) has considered suspension or debarment and determined that further action is not required to protect the Government's interests. The applicant therefore should provide information about its tax liability or conviction to the agency's SDO as soon as it can do so, to facilitate completion of the required considerations before award decisions are made.

PROHIBITION ON CONTRACTING WITH ENTITIES USING CERTAIN TELECOMMUNICATIONS AND VIDEO SURVEILLANCE SERVICES OR EQUIPMENT

Section 889 of the National Defense Authorization Act (NDAA) for Fiscal Year (FY) 2019 (Public Law 115-232) prohibits the head of an executive agency from obligating or expending loan or grant funds to procure or obtain, extend, or renew a contract to procure or obtain, or enter into a contract (or extend or 105 renew a contract) to procure or obtain the equipment, services, or systems prohibited systems as identified in section 889 of the NDAA for FY 2019. For more information on how this applies to all grant recipients and sub-recipients after August 13, 2020, please see DoD Research General Terms and Conditions (SEP 2020) NP Article IV. Other national policy requirements, paragraph 18.

b. Policy Requirements:

The following list provides notable national policy requirements that may be applicable to an award. NOTE: The following is not an all-inclusive list of policy requirements. For assistance awards, refer to the DoD Research and Development General Terms and Conditions at https://www.onr.navy.mil/en/work-with-us/manage-your-award/manage-grant-award/grants-terms-conditions for additional national policy requirements that may apply. For contract awards, appropriate clauses will be added to award documents.

i. PROTECTION OF HUMAN SUBJECTS:

(1) Assistance Instruments:

(a) The recipient must protect the rights and welfare of individuals who participate as human subjects in research under this award and comply with the requirements at 32 CFR part 219, Department of Defense Instruction (DoDI) 3216.02, 10 U.S.C. 980, and when applicable, Food and Drug Administration (FDA) regulations.

(b) The recipient must not begin performance of research involving human subjects, also known as human subjects research (HSR), that is covered under 32 CFR part 219, or that meets exemption criteria under 32 CFR 219.101(b), until you receive a formal notification of approval from a DoD Human Research Protection Official (HRPO). Approval to perform HSR under this award is received after the HRPO has performed a review of the recipient's documentation of planned HSR activities and has officially furnished a concurrence with the recipient's determination as presented in the documentation.

(c) In order for the HRPO to accomplish this concurrence review, the recipient must provide sufficient documentation to enable his or her assessment as follows:

(i) If the HSR meets an exemption criteria under 32 CFR 219.101(b), the documentation must include a citation of the exemption category under 32 CFR 219.101(b) and a rationale statement.

(ii) If the recipient's activity is determined as "non-exempt research involving human subjects", the documentation must include:

- Assurance of Compliance (i.e., Department of Health and Human Services Office for Human Research Protections (OHRP) Federal Wide Assurance (FWA)) appropriate for the scope of work or program plan; and

- Institutional Review Board (IRB) approval, as well as all documentation reviewed by the IRB to make their determination.

(d) The HRPO retains final judgment on what activities constitute HSR, whether an exempt category applies, whether the risk determination is appropriate, and whether the planned HSR activities comply with the requirements in paragraph (a) of this section.

(e) The recipient must notify the HRPO immediately of any suspensions or terminations of the Assurance of Compliance.

(f) DoD staff, consultants, and advisory groups may independently review and inspect the recipient's research and research procedures involving human subjects and, based on such findings, DoD may prohibit research that presents unacceptable hazards or otherwise fails to comply with DoD requirements.

(g) Definitions for terms used in this article are found in DoDI 3216.02.

(2) Contracts: The appropriate clauses shall be added to the award.

ii. ANIMAL USE:

(1) Assistance Instruments:

(a) Prior to initiating any animal work under the award, the recipient must:

(i) Register the recipient's research, development, test, and evaluation or training facility with the Secretary of Agriculture in accordance with 7 U.S.C. 2136 and 9 CFR section 2.30, unless otherwise exempt from this requirement by meeting the conditions in 7 U.S.C. 2136 and 9 CFR parts 1-4 for the duration of the activity.

(ii) Have the recipient's proposed animal use approved in accordance with DoDI 3216.01, Use of Animals in DoD Programs by a DoD Component Headquarters Oversight Office.

(iii) Furnish evidence of such registration and approval to the grants officer.

(b) The recipient must make the animals on which the research is being conducted, and all premises, facilities, vehicles, equipment, and records that support animal care and use

available during business hours and at other times mutually agreeable to the recipient, the United States

Department of Agriculture Office of Animal and Plant Health Inspection Service (USDA/APHIS) representative, personnel representing the DoD component oversight offices, as well as the grants officer, to ascertain that the recipient is compliant with 7 U.S.C. 2131 et seq., 9 CFR parts 1-4, and DoDI 3216.01.

(c) The recipient's care and use of animals must conform with the pertinent laws of the United States, regulations of the Department of Agriculture, and regulations, policies, and procedures of the DoD (see 7 U.S.C. 2131 et seq., 9 CFR parts 1-4, and DoDI 3216.01).

(d) The recipient must acquire animals in accordance with DoDI 3216.01.

(2) Contracts: The appropriate clauses shall be added to the award.

iii. BIOLOGICAL SAFETY PROGRAM REQUIREMENTS:

(1) Assistance Instruments and Contracts: Awards may be subject to biological safety program requirements IAW:

(a) Army Regulation (AR) 385-10, Chapter 20
http://armypubs.army.mil/epubs/DR_pubs/DR_a/pdf/web/r385_10.pdf

(b) Department of Army (DA) PAM 385-69
http://armypubs.army.mil/epubs/DR_pubs/DR_a/pdf/web/p385_69.pdf

(c) DoD Manual 6055.18-M, Enclosure 4, Section 13
http://www.dtic.mil/whs/directives/corres/pdf/605518m.pdf

(d) DoD Executive Agent List (see item 3)
http://www.oaa.army.mil/aea_functions.aspx

iv. MILITARY RECRUITING:

(1) Assistance Instruments: This is to notify potential applicants that each grant or cooperative agreement awarded under this announcement to an institution of higher education must include the following term and condition:

(a) As a condition for receiving funds available to the DoD under this award, you agree that you are not an institution of higher education (as defined in 32 CFR part 216) that has a policy or practice that either prohibits, or in effect prevents:

(i) The Secretary of a Military Department from maintaining, establishing, or operating a unit of the Senior Reserve Officers Training Corps (ROTC)—-in accordance with 10 U.S.C. 654 and other applicable Federal laws—-at that institution (or any sub-element of that institution);

(ii) Any student at that institution (or any sub-element of that institution) from enrolling in a unit of the Senior ROTC at another institution of higher education.

(iii) The Secretary of a Military Department or Secretary of Homeland Security from gaining access to campuses, or access to students (who are 17 years of age or older) on campuses, for purposes of military recruiting in a manner that is at least equal in quality and scope to the access to campuses and to students that is provided to any other employer; or

(iv) Access by military recruiters for purposes of military recruiting to the names of students (who are 17 years of age or older and enrolled at that institution or any sub-element of that institution); their addresses, telephone listings, dates and places of birth, levels of education, academic majors, and degrees received; and the most recent educational institutions in which they were enrolled.

(b) If you are determined, using the procedures in 32 CFR part 216, to be such an institution of higher education during the period of performance of this award, we:

(i) Will cease all payments to you of DoD funds under this award and all other DoD grants and cooperative agreements; and

(ii) May suspend or terminate those awards unilaterally for material failure to comply with the award terms and conditions.

(2) Contracts: Each contract awarded under this announcement to an institution of higher education shall include the following clause: DFARS 252.209-7005, Military Recruiting on Campus.

v. SUBCONTRACTING:

(1) Assistance Instruments: N/A

(2) Contracts: Pursuant to Section 8(d) of the Small Business Act (15 U.S.C. § 637(d)), it is the policy of the Government to enable small business and small disadvantaged business (SDB) concerns to be considered fairly as subcontractors. All other than U.S. small businesses proposing contracts expected to exceed $700,000 and that have subcontracting possibilities are required to submit a subcontracting plan IAW FAR 19.702(a), and shall do so with their proposal.

Subcontracting plans are determined to be acceptable or unacceptable based on the criteria established at FAR 19.705-4, DFARS 219.705-4, and AFARS 5119.705-4. Goals are established on an individual contract basis and should result in realistic, challenging and attainable goals that,

to the greatest extent possible, maximize small business participation in subcontracting for Small Business, SDB, Woman-Owned Small Business (WOSB), Economically-Disadvantaged Woman-Owned Small Business (EDWOSB), Service-Disabled Veteran-Owned Small Business (SDVOSB), Veteran-Owned Small Business (VOSB), and Historically Underutilized Business Zone (HUBZone) Small Business consistent with applicants' make-or-buy policy, the pool of and availability of qualified and capable small business subcontractors, their performance on subcontracts, and existing relationships with suppliers.

Subcontracting goals should result in efficient contract performance in terms of cost, schedule, and performance and should not result in increased costs to the government or undue administrative burden to the prime contractor. For reference, DoD Small Business Subcontracting Goals may be found at: https://business.defense.gov/About/Goals-and-Performance/ ,

vi. EXPORT CONTROL LAWS:

(1) Assistance Instruments: N/A

(2) Contracts: Applicants should be aware of current export control laws and are responsible for ensuring compliance with all International Traffic in Arms Regulation (ITAR) (22 CFR 120 et. Seq.) requirements, as applicable. In some cases, developmental items funded by the DoD are now included on the United States Munition List (USML) and are therefore subject to ITAR jurisdiction. Applicants should address in their proposals whether ITAR restrictions apply or do not apply, such as in the case when research products would have both civil and military application, to the work they are proposing to perform for the DoD. The USML is available online at http://www.ecfr.gov/cgi-bin/text-idx?node=pt22.1.121. Additional information regarding the President's Export Control Reform Initiative can be found at http://export.gov/ecr/index.asp.

vii. DRUG-FREE WORKPLACE:

(1) Assistance Instruments: The recipient must comply with drug-free workplace requirements in Subpart B of 2 CFR part 26, which is the DoD implementation of 41 U.S.C. chapter 81, "Drug Free Workplace."

(2) Contracts: The appropriate clause(s) shall be added to the award.

viii. DEBARMENT AND SUSPENSION:

(1) Assistance Instruments: The recipient must comply with requirements regarding debarment and suspension in Subpart C of 2 CFR part 180, as adopted by DoD at 2 CFR part 1125. This includes requirements concerning the recipient's principals under an award, as well as requirements concerning the recipient's procurement transactions and sub-awards that are implemented in DoD Research and Development General Terms and Conditions PROC Articles I through III and SUB Article II.

(2) Contracts: The appropriate clause(s) shall be added to the award.

ix. REPORTING SUBAWARDS AND EXECUTIVE COMPENSATION:

(1) Assistance Instruments: The recipient must report information about sub-awards and executive compensation as specified in the award term in Appendix A to 2 CFR part 170, "Reporting sub-award and executive compensation information," modified as follows:

(a) To accommodate any future designation of a different Government wide Web site for reporting sub-award information, the Web site "http://www.fsrs.gov" cited in paragraphs a.2.i. and a.3 of the award provision is replaced by the phrase "http://www.fsrs.gov or successor OMB designated Web site for reporting sub-award information";

(b) To accommodate any future designation of a different Government wide Web site for reporting executive compensation information, the Web site "http://www.sam.gov" cited in paragraph b.2.i. of the award provision is replaced by the phrase "https://www.sam.gov or successor OMB-designated Web site for reporting information on total compensation"; and

(c) The reference to "Sec._ _.210 of the attachment to OMB Circular A-133, "Audits of States, Local Governments, and Non-Profit Organizations" in paragraph e.3.ii of the award term is replaced by "2 CFR 200.330, as implemented in DoD Research and Development General Terms and Conditions SUB Article I of this award."

(2) Contracts: The appropriate clause(s) shall be added to the award.

x. NATIONAL SECURITY:

(1) This announcement requires that all current and pending research support, as defined by Section 223 of the FY21 National Defense Authorization Act must be disclosed annually, for all covered individuals identified in the proposal. Such disclosure will be updated annually during the performance of any research project selected for funding, and whenever covered individuals are added or identified as performing under the project.

(2) Any decision to accept a proposal for funding under this announcement will include full reliance on the applicant's statements. Failure to report fully and completely all sources of project support and outside positions and affiliations may be considered a material statement within the meaning of the federal False Claims Act, and constitute a violation of law.

(3) The funding agency will conduct a pre-award security review of any proposal selected for funding, and may impose additional security requirements on a resulting award, based on that review. Additional award requirements, where applicable, may include requirements for personnel or facility security clearances, additional background reporting on participants, including students and post graduate researchers, and/or imposition of citizenship requirements on participants. Offerors are advised that any significant national security risk identified may be a basis for the rejection of an otherwise awardable proposal.

3. Reporting

a. Additional reports including number and types will be specified in the award document but will include as a minimum monthly financial status reports. The reports shall be prepared and submitted in accordance with the procedures contained in the award document and mutually agreed upon before award. Reports and briefing material will also be required as appropriate to document progress in accomplishing program metrics. A final report that summarizes the project and tasks will be required at the conclusion of the performance period for the award.

b. SERVICE CONTRACT REPORTING (SCR): For Contracts Only. The Office of Management and Budget (OMB) requires federal agencies to report on activities performed by service contractors annually. Entities with service contracts (including subcontractors) are required to submit a report on all cost-reimbursement, time-and-materials, and labor-hour service contracts and orders. The contractor is required to completely fill in all the information in the format using the following web address: https://sam.gov/. The following contracts are subject to Service Contract Reporting (SCR):

Federal contract awards, not indefinite delivery vehicles (IDVs), are subject to Service Contract Reports (SCRs)

Contract awards include:

- Purchase orders
- Delivery or task orders
- Blanket purchase agreement (BPA) calls
- Definitive contracts

FY2021 DoD funded contract criteria:

1. Contracts with a base effective date between 10/01/2008 and 9/30/2021 for the FY21 report
2. Service Contracts with any PSC that starts with a letter AND belongs to any of the following Category Management subcategories: 1, 2, 3.3, 5, 7.1, 7.2, 7.5, 7.6, 9, 18, and 19
3. All contracts including FY09 to FY21 awards where the total net number of obligations in FY21 is either >/= $3M or </= −$3M

For questions and clarifications about the details of specific federal contracts, contact the contracting officer or agency directly.

(End of Section)

G. Agency Contacts

1. Questions of a technical or programmatic nature shall be directed to the TPOC for each research area of interest. The TPOC information may be found in the description of each research area of interest in Section II.A of this BAA.

2. Questions of a business or administrative nature are to be directed to the following email: usarmy.rtp.devcom-arl.mbx.baa@army.mil.

3. Comments or questions submitted should be concise and to the point, eliminating any unnecessary verbiage. In addition, the relevant part and paragraph of the announcement should be referenced.

4. Requests to withdraw a proposal shall be directed to usarmy.rtp.devcom-arl.mbx.baa@army.mil.

(End of Section)

H. Other Information

Below are two separate outlines of the informational requirements for a sample cost proposal. Section H.1 is for a procurement contract and Section H.2 is for grants and cooperative agreements.

1. CONTRACT Proposals

Cost Proposal – {No Page Limit}

Cover sheet to include:

1	BAA number
2	Technical area
3	Lead organization submitting proposal
4	Type of business, selected among the following categories: "LARGE BUSINESS", "SDB", "OTHER SMALL BUSINESS", "HBCU", "MI", "OTHER EDUCATIONAL", OR "OTHER NONPROFIT"
5	Contractor's reference number (if any)
6	Other team members (if applicable) and type of business for each
7	Proposal title
8	TPOC to include: salutation, last name, first name, street address, city, state, zip code, telephone, fax (if available), electronic mail (if available)
9	Administrative point of contact to include: salutation, last name, first name, street address, city, state, zip code, telephone, fax (if available), and electronic mail (if available)
10	Award instrument requested: cost plus fixed fee (CPFF), cost-contract—no fee, cost sharing contract – no fee, or other type of procurement contract (specify)
11	Place(s) and period(s) of performance
12	Total proposed cost separated by basic award and option(s) (if any)
13	Name, address, and telephone number of the proposer's cognizant Defense Contract Management Agency (DCMA) administration office (if known)
14	Name, address, and telephone number of the proposer's cognizant Defense Contract Audit Agency (DCAA) audit office (if known)
15	Date proposal was prepared
16	DUNS number
17	TIN number
18	CAGE code
19	Subcontractor information
20	Proposal validity period
21	Any Forward Pricing Rate Agreement, other such approved rate information, or such other documentation that may assist in expediting negotiations (if available)

a. Reasoning for Submitting a Strong Cost Proposal

The ultimate responsibility of the Contracting Officer is to ensure that all prices offered in a proposal are fair and reasonable before contract award. To establish the reasonableness of the offered prices, the Contracting Officer may ask the applicant to provide supporting documentation that assists in this determination. The applicant's ability to be responsive to the Contracting Officer's requests can expedite contract award. As specified in Section 808 of Public Law 105-261, an applicant who does not comply with a requirement to submit information for a contract or subcontract in accordance with paragraph (a)(1) of FAR 15.403-3 may be ineligible for award.

b. DCAA-Accepted Accounting System

i. Before a cost-type contract can be awarded, the Contracting Officer must confirm that the applicant has a DCAA-accepted accounting system in place for accumulating and billing costs under Government contracts [FAR 53.209-1(f)]. If the applicant has DCAA correspondence, which documents the acceptance of its accounting system, this should be provided to the Contracting Officer (i.e. attached or referenced in the proposal). Otherwise, the Contracting Officer will submit an inquiry directly to the appropriate DCAA office and request a review of the applicant's accounting system.

ii. If an applicant does not have a DCAA-accepted accounting system in place, the DCAA review process can take several months depending upon the availability of the DCAA auditors and the applicant's internal processes. This will delay contract award.

iii. For more information about cost proposals and accounting standards, view the link titled "Information for Contractors" on the main menu of the DCAA website.

c. Field Pricing Assistance

During the pre-award cost audit process, the Contracting Officer may solicit support from DCAA to determine commerciality and price reasonableness of the proposal [FAR 15.404-2]. Any proprietary information or reports obtained from DCAA field audits will be appropriately identified and protected within the Government.

d. Sample Cost Proposal – "Piece by Piece"

To help guide applicant s through the pre-award cost audit process, a sample cost proposal is detailed below. This sample allows the applicant to see exactly what the Government is looking for so that all cost and pricing back-up data can be provided to the Government in the first cost proposal submission. Review each cost element within the proposal, and take note of the types of documentation that the Contracting Officer will require from the applicant.

i. *Direct Labor*: The first cost element included in the cost proposal is Direct Labor. Each proposed employee must be listed by name and labor category.

Below is the Direct Labor as proposed by our sample applicant:

DIRECT LABOR		YEAR 1			YEAR 2		
Employee Name	**Labor Category**	**Direct Hourly Rate**	**Hours**	**Total Direct Labor**	**Direct Hourly Rate**	**Hours**	**Total Direct Labor**
Andy Smith	Program Manager	$55.00	720.00	$39,600.00	$56.65	720.00	$40,788.00
Bryan Andrews	Senior Engineer	$40.00	672.00	$26,880.00	$41.20	672.00	$27,686.40
Cindy Thomas	Principal Engineer	$50.00	512.00	$25,600.00	$51.50	512.00	$26,368.00
David Porter	Entry Level Engineer	$10.00	400.00	$4,000.00	$10.30	400.00	$4,120.00
Edward Bean	Project Administrator	$25.00	48.00	$1,200.00	$25.75	48.00	$1,236.00
Subtotal Direct Labor (DL)				$97,280.00			$100,198.40

(1) For this cost element, the Contracting Officer requires the applicant to provide adequate documentation in order to determine that the labor rate for each employee/labor category is fair and reasonable. The documentation must explain how these labor rates were derived. For example, if the rates are DCAA-approved labor rates, provide the Contracting Officer with copies of the DCAA documents stating the approval. This is the most acceptable means of documentation to determine the rates fair and reasonable. Other types of supporting documentation may include General Service Administration (GSA) contract price lists, actual payroll journals, or Salary.com research. If an employee listed in a cost proposal is not a current employee (maybe a new employee, or one contingent upon the award of this contract), a copy of the offer letter stating the hourly rate, signed and accepted by the employee, may be provided as adequate documentation.

Sometimes the hourly rates listed in a proposal are derived through subjective processes, i.e., blending of multiple employees in one labor category, or averaged over the course of the year to include scheduled payroll increases, etc. These situations should be clearly documented for the Contracting Officer.

(2) Another cost element in Direct Labor is labor escalation, or the increase in labor rates from year to year. In the example above, the proposed labor escalation is 3% (ex., Andy Smith's direct labor rate increased by 3% from $55.00/hour in Year 1 to $56.65/hour in Year 2). Often times, an applicant may not propose escalation on labor rates during a 24-month period. Whatever the proposed escalation rate is, please be prepared to explain why it is fair and reasonable. For example, a sufficient explanation for our sample escalation rate would be "The Government's General Schedule Increase and Locality Pay for the same time period (name FY) in the same location (name location) was published as 3.5%; therefore a 3% increase is fair and

reasonable". ii. *Other Direct Costs (ODCs)*: This section of the cost proposal includes all other directly related costs required in support of the effort (i.e., materials, subcontractors, consultants, travel, etc.). Any cost element that includes various items must be detailed in a cost breakdown.

(1) Direct Material Costs: This subsection of the cost proposal will include any special tooling, test equipment, and material costs necessary to perform the project. Items included in this section must be carefully reviewed relative to need and appropriateness for the work proposed, and must, in the opinion of the Contracting Officer, be advantageous to the Government and directly related to the specific topic.

The Contracting Officer will require adequate documentation from the applicant to determine the cost reasonableness for each material cost proposed. The following methods are ways in which the Contracting Officer can determine this [FAR 15.403-1]:

(a) Adequate Price Competition. A price is based on adequate price competition when the applicant solicits and receives quotes from two or more responsible vendors for the same or similar items or services. Based on these quotes, the applicant selects the vendor who represents the best value to the Government. The applicant will be required to provide to the Contracting Officer copies of all vendor quotes received.

*NOTE: Price competition is not required for items at or below the micro-purchase threshold ($3,000) [FAR 15.403-1]. If an item's unit cost is less than or equal to $3,000, price competition is not necessary. However, if an item's total cost over the period of performance (unit cost x quantity) is higher than $3,000, two or more quotes must be obtained by the applicant.

(b) Commercial Prices. Commercial prices are those published on current price lists, catalogs, or market prices. This includes vendors who have prices published on a GSA schedule contract. The applicant will be required to provide copies of such price lists to the Contracting Officer.

(c) Prices set by law or regulation. If a price is mandated by the Government (i.e. pronouncements in the form of periodic rulings, reviews, or similar actions of a governmental body, or embodied in the laws) that is sufficient to set a price.

Below is the list of Direct Material costs included in our sample proposal:

DIRECT MATERIAL COSTS	YEAR 1	YEAR 2
Raw Materials	$35,000.00	$12,000.00
Computer for experiments	$4,215.00	$0.00
Cable (item #12-3657, 300 ft.)	$1,275.00	$0.00
Software	$1,825.00	$1,825.00
Subtotal Direct Materials Costs	$42,315.00	$13,825.00

"Raw Materials": This is a generic label used to group many material items into one cost item

within the proposal. The Contracting Officer will require a detailed breakout of all the items that make up this cost. For each separate item over $3,000 (total for Year 1 + Year 2), the applicant must be able to provide either competitive quotes received, or show that published pricing was used.

“Computer for experiments”: This item is most likely a grouping of several components that make up one system. The Contracting Officer will require a detailed breakout of all the items that make up this cost. For each separate item over $3,000 (total for Year 1 + Year 2), the applicant must be able to provide either competitive quotes received, or show that published pricing was used.

“Cable”: Since this item is under the simplified acquisition threshold of $3,000, competitive quotes or published pricing are not required. Simply provide documentation to show the Contracting Officer where this price came from.

“Software”: This cost item could include either one software product, or multiple products. If this includes a price for multiple items, please provide the detailed cost breakdown. Note: The price for Year 1 ($1,825) is below the simplified acquisition threshold; however, in total (Year 1 + Year 2) the price is over $3,000, so competitive quotes or published pricing documentation must be provided.

Due to the specialized types of products and services necessary to perform these projects, it may not always be possible to obtain competitive quotes from more than one reliable source. Each cost element over the simplified acquisition threshold ($3,000) must be substantiated. There is always an explanation for how the cost of an item was derived; document how you came up with that price.

When it is not possible for an applicant to obtain a vendor price through competitive quotes or published price lists, the Contracting Officer may accept other methods to determine cost reasonableness. Below are some examples of other documentation, which the Contracting Officer may accept to substantiate costs:

(a) Evidence that a vendor/supplier charged another applicant a similar price for similar services. Has the vendor charged someone else for the same product? Two (2) to three (3) invoices from that vendor to different customers may be used as evidence.

(b) Previous contract prices. Has the applicant charged the Government a similar price under another Government contract for similar services? If the Government has already paid a certain price for services, then that price may already be considered fair and reasonable. Provide the contract number, and billing rates for reference.

(c) DCAA approved. Has DCAA already accepted or verified specific cost items included in your proposal? Provide a copy of DCAA correspondence that addressed these costs.

(2) ODCs: Below is the remaining ODC portion of our proposal including equipment, subcontractors, consultants, and travel. Assume in this scenario that competitive quotes or catalog prices were not available for these items:

ODCs	YEAR 1	YEAR 2
Equipment Rental for Analysis	$5,500.00	$5,600.00
Subcontractor – Widget, Inc.	$25,000.00	$0.00
Consultant: John Bowers	$0.00	$12,000.00
Travel	$1,250.00	$1,250.00
Subtotal: ODCs	$31,750.00	$18,850.00

"Equipment Rental for Analysis": The applicant explains that the Year 1 cost of $5,500 is based upon 250 hours of equipment rental at an hourly rate of $22.00/hr. One (1) invoice from the vendor charging another vendor the same price for the same service is provided to the Contracting Officer as evidence. Since this cost is over the simplified acquisition threshold, further documentation to determine cost reasonableness is required. The applicant is able to furnish another invoice charging a second vendor the same price for the same service.

"Subcontractor – Widget, Inc.": The applicant provides a copy of the subcontractor quote to the Contracting Officer in support of the $25,000 cost. This subcontractor quote must include sufficient detailed information (equivalent to the data included in the prime's proposal to the Government), so that the Contracting Officer can make a determination of cost reasonableness.

(a) As stated in Section 3.5(c)(6) of the DoD Cost Proposal guidance, "All subcontractor costs and consultant costs must be detailed at the same level as prime contractor costs in regards to labor, travel, equipment, etc. Provide detailed substantiation of subcontractor costs in your cost proposal."

(b) In accordance with FAR 15.404-3, "the Contracting Officer is responsible for the determination of price reasonableness for the prime contract, including subcontracting costs". This means that the subcontractor's quote/proposal may be subject to the same scrutiny by the Contracting Officer as the cost proposal submitted by the prime. The Contracting Officer will need to determine whether the subcontractor has an accepted purchasing system in place and/or conduct appropriate cost or price analyses to establish the reasonableness of proposed subcontract prices. Due to the proprietary nature of cost data, the subcontractor may choose to submit their pricing information directly to the Contracting Officer and not through the prime. This is understood and encouraged.

(c) When a subcontractor is selected to provide support under the prime contract due to its specialized experience, the Contracting Officer may request sole source justification from the applicant.

"Consultant – John Bowers": The applicant shall provide a copy of the consultant's quote to the Contracting Officer as evidence. In this example, the consultant will be charging an hourly rate of $125 an hour for 96 hours of support. The applicant indicates to the Contracting Officer that this particular consultant was used on a previous contract with the Government (provide contract number), and will be charging the same rate. A copy of the consultant's invoice to the applicant under the prior contract is available as supporting evidence. Since the Government has paid this price for the same services in the past, determination has already been made that the price is fair.
"Travel": The Contracting Officer will require a detailed cost breakdown for travel expenses to determine whether the total cost is reasonable based on Government per diem and mileage rates. This breakdown shall include the number of trips, the destinations, and the number of travelers. It will also need to include the estimated airfare per round trip, estimated car rental, lodging rate per trip, tax on lodging, and per diem rate per trip. The lodging and per diem rates must comply with the Joint Travel Regulations. Please see the following website to determine the appropriate lodging and per diem rates: http://www.defensetravel.dod.mil. Additionally, the applicant must provide why the airfare is fair and reasonable as well. Sufficient back up for both airfare and car rental would include print outs of online research at the various travel search engines (Expedia, Travelocity, etc.), documenting the prices for airfare and car rentals are fair and reasonable.

Below is a sample of the travel portion:

TRAVEL	Unit	Trips	Travelers	Nights	Days	Unit Cost	Total Travel
Airfare	roundtrip	1	1			$996.00	$996.00
Lodging	day	1	1	1		$75.00	$75.00

Tax on Lodging (12%)	day	1	1	1		$9.00	$9.00
Per Diem	day	1	1		2	$44.00	$88.00
Automobile Rental	day	1	1		2	$41.00	$82.00
Subtotal Travel							$1,250.00

Indirect Costs: Indirect costs include elements such as fringe benefits, general and administrative (G&A), overhead, and material handling costs. The applicant shall indicate in the cost proposal both the indirect rates (as a percentage) as well as how those rates are allocated to the costs in the proposal.

Below is the indirect portion of our sample proposal:

IRECTS	YEAR 1	YEAR 2
Subtotal Direct Labor (DL):	$97,280.00	$100,198.40
Fringe Benefits, if not included in Overhead, rate (15.0000 %) X DL =	$14,592.00	$15,029.76
Labor Overhead (rate 45.0000 %) X (DL + Fringe) =	$50,342.40	$51,852.67
Total Direct Labor (TDL):	$162,214.40	$167,080.83

In this example, the applicant includes a fringe benefit rate of 15.00% that it allocated to the direct labor costs. The applicant also proposes a labor overhead rate of 45.00% that is allocated to the direct labor costs plus the fringe benefits.

All indirect rates and the allocation methods of those rates must be verified by the Contracting Officer. In most cases, DCAA documentation supporting the indirect rates and allocation methods can be obtained through a DCAA field audit or proposal review. Many applicants have already completed such reviews and have this documentation readily available. If an applicant is unable to participate in a DCAA review to substantiate indirect rates, the Contracting Officer may request other accounting data from the applicant to make a determination.

iii. *FCCM:* Cost of money is an imputed cost that is not a form of interest on borrowings (see FAR 31.205-20). FCCM is an “incurred cost” for cost-reimbursement purposes under applicable cost-reimbursement contracts and for progress payment purposes under fixed-price contracts. It refers to (1) FCCM (48 CFR 9904.414) and (2) cost of money as an element of the cost of capital assets under construction (48 CFR 9904.417). If cost of money is proposed in accordance with

FAR 31.205-10, a DD Form 1861 is required to be completed and submitted with the applicant's proposal.

iv. *Fee/Profit*: The proposed fee percentage will be analyzed in accordance with DFARS 215.404, the Weighted Guidelines Method.

v. *Subcontracting Plan*: If the total amount of the proposal exceeds $700,000 and the applicant is a large business or an institute of higher education (other than HBCU/MI) and the resultant award is a contract, the applicant shall be prepared to submit a subcontracting plan for small business and SDB concerns. A mutually agreeable plan will be included in and made a part of the contract (see Section II.F.2.b.v).

2. GRANT and COOPERATIVE AGREEMENT Proposals

Before award it must be established that an approved accounting system and financial management system exist.

a. *Direct Labor*: Show the current and projected salary amounts in terms of man-hours, man-months, or annual salary to be charged by the PI(s), faculty, research associates, postdoctoral associates, graduate and undergraduate students, secretarial, clerical, and other technical personnel either by personnel or position. State the number of man-hours used to calculate a man-month or man-year. For proposals from universities, research during the academic term is deemed part of regular academic duties, not an extra function for which additional compensation or compensation at a higher rate is warranted. Consequently, academic term salaries shall not be augmented either in rate or in total amount for research performed during the academic term. Rates of compensation for research conducted during non-academic (summer) terms shall not exceed the rate for the academic terms. When part or all of a person's services are to be charged as project costs, it is expected that the person will be relieved of an equal part or all of his or her regular teaching or other obligations. For each person or position, provide the following information:

i. The basis for the direct labor hours or percentage of effort (e.g., historical hours or estimates);

ii. The basis for the direct labor rates or salaries. Labor costs should be predicted upon current labor rates or salaries. These rates may be adjusted upward for forecast salary or wage cost-of-living increases that will occur during the agreement period. The cost proposal should separately identify the rationale applied to base salary/wage for cost-of living adjustments and merit increases. Each must be fully explained;

iii. The portion of time to be devoted to the proposed research, divided between academic and non-academic (summer) terms, when applicable;

iv. The total annual salary charged to the research project; and

v. Any details that may affect the salary during the project, such as plans for leave and/or remuneration while on leave.

Note: There is no page limitation for budget proposals or budget justifications.

b. *Fringe Benefits and Indirect Costs (Overhead, G&A, and Other)*: The most recent rates, dates of negotiation, the base(s) and periods to which the rates apply must be disclosed and a statement included identifying whether the proposed rates are provisional or fixed. If the rates have been negotiated by a Government agency, state when and by which agency. A copy of the negotiation memorandum should be provided. If negotiated forecast rates do not exist, applicants must provide sufficient detail to enable a determination to be made that the costs included in the forecast rate are allocable according to applicable cost provisions. Applicants' disclosure should be sufficient to permit a full understanding of the content of the rate(s) and how it was established. As a minimum, the submission should identify:

   i. All individual cost elements included in the forecast rate(s);

   ii. Basis used to prorate indirect expenses to cost pools, if any;

   iii. How the rate(s) was calculated;

   iv. Distribution basis of the developed rate(s);

   v. Basis on which the overhead rate is calculated, such as "salaries and wages" or "total costs;" and

   vi. The period of the applicant's FY.

c. *Permanent Equipment*: If facilities or equipment are required, a justification why this property should be furnished by the Government must be submitted. State the organization's inability or unwillingness to furnish the facilities or equipment. Applicants must provide an itemized list of permanent equipment showing the cost for each item. Permanent equipment is any article or tangible nonexpendable property having a useful life of more than one year and an acquisition cost of $5,000 or more per unit. The basis for the cost of each item of permanent equipment included in the budget must be disclosed, such as:

   i. Vendor Quote: Show name of vendor, number of quotes received and justification, if intended award is to other than lowest bidder.

   ii. Historical Cost: Identify vendor, date of purchase, and whether or not cost represents lowest bid. Include reason(s) for not soliciting current quotes.

   iii. Engineering Estimate: Include rationale for quote and reason for not soliciting current quotes.

If applicable, the following additional information shall be disclosed in the applicant's cost proposal:

iv. Special test equipment to be fabricated by the awardee for specific research purposes and its cost.

v. Standard equipment to be acquired and modified to meet specific requirements, including acquisition and modification costs, listed separately.

vi. Existing equipment to be modified to meet specific research requirements, including modification costs. Do not include equipment the organization will purchase with its funds if the equipment will be capitalized for Federal income tax purposes. Proposed permanent equipment purchases during the final year of an award shall be limited and fully justified.

vii. Grants and cooperative agreements may convey title to an institution for equipment purchased with project funds. At the discretion of the Contracting/Grants Officer, the agreement may provide for retention of the title by the Government or may impose conditions governing the equipment conveyed to the organization per the governing laws and regulations.

d. *Travel*: Forecasts of travel expenditures (domestic and foreign) that identify the destination and the various cost elements (airfare, mileage, per diem rates, etc.) must be submitted. The costs should be in sufficient detail to determine the reasonableness of such costs. Allowance for air travel normally will not exceed the cost of round-trip, economy air accommodations. Specify the type of travel and its relationship to the research project. Requests for domestic travel must not exceed $3,000 per year per PI. Separate, prior approval by the ARL is required for all foreign travel (i.e., travel outside the continental U.S., its possessions and Canada). Foreign travel requests must not exceed $1,800 each per year per PI. Special justification will be required for travel requests in excess of the amounts stated above and for travel by individuals other than the PI(s). Individuals other than the PI(s) are considered postdoctoral associates, research associates, graduate and undergraduate students, secretarial, clerical, and other technical personnel.

Additional travel may be requested for travel to Army laboratories and facilities to enhance agreement objectives and to achieve technology transfer.

(1) *Participant Support Costs*: This budget category refers to costs of transportation, per diem, stipends, and other related costs for participants or trainees (but not employees) in connection with ARO-sponsored conferences, meetings, symposia, training activities, apprenticeships and workshops (see the "Other Programs" section as described earlier in this BAA). Generally, indirect costs are not allowed on participant support costs. The number of participants to be supported should be entered in the parentheses on the budget form. These costs should also be justified in the budget justification page(s) attached to the cost proposal.

(2) *Materials, Supplies, and Consumables*: A general description and total estimated cost of expendable equipment and supplies are required. The basis for developing the cost estimate (vendor quotes, invoice prices, engineering estimate, purchase order history, etc.) must be included. If possible, provide a material list.

(3) *Publication, Documentation, and Dissemination*: The budget may request funds for the costs of preparing, publishing, or otherwise making available to others the findings and products of the work conducted under an agreement, including costs of reports, reprints, page charges, or other journal costs (except costs for prior or early publication); necessary illustrations, cleanup, documentation, storage, and indexing of data and databases; and development, documentation, and debugging of software.

(4) *Consultant Costs*: Applicants normally are expected to utilize the services of their own staff to the maximum extent possible in managing and performing the project's effort. If the need for consultant services is anticipated, the nature of proposed consultant services should be justified and included in the technical proposal narrative. The cost proposal should include the names of consultant(s), primary organizational affiliation, each individual's expertise, daily compensation rate, number of days of expected service, and estimated travel and per diem costs.

(5) *Computer Services*: The cost of computer services, including computer-based retrieval of scientific, technical, and educational information, may be requested. A justification/explanation based on the established computer service rates at the proposing organization should be included. The budget also may request costs, which must be shown to be reasonable, for leasing automatic data processing equipment. The purchase of computers or associated hardware and software should be requested as items of equipment.

(6) *Sub-awards (Subcontracts or Sub-grants)*: A precise description of services or materials that are to be awarded by a sub-award must be provided. For sub-awards totaling $10,000 or more, provide the following specific information:

- A clear description of the work to be performed;
- If known, the identification of the proposed sub-awardee and an explanation of why and how the sub-awardee was selected or will be selected;

i. The identification of the type of award to be used (cost reimbursement, fixed price, etc.);

ii. Whether or not the award will be competitive and, if noncompetitive, rationale to justify the absence of competition; and

iii. A detailed cost summary.

e. *ODCs*: Itemize and provide the basis for proposed costs for other anticipated direct costs such as communications, transportation, insurance, and rental of equipment other than computer related items. Unusual or expensive items must be fully explained and justified.

f. *Profit/ Fee*: Profit/fee is not allowed for the recipient of or sub-award to an assistance instrument, where the principal purpose of the activity to be carried out is to stimulate or support a public purpose (i.e., to provide assistance), rather than acquisition (i.e., to acquire goods and services for the direct benefit of the Government). A sub-award is an award of financial assistance in the form of money, or property in lieu of money, made under a DoD grant or cooperative agreement by a recipient to an eligible sub-recipient. The term includes financial assistance for substantive program performance by the sub-recipient of a portion of the program for which the DoD grant or cooperative agreement was made. It does not include the recipient's procurement of goods and services needed to carry out the program.

g. *Subcontracting Plan*: Subcontracting plans do not apply to assistance instruments.

h. *FCCM*: If cost of money is proposed, a completed FCCM (DD Form 1861) is required.

(End of Section)

APPENDIX 1: TABLE OF ACRONYMS

AA	Assessment and Analysis
ACC	Army Contracting Command
AEM	Anion Exchange Membrane
AFARS	Army Federal Acquisition Regulation Supplement
ALD	Atomic Layer Deposition
AMC	Army Materiel Command
AOR	Authorized Organization Representative
APG	Aberdeen Proving Ground
AR	Army Regulation
ARL	Army Research Laboratory
ARO	Army Research Office
ASA(ALT)	Assistant Secretary of the Army for Acquisition, Logistics, and Technology
BAA	Broad Agency Announcement
CAGE	Commercial and Government Entity
CCE	Core Campaign Enablers
CCM	Computational Chemistry and Materials
CE	Chemical Energy
CEA	Computational Electromagnetics and Acoustics
CFD	Computational Fluid Dynamics
CFR	Code of Federal Regulations
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance
CFDA	Catalog of Federal Domestic Assistance
COTS	Commercial Off the Shelf
CPFF	Cost Plus Fixed Fee
C-RAM	Counter-Rockets, Artillery, and Mortar
C-UAS	Counter Unmanned Aerial System
CS	Computational Sciences
CSA	Chief of Staff of the Army
CSM	Computational Structural Mechanics
DA	Department of Army
D&B	Dun and Bradstreet
DBA	Doing Business Name
DCAA	Defense Contract Audit Agency
DCMA	Defense Contract Management Agency
DES	Discrete Event Simulation
DFARS	Defense Federal Acquisition Regulation Supplement
DLSC	Defense Logistics Service Center
DoD	Department of Defense
DoDI	Department of Defense Instruction

DoE	Design of Experiments
DSL	Doman Specific Language
DVE	Degraded Visual Environment

EA	Electronic Attack
ECM	Energy Coupled to Matter
EDWOSB	Economically-Disadvantaged Woman-Owned Small Business
EME	Electromagnetic Environment
ET	Embedded Training
EW	Electronic Warfare
FAPIIS	Federal Awardee Performance and Integrity Information System
FAR	Federal Acquisition Regulation
FCCM	Facilities Capital Cost of Money
FFRDC	Federally Funded Research and Development Center
FSC	Federal Service Code
FWA	Federal Wide Assurance
FY	Fiscal Year
G&A	General and Administrative
GCS	Ground Combat System
GFD	Government Furnished Data
GFE	Government Furnished Equipment
GFI	Government Furnished Information
GFP	Government Furnished Property
GSA	General Service Administration
HBCU/MI	Historically Black Colleges and Universities and Minority-Serving Institutions
his	Human Systems Integration
HPC	High Performance Computing
HRPO	Human Research Protection Official
HS	Human Sciences
HSATS	Human Systems Analytic Tool Suite
HSR	Human Subjects Research
HUBZone	Historically Underutilized Business Zone
HWIL	Hardware in the Loop
IE	Information Extraction
IED	Improvised Explosive Device
IMU	Inertial Measurement Unit
IR&D	Independent Research and Development
IRB	Institutional Review Board
IS	Information Sciences
IT	Information Technology
ITAR	International Traffic in Arms Regulation

KCI	Key Campaign Initiative
KE	Kinetic Energy
LED	Light Emitting Diodes
MAR	Mixed Augmented Reality
MAV	Manned Aerial Vehicle
MBE	Molecular Beam Epitaxy
MEMS	Microelectromechanical Systems
METT-TC	Mission, Enemy, Terrain and Weather, Troops and Support Available, Time Available, Civil Considerations
M2M	Machine to Machine
MOCVD	Metal Organic Chemical Vapor Deposition
MR	Materials Research
M&S	Modeling and Simulation
MSC	Major Subordinate Command
MT	Machine Translation
MTF	Modulation Transfer Function
NLOS	Non Line of Sight
NLP	Natural Language Processing
ODC	Other Direct Cost
OMB	Office of Management and Budget
OHRP	Office for Human Research Protections
OTA	Other Transaction for Prototype
PAM	Pamphlet
PDF	Portable Document Format
PE	Programming Environments
PFN	Pulse-Forming Network
PI	Principal Investigator
PIC	Photonic Integrated Circuit
PNT	Position, Navigation, and Timing
POC	Point of Contact
PPE	Personal Protective Equipment
PWS	Performance Work Statement
R&D	Research and Development
RDECOM	Research, Development, and Engineering Command
ROTC	Reserve Officer Training Corps
R&R	Research and Related
RTP	Research Triangle Park
SAM	System for Award Management
SBS	Stimulated Brillouin Scattering
SbT/MgC	Subterranean and Megacity
ScL/P	Sciences for Lethality and Protection
ScMVR	Sciences for Maneuver

SDB	Small Disadvantaged Business
SDO	Suspension and Debarment Official
SDN	Software Defined Network
SDVOSB	Service-Disabled Veteran-Owned Small Business
SF	Standard Form
SLV	Survivability, Lethality, and Vulnerability
S&T	Science & Technology
STTW	Sensing Through the Wall
TBI	Traumatic Brain Injury
TCAD	Technology Computer-Aided Design
T&E	Test & Evaluation
TIA	Technology Investment Agreement
TIC	Toxic Industrial Chemical
TIM	Toxic Industrial Material
TIN	Taxpayer Identification Number
TPOC	Technical Point of Contact
TRADOC	Training and Doctrine Command
TTP	Tactics, Techniques, and Procedures
UAS	Unmanned Aerial System
UAV	Unmanned Aerial Vehicle
UB	Underbody Blast
UEI	Unique Entity Identifier
UIC	Unit Identification Code
UQ	Uncertainty Quantification
U.S.C.	United States Code
USDA/APHIS	Department of Agriculture Office of Animal and Plant Health Inspection Service
USML	United States Munition List
UWB	Ultra-Wideband
UXO	Unexploded Ordinance
VCSEL	Vertical Cavity Surface Emitting Laser
VOSB	Veteran-Owned Small Business
VRAMS	Virtual Risk-Informed Agile Maneuver Sustainment
VSP	Visiting Scientist Program
VTOL	Vertical Takeoff and Landing
WOSB	Woman-Owned Small Business

(End Section)