U. S. DEPARTMENT OF ARMY
ARMY RESEARCH LABORATORY

TO INCLUDE
ARMY RESEARCH OFFICE
COMPUTATIONAL AND INFORMATION SCIENCES DIR.
HUMAN RESEARCH AND ENGINEERING DIR.
SENSORS AND ELECTRON DEVICES DIR.
SURVIVABILITY/LETHALITY ANALYSIS DIR.
VEHICLE TECHNOLOGY DIR.
WEAPONS AND MATERIALS RESEARCH DIR.

BROAD AGENCY ANNOUNCEMENT
FOR
CONTRACTS, GRANTS, COOPERATIVE AGREEMENTS, AND OTHER TRANSACTIONS

DAAD19-03-R-0017

October 2003 - FY 2006

ISSUED BY:

U.S. Army Robert Morris Acquisition Center
Research Triangle Park Contracting Division
P. O. BOX 12211
RESEARCH TRIANGLE PARK, NC 27709-2211

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INTRODUCTION

This Broad Agency Announcement (BAA) which sets forth research areas of interest to the Army Research Laboratory (ARL) directorates and the Army Research Office (ARO) is issued under the paragraph 6.102(d)(2) of the Federal Acquisition Regulation (FAR), which provides for the competitive selection of basic research proposals. 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 98-369, "The Competition in Contracting Act of 1984" and subsequent amendments.

Research proposals are sought from educational institutions, nonprofit organizations, and commercial organizations for research in chemistry, electronics, environmental sciences, life sciences, materials science, mathematical and computer sciences, mechanical sciences, physics, computational and information sciences, sensors and electron devices, survivability/lethality analysis, and weapons and materials research. Proposals shall be evaluated only if they are for scientific study and experimentation directed toward advancing the state of the art or increasing knowledge and understanding.

The ARL will consider proposals for comprehensive and interdisciplinary research programs. However, the majority of these proposals would be executed by the ARO. The ARL can initiate only a small number of these large programs in a single fiscal year.

Foreign owned, controlled, or influenced firms are advised that security restrictions may apply that could preclude their participation in these efforts. Before preparing a proposal, such firms are requested to contact the ARL Security and Counterintelligence Branch (301) 394-4166 concerning their eligibility. Pursuant to the policy of FAR 35.017 and supplements, selected Federally Funded Research and Development Centers may propose under this BAA.

PART II, Other Programs, addresses specific contributions to Conferences and Symposia and HBCU/MI support.

The Army has a long history of advocating and supporting research at historically black colleges and universities and minority institutions (HBCU/MI). We actively seek research proposals from HBCUs and MIs in full competition with all offerors who may submit proposals under this BAA. Proposals may be submitted at any time. We also encourage the inclusion of HBCUs and/or MIs as part of a consortium proposal or as subcontractors/ subgrantees to prime recipients.

In order to conserve valuable offeror and Government resources and to facilitate determining whether a proposed research idea meets the guidelines described herein, prospective offerors contemplating submission of a white paper or proposal are strongly encouraged to contact the appropriate technical point of contact (TPOC). The TPOCs' names, telephone numbers, and e-mail addresses are listed immediately after each research area of interest. If an offeror elects to submit a white paper, it shall be prepared in accordance with the instructions contained in PART IV, Section 3. Upon receipt of a white paper, it will be evaluated and the offeror shall be advised of the evaluation results. Offerors whose white papers receive a favorable evaluation may be contacted to prepare a complete proposal in accordance with instructions contained in PART IV, Section 4.

The costs of white papers and/or complete 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 cost specified in FAR 31.205-18.

In accordance with federal statutes, regulations, and Department of Defense 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.

Offerors submitting proposals are cautioned that only a Contracting or Grants Officer may obligate the Government to any agreement involving expenditure of Government funds.

This BAA also applies to research proposals submitted to the ARL European Research Office and the Far East Office from Europe, Africa, the Middle East, and Southwest Asia.

For Research Areas 1-6, offerors shall discuss the preferred performance period with the technical point of contact (TPOC). For ARO's Research Areas 7-15, it is preferred that proposals are submitted to cover a 3-year period and include a brief summary of work contemplated for each 12-month period so that awards may be negotiated for an entire 3-year program or for individual 1-year increments of the total program. All administrative inquires regarding this BAA shall be addressed to voice mailbox number 919-549-4375. If an inquiry is made, please clearly state your name, correct spelling, and telephone number. Technical questions should be referred to the TPOCs shown following each research area of interest.

This BAA is available on the following websites:

http://www.aro.army.mil
http://www.fedbizopps.gov/.

This BAA is a continuously open announcement valid throughout the period from the date of issuance through 30 September 2006, unless announced otherwise, and supersedes the ARL BAA dated July 2000. The current BAA, DAAD19-00-R-0010 dated July 2000 remains effective only until 30 September 2003. Amendments to this BAA will be posted to the FedBizOpps web site and published at the above websites when they occur. Interested parties are encouraged to periodically check these websites for updates and amendments.

John M. Miller
Director
Army Research Laboratory

PART I – RESEARCH AREAS OF INTERESTS

A. ARMY RESEARCH LABORATORY DIRECTORATES

RESEARCH AREA 1
COMPUTATIONAL AND INFORMATION SCIENCES

1.1. Military Extensible Markup Language (milXML). Extensible markup language (XML), a subset of standard generalized markup language (SGML), was approved by the World Wide Web Consortium in 1998, with the hope that XML would offer a more efficient way to publish Web pages. Gradually, developers found out that the power of defining their own tags separate from the file contents meant that data could be defined and easily exchanged. Web publishing is now spreading to more data interchange situations. Now XML is taking on e-commerce. Commerce XML (cXML) initiative is launched with the goal of fitting the document schema into the data-flow environment.

The electronic business XML (ebXML Initiative™) creates a single global XML framework solution. The ebXML is hoped to revolutionize how business transactions are tracked, affecting worldwide impacts, removing paper from the process and by empowering people to create whole new work models.

Financial products markup language (FpML) is a new protocol to enable e-commerce activities in the field of financial derivatives. The synchronous markup language (SyncML), which leverages XML, is the common language for synchronizing all devices and applications over any network. With SyncML, networked information can be synchronized with any mobile device and mobile information can be synchronized with any networked application. These developments will prompt one to conceive a military XML (milXML) that will assist military strategic and tactical transactions. The ARL would like to receive research proposals to explore the possibility of defining and developing a milXML protocol that is consistent with security and bandwidth issues in CONUS, joint, and coalition operations.

Technical Point of Contact: Dr. Som Karamchetty, e-mail: Somayajulu.kaaramchetty@us.army.mil (301) 394-3198.

1.2. Information Science and Technology. The ARL is interested in basic and applied research resulting in technologies that support state-of-the-art capabilities for the war fighter in the analysis, assimilation, and dissemination of real and simulated digitized battle space information. Areas of interest include, but not limited to:

a. Intelligent software agents.

b. Course of action analysis and comparison.

c. Software reuse.

d. Embedded training on the use of the system.

e. Automated distribution of operational orders.

f. Collaborative technologies for distributed work environments.

g. Information and data fusion/visualization.

h. Data mining

i. Machine translation of text and speech data.

j. Mixed small robot/soldier team collaboration and behavior.

Technical Point of Contact: Dr. John W. Gowens, II, email: Jay.gowens@us.army.mil (301) 394-1722.

1.3. Wireless Information Assurance and Survivable Communications. The ARL is interested in receiving proposals that address the underlying science and technology for survivable and secure communications over wireless networks, information infrastructure protection, and survivable systems engineering. The objectives of the research are to provide secure, survivable, and assured communications over wireless networks, including highly mobile networks. Research interests include, but should not be limited to, advancing the state of the art in the following areas:

a. Research on automated vulnerability assessment and intrusion detection tools and techniques.

b. Genetic algorithms used to spawn and control intelligent agents for information assurance.

c. Information hiding in images and text (steganography and watermarking).

d. Key distribution and security in a mobile wireless ad hoc network.

e. Tools and techniques for automating the creation and distribution of interoperable vulnerability knowledge bases.

f. Tools and techniques for automated and analysis and correlation of anomalies, probes, and detections from multiple sites and to support post-incident forensic analysis.

g. Network management and visualization tools that support real time planning and control of tactical nets as well as tools for intrusion detection and forensic analysis in hybrid networks.

Technical Point of Contact: Mr. Greg Cirincione, e-mail: greg.circincione@us.army,mil (301) 394-4809.

1.4. Sensor Network Communications. ARL is developing communications devices and technologies for unattended sensors. These unattended devices must work for long periods on limited battery power, use Anti-Jam and Low Probability of Detection waveforms, perform ad-hoc networking for autonomous self-healing routing, and provide network security for authentication, data integrity and privacy. Areas of interest include, but not limited to:

a. Ad-hoc network protocols

b. Security protocols

c. Robust AJ/LPD waveforms

d. Energy efficient modems

e. Energy efficient RF front-ends

f. Low power signal processing

g. Small broadband antenna

h. Forward-error-correction

Technical Point of Contact: Mr. Ronald Tobin, e-mail: ronald.tobin@us.army.mil, (301) 394-2184.

1.5. Wireless Mobile Communications. The ARL is interested in receiving proposals that address the underlying science and technology for mobile wireless communications networks, especially the mobile tactical domain, and including sensor networks. The objectives of this research are to enable Army multimedia communications among highly mobile users, sensors, and robotic platforms under adverse channel conditions, with desired quality of service

on demand. Research areas of interest include, but are not limited to, advancing the state of the art in the following areas:

a. Bandwidth and energy constrained mobile transceiver design.

b. Cross-layer designs, especially with respect to physical layer and media access layer interaction.

c. Multi-antenna methods, including space-time processing, for mitigating multi-user and intentional interference, while achieving very high capacity.

d. Techniques for overcoming electronic warfare and jamming threats.

e. Frequency agile systems.

f. The combination of channel equalization and coding techniques.

g. Wideband modulation methods such as orthogonal frequency division multiplexing.

h. Ultra wideband systems, including coexistence issues and system overlays.

i. Sensor networking systems, including signal processing and communications interactions, distributed detection and estimation, and networking protocols.

j. Ad hoc mobile networking protocols and procedures.

Technical point of contact: Dr. Brian M. Sadler, email: brian.sadler@us.army.mil, (301) 394-1239.

1.6. Atmospheric Effects Modeling and Simulation. The ARL is interested in receiving proposals that address the technology and technical barriers for improving the state of the art of critical scientific areas that affect atmospheric modeling and simulation. The objectives of the research are to mitigate the effects of weather and battle-induced atmospheres on combat materiel, personnel, and doctrine; to optimize the performance of friendly forces under realistic battlefield conditions; and to enhance the use of smoke, camouflage, concealment, deception, and low-observable technology. Research interests include, but should not be limited to, advancing the state of the art in the following areas:

a. Research on and models of the propagation of acoustic energy in the atmospheric environment under neutral and battlefield conditions.

b. Atmospheric effects decision aids for acoustic systems.

c. Sound detection and ranging techniques.

d. Computer, artificial intelligence, display, and man-machine interface techniques in weather intelligence concepts.

e. Unified weather packages of atmospheric effects decision aids for potential use in automated systems of the different battlefield functional mission areas.

f. Atmospheric effects decision aids consolidating the effects of realistic battlefield conditions and operations, systems, and sub-systems.

g. Models of electromagnetic propagation through the atmosphere at UV through millimeter-wave lengths under natural and battlefield conditions for mitigating atmospheric effects on Army systems.

h. Research on and models of atmospheric effects on images and scenes under natural and battle-induced conditions.

i. Obscuration models for battlefield conditions, including weather, natural and battle-induced smokes, and dust.

j. Atmospheric effects decision aids for the use of smoke, camouflage, decoys, and low observables.

k. Incorporation of the effects of weather, clutter, and battlefield obscurants into target acquisition.

l. Atmospheric effects decision aids for mitigating the effects of natural and battle-induced atmospheres on target acquisition.

m. Simulation of battlefield environmental effects for distributed simulation and high-level architecture.

n. Advanced numeric modeling techniques that use state-of-the-art computer technology, such as parallel processing.

Technical Point of Contact: Dr. Alan Wetmore, e-mail: alan.wetmore@us.army.mil, (301) 394-2499.

1.7. Database Technology. Explore ideas and prototype tools for advanced data management concepts, including schema integration and data warehousing in a standardized data environment, enable transparent access to multiple heterogeneous databases, data mining and knowledge discovery in large distributed databases, automated query formulation strategies using data element thesaurus capabilities, integration of data encyclopedia tools with data and process modeling tools, and automated support for electronic records management and digital signature. Implement and experiment with simultaneously and transparently accessing and manipulating data from different databases, to include support for imaging, multimedia, object-oriented, and traditional applications. Investigate new ideas, and design, implement, and evaluate prototype data management tools that support the Army Information Architecture, Army modernization efforts, and the Army's Future Combat System (FCS).

Technical Point of Contact: Ms. Pat Jones, email: patricia.h.jones@us.army.mil, (410) 278-5840.

1.8. Software Engineering. In an open systems environment, develop concepts for prototype components of software engineering technologies which reduce software life-cycle costs, increase modularity and interoperability, increase productivity of software design/development and support organizations, and improve the quality, reliability and reusability of delivered components, systems, and products. Explore methodologies and technologies (e.g., object-oriented), which achieve substantial improvement and cost reduction in software development, requirements analysis and definition, software management, complexity, and quality metrics, reuse, re-engineering, maintenance. This includes tools and techniques (e.g., intelligent agents, wrappers) to aid in migrating or interfacing legacy systems to Java-based or other state-of-the-art systems. Topic includes any software engineering technologies, which aid in the Army's efforts to digitize the battlefield and its tactical command and control systems.

Technical Point of Contact: Ms. Pat Jones, email, patricia.h.jones@us.army.mil, (410) 278-5840.

1.9 Research in Mission Execution Analysis. The Future Force will rely on new concepts of networks, information, and integration (NII) supported by prolific data collection assets. Novel methodologies will harness the data-rich battle space to improve the planning/re-planning cycle. ARL has been exploring the applicability of combat simulation to NII, with endeavors centering on course of action (COA) parameterization and assessment. Objectives are of the following nature: develop COA decision methodologies for the commander; establish analytical relationships between simulation and actual battle; extend mathematics of combat modeling for COA evaluation; and apply experimental statistical analyses to battle dynamics. A long-term intent is to utilize simulation-based techniques to improve the planned/ongoing operation. The scope is development of a consistent set of tools that assist the war fighter in aspects of battle space decision support (e.g., situation assessment, planning, war-gaming, execution monitoring).

ARL is soliciting proposals for basic and applied research leading to tools that support mission planning, monitoring, and adaptation. ARL seeks approaches extensible across the spectrum of Future Force operations, particularly in complex and urban terrain. Areas of interest include: techniques for automation-augmented planning and decision making; methods for COA evaluation, including characterization of battle progress and outcome;

consideration of mismatches between battle space data and simulation results; approaches to integration of multiple simulation results; approaches accounting for incomplete/uncertain data; identification of data structures for analyses of near-term COAs; statistical techniques for COA comparison (e.g., nonparametric hypothesis testing); operations research methods for COA evaluation (e.g., multi-attribute utility analysis); and techniques for checking COAs against "standards" (e.g., principles of war, historical cases) or criteria (e.g., commander's intent, supportability).

Technical Point of Contact: Mr. Richard Kaste, e-mail: richard.kaste@us.army.mil, (410) 278-7781.

1.10. Battlefield Environmental Research. The ARL is interested in basic and applied research resulting in technologies that support state-of-the-art capabilities for the war fighter in the measurement, analysis, assimilation, and dissemination of real and simulated digitized battle space weather and atmospheric information. Areas of interest include, but are not limited to:

a. Microscale atmospheric boundary layer meteorology and numerical simulation, at resolutions below 1 km that consider real urban and vegetative canopy effects, including methodology and automated technology for application and incorporation of high resolution microscale natural and man-made land surface features.

b. Efficient distributed weather forecasting/nowcasting technology for hosting on future Army tactical computer platforms.

c. Physically accurate weather visualization tools.

d. Diagnostic tools for determining the realistic spatial variability of atmospheric parameters in limited complex domains.

e. Methodology and applications for the use of satellite remote sensing of boundary layer environmental conditions.

f. Innovative new techniques and novel technology exploitation to retrieve data and extract information on boundary layer weather and atmospheric aerosols from traditional and non traditional sensors and sources.

g. Electromagnetic and acoustic propagation, especially electro-optical EM propagation and infrasonic acoustic propagation.

h. Atmospheric aerosol properties and behavior, including the natural background, as well as man-made liquid/solid mineral, chemical and biological components.

i. Environmental decision support technology (tactical decision aids) for transforming weather information into mission planning and battle decision intelligence.

Technical Point of Contact: Dr. Douglas R. Brown, email: douglas.r.brown@us.army.mil, (301) 394-2500.

1.11. Scalable Computational Sciences. Research and development proposals are required in the areas of multi-disciplinary computational approaches on high performance computers to address challenges in simulating practical Army applications. Specific areas of interest include: (i) innovative and scalable methodologies (including finite element methods, particle methods, etc.) for computational mechanics Computational Fluid Dynamics (CFD), Computational Structural Mechanics (CSM), Computational Electromagnetics and Acoustics (CEA), and Computational Chemistry and Materials (CCM), etc.); (ii) innovative space and time discretization numerical algorithms including scalable equation solvers for a wide class of nonlinear computational mechanics problems; (iii) computational methods for interdisciplinary applications (example: structure-medium interaction, Eulerian-Lagrangian, etc.); (iv) multi-scale computational approaches (example: Macro-meso-micro approaches, molecular dynamics-continuum mechanics coupled approaches, etc.); (v) computational methods to address innovative structures for Army applications (designing, manufacturing, testing, verification and validation); and (vi) data mining for scientific applications.

Technical Point of Contact: Dr. Raju Namburu, e-mail: raju.namburu@us.army.mil, (410) 278-9761.

1.12. Knowledge Fusion Research. ARL is interested in proposals for developing in-depth knowledge and understanding of fundamental science and technology elements required for knowledge fusion, especially for the battlefield and homeland defense domains. A primary objective is to investigate different facets of integration and fusion phenomena with the goal of fusing together data from a wide variety of heterogeneous sources in a way that distills the combined information and adds intelligence to create knowledge. The data involved comes from databases (relational, object, legacy, spatial, temporal, and others), from knowledge bases, from semantic nets that include the coming semantic Web, as well as from sensor data Knowledge fusion involves fusing the data, applying and integrating various knowledge producing transforms (e.g. threat indices) and inferences (e.g. logical, nonmonotonic, hypothetical) as part of a comprehensive, domain-specific system that provides focused and quickly identifiable knowledge to the human user.

Technical point of contact: Dr. Dana L. Ulery, email: dana.ulery@us.army.mil 410-278-8609.

1.13. Battlefield Knowledge Management. ARL is interested in proposals that address knowledge management and information fusion to develop the situational understanding required for planning and acting within the adversary's decision cycle, including the development of computational models that address the complexity of this class of battlespace problems. There is a need to develop knowledge-intensive systems that require not only the elicitation of human expertise but encoding it in computational formalisms required to implement the reasoning processes. Automated support for discovering knowledge such as interesting patterns in data is required. ARL's interest includes knowledge of heterogeneous data and multimedia types, data mining, text mining, knowledge agents, knowledge brokers, knowledge visualization systems, federated data warehouses, and knowledge standards for application in the wireless environment of the battlefield.

Technical Point of Contact: Ms. Barbara Broome, email b.d.broome@us.army.mil, (410) 278-4773.

1.14. Technology Demonstrations and Assessments for Special Operations and Low Intensity Conflict (SOLIC). ARL is interested in proposals that focus on demonstrating (prototype level) or assessing (unique facilities) across any and all of technical areas described in the Army Research Laboratory Directorates portion of this BAA for SOLIC applications. Demonstrations and assessments should be at least at the brass board prototype level. The focus is to demonstrate the transition of technology for the application of advanced systems and equipment to the U.S. Army, United States Special Operations Command, and other unique missions related to transformation of the U.S. military and the Global War on Terrorism in the following mission areas:

1.14.1. Direct Action Support: Development and demonstration of advanced technology supporting small team and transformational combat units (interim brigade, objective force, and future combat systems) combat operations. This includes close quarters combat and fire support (laser target designation, etc.).

1.14.2. Intelligence, Surveillance and Reconnaissance Support: Development and demonstration of technology supporting enhanced situational awareness and real-time intelligence for small team and transformational combat units (interim brigade, objective force, future combat systems) and their tactical support elements at forward operating bases and joint special operations task force locations.

1.14.3. Special Reconnaissance Support: Development and demonstration of technology supporting dismounted, long-term reconnaissance into non-permissive areas. Psychological Operations: Development and demonstration of equipment providing production and dissemination and assessment of PSYOP media. This includes leaflets, RF broadcasts, and text messaging and other formats.

1.14.4. Expeditionary Warfare/Unconventional Warfare: Development and demonstration of technology and systems supporting rapid deployment operations. This involves the rapid build-up of lethal and sustainable forces in remote areas.

1.14.5. Military Operations in Urban Terrain: Development and demonstration of technology and systems supporting a range of military operations in urban terrain. This includes enhanced situational awareness and use of unmanned systems.

1.14.6. Network Centric Warfare: Development of technology and systems for engaging enemy network systems, and protecting friendly networks.

1.14..7. Knowledge Superiority: Development, application and demonstration of hardware and software to provide and apply knowledge superiority to U.S. Army and Special Operations Forces objectives.

1.14..8. Counter-drug Operations: Development and demonstration of technology and systems supporting counter-drug operations. This includes equipment that is able to detect and identify the presence of drugs in any form, or in any container.

Technical Point of Contact: Mr. Peter Paicopolis, email: peter.s.paicopolis@us.army.mil, (410) 278-4126.

1.15 Software Technologies Targeting Interoperability for Systems of Systems Emerging DoD systems represent a revolutionary leap ahead in the concept of "system of systems" and interdependent operations. Interoperability and the management of complexity are the chief challenges to harness technologies to meet the future needs of the Army for information infrastructure. For example, the Army's Future Combat System (FCS) will be a joint, networked architecture made up of 18 individual systems plus the network and Soldier. It will be an ensemble of manned and unmanned combat systems, designed to provide a multi-functional, multi-mission reconfigurable system of systems maximizing interoperability, strategic transportability and commonality of mission roles including direct and indirect fire, air defense, reconnaissance, troop transport, counter mobility, and Command and Control (C2) on the move. Full second generation digital systems will provide the nexus for combined arms operations, fully embedded training, and system operation. In order to realize these goals FCS will require 'glue' to bring together the multitude of components within each system as well as assure interoperability amongst the major systems. This 'glue' is the software which ties together all the pieces. However, the software must also accommodate nonfunctional system attributes such as adaptability, flexibility, agility. The predicted number of Lines of Code (LOC) for the FCS applications has been estimated as high as 40 million and may go beyond that. More important than the size of the software base, the complexity of the individual systems and the interface required for joint operations is staggering. The Warfighter Information Network – Tactical (WIN-T) will be the communications backbone. The difficulties of real world networking and communications will provide great challenges in keeping and securing the required information flow. Great complexity surfaces from the merging of system embedded computing and ad hoc networking. The complexity is exacerbated by the fact that FCS will also have to interface and integrate with legacy systems, systems under development and yet-to-be developed applications. Software will be the key component to assure these goals are realized. This realization is both in terms of correct, reliable, and fault tolerant algorithms as well as development tools and processes which assure project schedules are met in terms of time and cost. Both the Air Force and the Navy have similar commitments to network-dependent operations.

The objective is to develop and transition new methodologies, tools, technologies and techniques that improve the quality, dependability and interoperability of software for large, net-centric systems of systems. Key in this effort is to develop and establish principles of interoperability and complexity management as a foundation for developing a service-oriented architecture for these ultra large scale systems. These principles will enable the precise description of components, their construction and their acceptable interactions (e.g., to enforce performance and security requirements), leading to new approaches for building and assembling systems.

Research Concentration Areas**:** In order to address these challenges, the U.S. Army Research Laboratory (ARL) under the auspices of the OSD Software-Intensive Systems Producibility Initiative (SISPI) is soliciting proposals in the following areas. They are suggestive of topic areas which will enable future DoD systems to move towards net-centric environments. They are not in priority order and are meant to stimulate ideas for prospective proposals. Other novel and creative solutions are strongly encouraged.

Proposals must show and will be expected to deliver prototype but usable software methodologies, prototypes, and/or tools which can be tested and incorporated into DoD R&D programs. "The Software and Systems Test Track http://www.fbo.gov/spg/USAF/AFMC/AFRLRRS/Reference%2DNumber%2DBAA%2D06%2D13%2DIFKA/listing.html , another component of the OSD SISPI will provide an open framework environment where tools and products may be deployed allowed to interact in real-time, interactive, evolutionary and interdependent means, allowing rigorous testing of new technologies, methodologies and theories in support of the OSD Software-Intensive

Systems Producibility Initiative. The Software and Systems Test Track is one place prototype software could be delivered."

a. Domain-specific modeling languages and semantics
b. Model-based design and development/engineering for system of systems architectures and ultra large scale software intensive architectures.
c. Models which support reflective (self-referential) capability
d. Principles and ontology development for organization of components, their design and construction
e. Verifiably correct generators and models
f. Re-engineering and Integration technologies (methods, tools, metrics, models, etc.) for legacy systems

Technical Points of Contact: Mr. Glenn Racine, e-mail:glenn.racine@us.army.mil (301) 394-3990 or, Mr. Jeff DeHart, e-mail:jdehart@arl.army.mil, (301) 394-2263.

RESEARCH AREA 2
SENSORS AND ELECTRON DEVICES

2.1. Photonic Devices and Modules. Research is encouraged pertaining to active and passive devices for optical signal processing. Active device research includes the development of bulk and integrated sources, modulators, and detectors, and the development of technologies for their integration into processor architectures. Active interface devices such as vertical cavity surface emitting laser (VCSEL) arrays and photo detectors are also of critical interest. VCSEL research should focus on smart pixel processing functions and interfacing issues. Photo detector array research should focus on on-chip processing, layout, mounting, and device cooling for both one- and two-dimensional arrays. Parameters of interest include number of elements, readout speed, noise levels, and dynamic range. Passive device research includes the theory, design, fabrication, and application of diffractive optical elements in signal processing architectures.

Technical Point of Contact: Dr. George Simonis, e-mail: george.simonis@us.army.mil , (301) 394-5754.

2.2. Novel Optical Processing Algorithms and Techniques. Proposals relating to ideas for new processing systems and configurations are welcome. Methods for modulating light beams with signals of appropriate nature are of interest here. Also of interest are methods for realizing certain processing algorithms (e.g., multispectral image processing) and methods for detection using elaborate photosensitive devices (e.g., charge-coupled devices and CMOS detectors). Important factors are speed, reasonable laser power requirements, insensitivity to lens aberration, small size, noise and environmental immunity, and other aspects of high performance. Both pre- and post-processing electronics are among the system components subject to possible improvement, with interfaces and co-processors being of particular interest.

Technical Point of Contact: Dr. George Simonis, e-mail: george.simonis@us.army.mil , (301) 394-5754.

2.3. Sensors, Actuators, and Micro-Mechanics. The Army requires research investigations into electronic materials, devices, and components, and relevant basic physics studies that couple electrical, magnetic, and optical fields with mechanical (elastic) fields. These are needed to ensure that the integration and interfacing of new materials and components into electronic systems will result in the improved system performance required to carry out complex military missions. The Sensors and Electron Devices Directorate (SEDD) is interested in receiving novel proposals that address the technical barriers associated with improving the current state of the art in electronic materials, devices, and components used as sensors, actuators, and micro-mechanical structures. Technical areas of interest include, but are not limited to, the following:

a. Theoretical and experimental studies of electro-mechanical interactions in solids.

b. Studies of micro-mechanics that impact electronic/photonic devices.

c. Investigation of dielectric semiconductors, and ceramic material parameters, including ferroelectric, piezoelectric, and elastic properties.

d. Nanoelectronic investigation, including the physics of structures that incorporate polarization gradient, strain gradient, and nonlinear interactions.

Technical Points of Contact: Dr. Steven Tidrow, e-mail: steven.tidrow@us.army.mil , (301) 394-3180 or Dr. Madan Dubey, e-mail: madan.dubey@us.army.mil , (301) 394-1186.

2.4. Frequency Selective Filter. Develop broad pass band frequency selective filter(s) capable of attenuating overpowering narrowband interferers. While interferers are greatly attenuated, all other desired signals pass through with negligible effects. A filter is desired that could attenuate multiple interferers without prior knowledge of their location in the spectrum. This device should also exhibit a high spurious-free dynamic range, minimum insertion loss and minimum ripple. Other desired features are small size, weight and power consumption, a high spurious-free dynamic range, minimum weight, and power consumption.

Technical Point of Contact: Mr. Eric Adler, e-mail: eric.d.adler@us.army.mil , (301) 394-0933.

2.5. Radio Frequency (RF) Signal Processing. Research efforts are sought in RF/microwave signal processing to extract parameters and features from a broadband frequency field. This area is concerned with processing techniques at both RF and intermediate frequency (IF). The systems or techniques proposed must have the high speed necessary to perform in real time, coupling with peripheral processors. Some of the processing characteristics sought are rapid acquisition, variable delay capabilities, signature analysis, tracking, decoding, and control.

Technical Point of Contact: Mr. Eric Adler, e-mail: eric.d.adler@us.army.mil (301) 394-0933.

2.6. Sensors. Research proposals are desired that will lead to the ability to sense, locate, identify, and engage targets at tactical ranges. These sensors must reliably discriminate between targets and clutter and detect targets in the presence of counter-measures. For example, it is desired to detect a camouflage-netted vehicle partially obscured by foliage. Sensors of interest include, but are not limited to, millimeter wave and electro-optical/infrared, both passive and active. Small size and gun or missile launch survivability are required for some applications and low cost is always important. Another area of interest is surveillance (UAV) and fighting platform (rotary wing and ground vehicle) based systems. Critical components of sensors, such as high-power eye-safe laser sources for laser radar, are of interest. Methods for fusing the outputs of various sensors and signal propagation modeling are also of interest. Applications include surveillance and target acquisition, target engagement for smart munitions, and navigation and obstacle avoidance.

Technical Points of Contact: Millimeter Waves - Mr. Bruce Wallace, e-mail: bruce.wallace@us.army.mil , (301) 394-2610 and Electro-Optical/Infrared - Dr. Greg Sztankay, e-mail: Zoltan.g.stankay@us.army.mil, (301) 394-3130.

2.7. Focal Plane Array Research and Development. The SEDD's research and development goal is to advance the technology for producing smart, multi-spectral, active and passive, focal plane arrays (FPAs) in ultra-violet to sub-millimeter wave spectral regions, with particular emphasis on the infrared region. Specific examples of areas of interest are:

a. Materials research, thin film growth, and device processing for fabricating multi-spectral detector arrays for active and passive sensors covering the major infrared bands.

b. Epitaxial growth processes for Group III-V and II-VI materials on compliant and non-compliant substrates (e.g. HgCdTe, GaAs, InGaAs, etc.) for detector and other optoelectronic applications.

c. Uncooled FPA technology and novel methods for determining FPA performance.

d. Computer simulation and modeling of single and multi-color detectors and systems.

e. Development of advanced readout circuits for tactical infrared detectors with large multispectral arrays.

Technical Point of Contact: Nibir Dhar, e-mail: nibir.dhar@us.army.mil (301) 394-0947.

2.8. Microwave Sensors. ARL is interested in radar models, techniques, concepts, algorithms, and hardware modules that support:

a. All-weather, wide-area detection, location, and recognition of stationary tactical ground targets that may be concealed in foliage and/or employing camouflage, concealment, and deception.

b. All-weather, wide-area detection, location, and discrimination of surface and near surface buried mines.

c. All-weather, wide area detection, location, and tracking of moving targets (e.g., personnel, tactical vehicles and low flying aircraft) from a ground-based, foliage penetrating sensor system.

d. All-weather, wide-area detection, location, tracking, and recognition of low radar cross-section (RCS) moving ground vehicles (in heavy clutter), low RCS hovering helicopters in defilade, and low RCS fixed-wing aircraft employing nap-of-the-Earth (NOE) flight profiles from an airborne real aperture sensor system.

Proposals are desired in support of ultra-wide frequency band (UWB) synthetic aperture radar (SAR) technology. In particular, research is desired in areas that address the technical obstacles associated with using a UWB SAR for the detection, location, and possibly classification of subsurface targets (ranging from near surface to deeply buried objects). Further, proposals are desired to support low frequency radar models, techniques and enabling component technology. The proposals may address such areas as:

a. Radar component technology, including wide-bandwidth/ low-frequency antennas, high-power transmitters, high-speed signal processors, and analog-to-digital converters.

b. Radio frequency interference (RFI) extraction/avoidance techniques.

c. Optimization of algorithm code.

d. Modeling to support subsurface detection in a variety of environments/soil conditions.

e. Improved means of estimating/measuring soil parameters, such as dielectric constant and conductivity for field experiments.

f. High-precision position location systems.

g. Motion compensation techniques and autofocus routines.

h. Beam-forming techniques.

i. Self-aligning and calibrating arrays.

j. Bistatic system concepts.

k. Target detection, tracking and classification algorithms.

Technical Point of Contact: Mr. Jeffrey Sichina, e-mail: jeff.sichina@us.army.mil , (301) 394-2530.

2.9. Electro-Optical Infrared (EO-IR) Image Processing. This topic addresses research interests in algorithmic development for target detection and identification based on EO-IR imagery, and other computational processes associated with these algorithms, such as clutter rejection and compression. The algorithms should improve the

ability to classify targets, increase the number of classifiable categories, and decrease the false alarm rate. Algorithms are needed for a variety of target detection/identification processes, including hyperspectral imagery, multispectral imagery, and networked or robotic imagery. These different types of imagery vary in resolution, wavelength, sensor type that can be exploited individually, or perhaps together in novel and useful ways. These algorithms when combined to form a consistently operating set of algorithms are called automatic or aided target recognition.

2.9.1. Algorithm methods. Early algorithms typically did not use information about specific target of scene characteristics when performing automatic target recognition (ATR) functions. New algorithms that exploit information about the scene or the targets need to be considered. There are several areas for potential ATR improvement that could be addressed:

(1) Model based ATR. Algorithms use knowledge, know a priori about the targets, scene, and sensor to perform one or more ATR functions.

(2) Knowledge-based ATR. These algorithms accomplish recognition through inferences from symbolic representations of the scene and environmental characteristics and knowledge of their interrelationship. Results of prior investigations have shown that poor scene feature classification was the most significant limiting factor for use of these techniques. Studies to extend scene classification algorithms by exploiting the increased information content of second and third generation imagery should be considered.

(3) Template matching. While this is strictly not a new technique, improvements in imagery and processing speed now make template matching more feasible. This technique was originally abandoned in the early days of forward-looking infrared (FLIR) development due to lack of image detail and slowness of processing templates. Template matching algorithms that use knowledge of the scene and sensor to reduce the number of matches could be considered.

(4) Novel approaches. There are a variety of concepts that have been suggested over the years that were not technologically feasible, but may be now. Such approached might include neural networks, genetic algorithms, optical processing, and novel processing. Also completely new approaches may be considered.

2.9.2. Multisensor ATR algorithms. The passive nature of FLIR ATR is frequently preferred in a battlefield scenario, however, the increased information content, and thus the increased potential performance of combinations of passive and active sensors, makes multisensor fusion approached worth investigation. Proposals for the development of algorithms providing fusion of FLIR imagery with one or more sensors, such as ladar, TV, or millimeter wave (MMW), will be considered if they represent a performance enhancement over current methods.
2.9.3. Hyperspectral ATR algorithms. Information content is highly multiplied by the increased spectral and spatial content of hyperspectral imagery. Special problems arise because of the large amounts of information. Novel methods by which to exploit the increased information content without sacrificing speed of computation are possible topics of research in this area.

2.9.4. Robotic or networked sensor ATR algorithms. Robotic and networked imagers may be somewhat different, but this research area emphasizes the use of simple algorithms that can give early indication of targets in the scene. The imagers typically are smaller and are of lower resolution than imagers considered for FLIR ATR or hyperspectral ATR. Information from different vantages may also be used for these types of sensors. Networked sensors may be of visible cameras, acoustic sensors, magnetic sensors, or any of a wide variety of sensors that can detect targets. Innovative use of these types of sensors to produce ATR will be considered.

2.9.5. Image and video compression. In digital battlefield video imagery is essential for real time monitoring and decision-making. However, real time transmission of video signal is a major problem that can be solved by using image compression techniques.

The current available RF channel [single-channel ground and airborne radio system (SINCGARS)] that the Army uses has a channel bandwidth of 4.8 Kbits/s that can be enhanced to 16 Kbits/s. The bandwidth of the SINCGARS channel is limited and suffers from high bit error rate (BER). Therefore, for real time transmission of FLIR video or transmission of synthetic aperture radar (SAR) imagery from an unmanned aerial vehicles (UAV) to a ground

station some sort of data compression and error correction techniques are needed. Typical wireless channels, such as the SINCGARS channel suffer from channel noise as well as fading errors.

Video compression techniques are also needed for missile cruisers that generate high frame rate video. Proposals to investigate and implement robust video compression algorithms for transmission of FLIR video and TV imagery are needed. Wireless channels are assumed and research will be conducted towards defining robust protocols for SINCGARS wireless channel. Forward Error Correction codes will be investigated as well as data packetization and error concealment methods. Examples of compression techniques that are of interest are two component-coding techniques, wavelet coding, and discrete cosine transform (DCT)-based compression techniques.

Technical Point of Contact: Dr. Patti Gillespie, e-mail: patti.gillespie@us.army.mil , (301) 394-1374.

2.10. Unattended Ground Sensor (UGS) Technology. Technology concepts, sensors, algorithms, and hardware modules that support:

a. Wide-area detection, localization, classification and identification of people, ground vehicles, aircraft, and ammunition fire (e.g., gunshots, mortar, artillery, etc).

b. Autonomous determination of accurate position, orientation, localization and field deployment of UGS.

c. Smart mine sensor field surveillance

c. Communication, networking and distributed fusion of information among various UGS nodes to provide robust ISR information

d. Remote control of UGS. Of particular interest are low-cost, low-powered, and small-sized hardware modules that implement the functions listed above.

These UGS should be capable of low-altitude air deployment. Issues relevant to variations in dispersion area, terrain, etc is critical.

Technical Point of Contact: Mr. Michael Kolodny, e-mail: michael.kolodny@us.army.mil , (301) 394-3110.

2.11. Acoustic Technology. Proposals are requested for technology in acoustic sensors and signal processing. Specific areas of interest include acoustic sensors and signal processing for beam forming, target tracking, target classification and identification, reduction of wind noise, reduction of platform noise, etc. Required detection capabilities include continuous sources (vehicles, aircraft, etc.) and impulsive sources (gun fire, artillery impacts, etc.). Other areas of interest include long-range hearing, auditory enhancement of individual soldiers, acoustic signature data collection techniques and equipment, acoustic propagation, novel data analysis techniques, and systems to employ acoustic sensors in new innovative ways.

Technical Point of Contact: Mr. Nino Srour, e-mail: nino.srour@us.army.mil , (301) 394-2623.

2.12. Sniper and Artillery Location Technology. Proposals are requested for research in sensor technology for detecting, tracking and locating the source of hostile small arms, artillery, rocket and mortar fire. Potential sensors include acoustic, seismic, radar, infrared, and ultra violet. Sensors proposed for this application should be capable of locating the source of enemy fire, and may include other data such as the distance of the miss, the type and number of rounds fired, etc. Source bearing accuracy of better than +/- 10 degrees is desirable.

For small arms, location of the firing source at ranges of 300 m and beyond is desirable. For mortar/artillery/rocket fire, location of likely firing positions despite intervening terrain or non-benign environmental conditions is of particular interest. The capability to locate the source of mortar firings at ranges greater than 2 km and artillery/ rocket firings at ranges greater than 10 km is desirable. Operation of sensors on individual soldiers, fixed sites, and moving vehicles are all of interest. Research into areas either directly addressing the sniper/mortar/artillery/rocket problem or supporting technologies will be considered.

Technical Points of Contact: Mr. Jerome Gerber, e-mail: Jerome.gerber@us.army.mil , (301) 394-2624 or Mr. Steve Tenney, e-mail: steve.tenney@us.army.mil , (301) 394-3080.

2.13. Field Tunable Radio Frequency (RF) Materials and Devices. The Army requires high performance, broadband frequency agile devices such as tunable filters, phase shifters and true-time delay devices that will help enable affordable single platform multi-mode electronic scanning RF systems for integrated sensors. We are looking for ways to meet Army requirements for frequency agile device performance and affordability through any technically reasonable approach that may include but is not limited to:

a. Development of higher performance field tunable (permittivity, permeability or their combination) materials.

b. Improved device designs and structures.

Technical Points of Contact: Dr. Steven Tidrow, e-mail: steven.tidrow@us.army.mil , (301) 394-3180 or Mr. Eric Adler, e-mail: eric.d.adler@us.army.mil , (301) 394-0933.

2.14. Synthetic Aperture Radar (SAR) Imaging and Image Exploitation. Research proposals are encouraged on novel techniques for human-in-the-loop and autonomous generation and exploitation of SAR. Imaging sensors for application during reconnaissance, surveillance, and target acquisition missions from manned and unmanned airborne platforms are of interest. Other areas of interest include algorithms and processing systems for automatic target recognition, terrain delimitation, scene analysis, image compression, image formation, image enhancement, presentation, visualization, and man-machine interface. Of particular interest are new approaches to demonstrate increased robustness against target variability, obscuration, camouflage, sensor geometry variation, and challenging clutter at high data rates for real-time implementation.

Technical Point of Contact: Mr. Edward Burke, e-mail: Edward.burke@us.army.mil , (301) 394-4375.

2.15. Novel Laser Sources. Research in this area involves new and novel laser sources. New laser sources include conventional lasing, minilasers, microcavity lasers, fiber lasers and wave-mixing techniques including quasi- phase matching, harmonic generation in new materials, and optical parametric oscillators. Laser sources include ultraviolet solid-state tunable lasers, visible tuneable lasers, 3 to 5-micron and/or 8 to 12-micron diode or solid-state sources, quasi-phase matching, tunable optical parametric oscillators (or difference frequency mixing), and new laser technologies that address high power, good beam divergence, and reliable output yet are low cost, efficient, and compact.

Technical Point of Contact: Dr. Bahram Zandi, e-mail: bahram.zandi@us.army.mil (301) 394-2091.

2.16. Traveling-Wave Tubes. The Army requires study and research in the areas of:

a. Design methodologies and advanced techniques for fabricating a K alpha-band lightweight, compact, high-power, low-noise, broadband, high- efficiency, high-duty, 0.5-kW traveling-wave tube (TWT). The device should be designed to meet all the performance requirements in a missile environment without failure, and it must have an extended dormant shelf life. A TWT must be fully operational in less than 5 s after application of heater voltages. The power conditioners for the TWT should be lightweight/compact and highly reliable, even after an extended shelf life. Components for both the TWT and power conditioner must meet the shelf-life goal of 10 years and still be capable of meeting the traveling-wave tube amplifier (TWTA) system operating requirements. Application of state-of-the-art component technology to meet the performance requirements of the TWT/power conditioner is encouraged.

b. Relatively small, high-peak/average RF power TWTs. These TWTs must also be lightweight and operate at relatively high efficiencies. Minimum characteristics to be met include peak/average RF power of 120 kW/10 kW in the S-band frequency range. Small, lightweight, air-cooled subsystems meeting the above characteristics are desired.

Technical Points of Contact: Mr. Romeo del Rosario, e-mail: romeo.delrosario@us.army.mil , (301) 394-3562 or Mr. Paul Fisher, e-mail: pete.fisher@us.army.mil , (732) 222-8687.

2.17. High-Power Vacuum Electronics RF Sources. The Army requires study and research in the areas of the following high-power vacuum electronics RF sources for electronic warfare (EW), countermeasures, communications, and radar systems; Klystrons, traveling-wave tubes, extended interaction oscillators, extended interaction amplifiers, backward-wave oscillators, microwave power modules, millimeter power modules and crossed field amplifiers. Solutions are sought for the above vacuum electronic RF sources with regard to the following characteristics: compact size and low weight, improved high reliability, low cost, increased life, reproducibility, reparability and simplicity of fabrication, long shelf life, broad bandwidth (or tunability), high power, high efficiency, high gain, high voltage stand-off capability and low noise. Proposed RF source designs must show the potential for meeting one or more of the above requirements. Solutions are also sought for test and evaluation techniques for the characteristics listed. Innovative simulation/computer techniques for the proposed design approaches are encouraged.

Technical Points of Contact: Mr. Romeo del Rosario, e-mail: romeo.delrosario@us.army.mil (301) 394-3562 or Mr. Paul Fisher, e-mail: pete.fisher@us.army.mil , (732) 222-8687.

2.18 Emerging Electronic Technologies Investigations. The Army requires research investigations into electronic materials, devices, and components, and relevant basic physics studies, including studies that couple electrical, magnetic, and optical fields with mechanical (elastic) fields. These are needed to ensure that the integration and interfacing of new materials and components into electronic systems will result in the improved system performance required for carrying out complex military missions. The SEDD is interested in receiving novel proposals that address the technical barriers associated with improving the current state of the art in electronic materials, devices, and components used as sensors, actuators, and micro-mechanical structures. Technical areas of interest include, but are not limited to, the following:

a. Phonic/physical optic studies that impact optical processors, switches, and opto-electronic integrated circuits.

b. Investigation of semiconductor and ceramic material parameters, including gallium arsenide (GaAs) and indium phosphide (InP), and the use of sophisticated film preparation tools, such as metallo-organic chemical vapor deposition (MOCVD) and molecular beam epitaxy.

c. Studies of solid-state diffusion, including thin films.

d. Nanoelectronic investigation, including the physics of superlattices and quantum wells.

e. Fault analysis of electronic devices and components.

f. Theoretical and experimental studies of electro-mechanical interactions in solids.

g. Studies of micro-mechanics that impact electronic/photonic devices.

h. Investigation of dielectric, and ceramic material parameters, including ferroelectric, pyroelectric, piezoelectric, and elastic properties.

Technical Point of Contact: Dr. Stefan Svensson, e-mail: Stefan.svensson@us.army.mil , (301) 935-6969 or (301) 394-5429.

2.19. Novel and Highly Scalable Diode-Pumped Solid State Lasers

a. Novel Solid State Lasers and Laser Materials: he Army is interested in research of innovative gain media, for example laser-quality ceramics; broad-gain media for frequency agile lasers in UV, NIR and Mid-IR; efficient solid-state materials for stimulated Brillouin scattering, e.g., low threshold, high reflectivity, low sound propagation speed; specialty fibers and fiber lasers suitable for high average powers and power scaling; laser materials for diode-pumped, eyesafe lasers.

b. 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; passive and active laser beam/aperture combining methods; laser wavelength shifting techniques for achieving high average powers with optimum eyesafety; active and passive wavefront distortion compensating/OPD reducing techniques.

Technical Points of Contact: Dr. Larry Merkle, e-mail: larry.d.merkle@us.army.mil , (301) 394-0941 or Dr. Mark Dubinskii, e-mail: mark.dubinskiy@us.army.mil, (301) 394-1821.

2.20. Three-Dimensional Microcircuit Packaging. The Army has a requirement for a new, three-dimensional (3-D) packaging approach for integrated micro-circuits to reduce size and weight and to improve electrical and thermal performance of ultra-large-scale-integration (ULSI) modules. Size, speed, and processing capability require advanced multichip packaging, using hybrid or monolithic wafer-scale integration (WSI) with 3-D wafer interconnection and assembly. The resulting multichip module must meet military environmental requirements, as well as exhibit high-speed electrical and high-power thermal characteristics. Future modules of this type will be used for ULSI, application-specific integrated circuits (ASIC), and ultra large integrated circuit (ULSIC) chips applied to DoD electronic systems. Proposals are desired that address new, advanced, high-density 3-D packaging and interconnection schemes for use in multi-chip modules, with an emphasis on the use of silicon or other dielectric materials as the substrate/wafer. Potential applications for use in military electronics should be addressed and specific system needs should be included. The 3-D multichip packaging technology developed must be reliable in the military environment. The government will consider proposals that provide for the design, fabrication, and demonstration of proof-of-principle experimental 3-D microcircuit packages.

Technical Point of Contact: Mr. Albert Lee, e-mail: albert.lee1@us.army.mil , (301) 394-2800.

2.21. Microwave Device and Analog Signal Processing Research and Development. The Army requires improved microwave devices that are reliable and cost effective, as well as lightweight, reliable signal processing components to handle large volumes of data on a real-time basis. Desired are novel proposals that address the technical barriers associated with improving the state of the art of such devices and components. Technical areas of interest include the following:

a. Physics-based modeling of microwave devices, components, packages, and radiating structures using semiconductor analysis and computational electromagnetics.

b. The research and/or novel application of low-cost analog signal processing components based on acoustic wave technology, acoustic charge transport, magnetostatic waves, or high-temperature superconducting materials, either singly or in combination.

c. Emphasis should be directed toward achieving larger bandwidth, reducing insertion loss, or lowering fabrication costs.

Technical Point of Contact: Dr. Chris Fazi, e-mail: Christian.fazi@us.army.mil , (301) 394-3011.

2.22. Frequency Control. The Army requires study and research of frequency control device technology since the accuracy and stability of RF sources and clocks are key determinants of the performance of radar, C3I, navigation surveillance, EW, missile guidance, IFF systems and sensors.

a. High purity quartz and new piezoelectric materials.
b. Gun Hardened RF oscillators and clocks for smart munitions.

c. Low-noise vibration resistant RF sources and clocks for FCS systems radar, communications, navigation surveillance, EW, missile guidance, IFF and sensors.

d. Low-jitter clocks and low phase noise RF sources from HF (1 MHz) to W-band (100GHz).

e. Resonator theory, modeling and computer aided design of resonators and oscillators. Including 3-d finite element of resonators with improved algorithms to reduce super computer calculation times.

f. Processing and packaging of high stability resonators and RF sources, including mode suppressant techniques to limit degradation of filters and RF sources, mounted in below cut-off wavelength size modules.

g. Resonators and oscillator theory leading to optimum performance.

h. Ultra-low-noise measurement techniques of SAW and bulk resonators, piezoelectric material parameters calculation, modeling and measurement, diagnostic analysis and probing techniques, including fundamental noise studies involving 1/f noise.

i. Thin film piezoelectric resonators and micro-resonators (MMIC compatible) for resonators filters and RF sources.

j. Hardware and software development of low power, high-stability clocks.

k. Design of miniature low loss (<2dB) piezoelectric resonators for compact size, narrow bandwidth bandpass filters (.01%-5%).

Technical Points of Contact: Dr. Chris Fazi, e-mail: Christian.fazi@us.army.mil , (301) 394-3011; Dr. Steve Tidrow, e-mail: steven.tidrow@us.army.mil , (301) 394-1801; or Mr. Mike Patterson, e-mail: mike.s.patterson@us.army.mil , (301) 394-6000.

2.23. Development of Multi-Spectral Low-Observable Material*. There is an interest for proposals that encompass multi-spectral low-observable material. This material, both structural and non-structural, shall exhibit absorptive, reflective, and/or transmissive characteristics (both wide and narrow band) as a function of wavelength frequency. The problems of inexpensive application and durability in the Army environment are of interest.

Technical Point of Contact: Dr. Donald Snider, e-mail: Donald.e.snider@us.army.mil , (301) 394-5166.
*For additional security information: Ms. Flo Boswell, e-mail: flo.e.boswell@us.army.mil , (301) 394-3863.

2.24. Temperature Control and Heat Transfer (Low Observable)*. Proposals are requested that examine innovative methods to control the radiant power from vehicles and aircraft by modification of radiometric properties and/or heat transfer control of internal combustion engines and heat-producing machinery. The electromagnetic (EM) region of interest is 16 to 2.0 microns.

Technical Point of Contact: Dr. Donald Snider, e-mail: (301) 394-5166 Donald.e.snider@us.army.mil
*For additional security information: Ms. Flo Boswell, e-mail: flo.e.boswell@us.army.mil (301) 394-3863.

2.25. Visual Signatures (Low Observables)*. Proposals are requested that examine methods to reduce the visual and near infrared (NIR) signature of ground and air vehicles using either active or passive methods or a combination.

Technical Point of Contact: Dr. Donald Snider, e-mail: Donald.e.snider@us.army.mil (301) 394-5166.
*For additional security information: Ms. Flo Boswell, e-mail: flo.e.boswell@us.army.mil (301) 394-3863.
2.26. Mathematical Simulators (Low Observables)*. There is an interest for proposals for modeling the effectiveness of signature-reduction applications and proposed applications in the visible, infrared, and radar portions of the EM spectrum and in the acoustic regime for various Army systems, including ground vehicles, aircraft, tactical units, etc.

Technical Point of Contact: Dr. Donald Snider, e-mail: Donald.e.snider@us.army.mil (301) 394-5166.
*For additional security information: Ms. Flo Boswell, e-mail: flo.e.boswell@us.army.mil, (301) 394-3863.

2.27. Technology Integration of Low Observables*. There is an interest for proposals that examine the effectiveness of incorporating low-observable (LO/CLO) technology into current and planned Army systems. Interest is in both air and ground systems.

Technical Point of Contact: Dr. Donald Snider, e-mail: Donald.e.snider@us.army.mil, (301) 394-5166.
*For additional security information: Ms. Flo Boswell, e-mail:, flo.e.boswell@us.army.mil (301) 394-3863.

2.28. Measuring Reduction Effectiveness (Low Observables)*. Proposals are requested for engineering measurement techniques and systems that would be effective for the development and evaluation testing of signature-reduction technology. Measurements are needed in the visual, infrared, and RF portions of the EM spectrum, as detailed in techniques.

Technical Point of Contact: Dr. Donald Snider, e-mail: Donald.e.snider@us.army.mil, (301) 394-5166.
*For additional security information: Ms. Flo Boswell, e-mail: flo.e.boswell@us.army.mil, (301) 394-3863.

2.29 Sound and Vibration (Low Observables)*. Proposals are requested that examine acoustic damping, both carrier wave and modulations of generated acoustic spectra. Applications are for ground vehicles, engine generators, and aircraft.

2.30 Countering Low Observables*. Proposals are requested that examine technologies to counter reduced-signature military systems, aircraft and ground vehicles. All areas of the EM spectrum are of interest.

Technical Point of Contact: Dr. Donald Snider, e-mail Donald.e.snider@us.army.mil:, (301) 394-5166.
*For additional security information: Ms. Flo Boswell, e-mail: flo.e.boswell@us.army.mil (301) 394-3863.

2.31. Software Implementation (Low Observable)*. Proposals are requested that examine existing and proposed software programs involving technology and/or security interfaces with low-observable work. Interest lies in upgrading existing programs as required by higher headquarters and developing new low-observable programs as the technology demands.

Technical Point of Contact: Dr. Donald Snider, e-mail: Donald.e.snider@us.army.mil (301) 394-5166.
*For additional security information: Ms. Flo Boswell, e-mail: flo.e.boswell@us.army.mil (301) 394-3863.

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

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

b. Circuit design and fabrication of highly-efficient Si-based and SiC- or GaN-based high-temperature power electronics for power conversion and motor-control applications.

c. Circuit simulation to allow topology and device trade off studies for the design of high-temperature power conversion circuits for specific Army Future Combat Systems applications.

d. Production of high-temperature high-field insulator materials for use as gate dielectric and field passivation layers for application to SiC and/or GaN power devices.

e. High-temperature packaging and thermal management systems for wide bandgap power electronics (Tj = 225 to 400 C).

Technical Point of Contact: Mr. Skip Scozzie, e-mail: charles.sscozzie@us.army.mil , (301) 394-5211.

2.33. Directed Energy. ARL is the designated leader for the Army's directed-energy weapon (DEW) technology base program. This includes high-power microwave (HPM), non-nuclear electromagnetic pulse (EMP) (NNEMP), e-beam/x-ray, and high-power acoustics and air pressure waves. ARL has a continuing interest in a broad spectrum of research in these areas, including:

a. A better understanding of the susceptibility of developmental and fielded systems to attack by an RF DEW

threat.

b. Improved methods and technologies for hardening systems against that threat.

c. The development of new components (sources, pulsers, and antennas) for possible future application in an RF weapon system:

(1) Generation of microwave power/energy--Novel pulsers/sources are needed that have programmable pulse characteristics so that rise time, pulse width, repetition rate and frequency bandwidth can be changed electronically, along with frequency-sweeping capability over octave bandwidths. Design considerations of low-cost compactness and high efficiency are of particular interest. Switch technologies that convert dc to RF directly with picosecond rise time capability are of interest. Radio frequency oscillators/amplifiers that use picosecond electronics to obtain programmable RF outputs are desired, along with picosecond RF exiters to drive amplifiers. Portable kilowatt and megawatt RF/microwave amplifiers with octave bandwidths are sought. Frequencies of interest are from 0.3 to 10 GHz, with microsecond pulse durations and high duty cycles. Efficiencies should exceed 30 percent and gain should exceed 30 dB. Novel technologies that are suitable to extend high-power pulse amplifiers to 40 GHz or higher are also sought. Bandwidths should be multi-gigahertz and gains should exceed 20 dB. Emphasis will be placed on efficiency, compactness, and portability.

(2) High-power (gigawatt-power) levels--Antennas are needed that can efficiently radiate ultra broadband and narrowband RF energy. Compact antennas are of interest that are small compared to the low-frequency wavelength and can be shaped in conformal configuration. Mode converters that can operate up to gigawatt levels are needed. Compact modulators capable of driving up to gigawatt sources at several kilohertz pulse repetition rate with impedances of 10 to 200 ohms and pulse lengths up to a few microseconds are also of interest. Research that increases our understanding of HPM antennas, mode converters, and modulators is sought.

(3) The effects of RF and microwave power/energy--Material susceptibility are the primary area of concern. Included are composite materials, electro-optical systems, computers, communications, displays, receivers, sensors, monolithic microwave integrated circuits (MMIC), very high speed integrated circuits (VHSIC), and other sophisticated electronic systems, subsystems, and devices. Upset and damage to electronic devices and their failure mechanisms, caused by RF transients, are of interest. RF coupling and failure mechanisms that are affected by such parameters as frequency, pulse width and shape, repetition rate, amplitude, and polarization are also of interest. Novel schemes are solicited for techniques that can be used for protection against the RF and HPM threats. Advanced methods and techniques are needed for housing composite materials. Methods for the theoretical understanding and prediction of RF effects from transients with a wide range of pulse characteristics are of great interest.

(4) Hardening to RF energy--Army system survivability is enhanced using hardening techniques that are readily verifiable, reliable, and maintainable in the RF environment. ARL needs improved interactive models that yield statistical parameters of the source/system environment for complex scenarios. Models are sought that are suitable for understanding the mechanisms of device susceptibility and leading to improved devices. Detailed models have been developed that use excessive computer resources. New approximate techniques need to be developed to readily accommodate complex scenarios. Models are needed for composite materials, including both resistive and inductive effects. Innovative techniques for hardening front- and back-door entry ports of systems are sought. Hardening includes techniques to limit the throughput of the path or to raise the susceptibility threshold of devices subject to burnout or upset from RF energy. Hardening devices are of interest that:

a. Can handle large average and peak powers.

b. Can limit or switch unwanted HPMs in protecting the system or subsystem.

c. Have frequency and amplitude selectivity. Vacuum microelectronics, semiconductor, and magnetic technologies are all of interest.

(5) RF microwave diagnostics--Novel, non-perturbing RF/microwave diagnostics are sought. Such devices should be able to measure RF/microwave power for microsecond durations and have rise times in the 0.1- to 10-ns

range. The diagnostics should be mountable inside enclosures near complex structures. High-frequency probes that can operate above 2 GHz are also of interest. Quality measuring techniques are needed for seams, joints, and contracts for composite materials. The Army has a great interest in testing military systems in a microwave environment. Research topics related to the Army's system testing effort include instrumentation and measurements, anechoic chamber design and characterization, microwave source development, novel testing techniques to allow a military system to be quickly evaluated in a microwave environment, experimentation to determine microwave effects, modulations of microwave signals, and high-power sources.

(6) Battlefield effectiveness of RF-DEW--The Army, as well as DoD in general, is involved in the impact of RF effects on the battlefield. Novel approaches are sought to develop techniques/models that can describe the effects of system degradation on battlefield systems and how the systems may impact the outcome of the battlefield-appropriate measures of effectiveness must be defined for various types of weapons and sensors that could be affected by RF energy.

(7) Air pressure waves (acoustics, vortex ring, etc.) DEWs/KEWs--The Army has a need for tunable DEWs, KEWS and hybrid DEWs/KEWs that are effective against personnel targets. High-power acoustic and vortex ring weapons are needed that are tunable to achieve the desired target effect at close in ranges (<25-meters) and extended ranges (>25-meters out to a kilometer). Research is needed to develop techniques that can effectively, efficiently, and safely deliver agents and pressure wave impulses to the target with minimal fratricide. Advanced non-lethal techniques are needed for crowd control; to stop riots, criminals, and terrorists; and to assist law enforcement agencies in combating illegal drugs and illegal immigrants. The military has a need for these non-lethal weapons to conduct military operations during war and other than war.

Technical Point of Contact: Dr. Al Kehs, e-mail: r.kehs@us.army.mil , (301) 394-2291.

2.34 Wide Band Gap Electronic Devices. We are interested in the high power, high temperature devices especially for electric drive systems. Currently, we are working on SiC gate turn off (GTO) thyristors for the short term and MIS controlled devices such as the MIS controlled thyristor (MCT) or the insulated gate bipolar transistor (IGBT). We are working on determining the proper design through modeling, and are developing the appropriate technologies such as implant activation, contracting, and etching. We are also making detailed studies of the insulators on SiC as well as the SiC-insulator interface.

We are also interested in high power, high frequency devices especially for multifunction applications such as radar and communications. We are also interested in the materials technology for growing GaN/AlGaN device structures and processing them into devices. This includes optimizing the growth conditions in our MOCVD reactor, and developing the appropriate technologies such as implant activation, contacting, and etching.

Technical Point of Contact: Dr. Kenneth A. Jones, e-mail: ken.a.jones@us.army.mil , (301) 394-2005.

2.35. RF Devices. The ARL is interested in research on innovative electronic materials and devices for RF applications. Work should involve new III–V and III-nitride materials, novel III-V materials growth technology, or novel device fabrication and integration.

Technical Point of Contact: Dr. Alfred Hung email: Alfred.hung@us.army.mil (301) 394-2997.

2.36. Next Generation Digital Imaging. The ARL is actively engaged in research leading to next generation digital imaging systems. Although several critical technologies, including image collection optics, solid state detectors, digital post-detection processing, and image display, impact critically the performance of digital imaging systems, traditional approaches to specifying these components for such systems do not pay sufficient attention to the interplay between them and the subsequent impact that has on overall system performance. In contrast, our integrated approach optimizes the design of the component technologies in parallel. Such an approach provides improved performance while also addressing size, weight, cost and power issues. Recent developments in detector technology, computational capabilities, and the manufacture of optical surfaces facilitate an integrated imaging design approach. We are interested in proposals that address two or more of the following topics: image

reconstruction, aspheric optical design, information theoretic imaging metrics and numerical optimization techniques.

Technical Point of Contact: Dr. Joseph Mait, (301) 394-2462.

2.37. RF Electronics. Research proposals are requested for electronic sensor devices, modules, and technology for signal generation, amplification, transmission, reception, control and processing. Perform research and development on electronic/optical and quasi-optical devices that will enable future Army C4I systems. Specific areas of interest include:

a. High frequency devices and modules to enhance situational analysis and increase the communication functionality of Army land forces.

b. Low power, high accuracy frequency control devices for navigation and communication systems.

c. Novel RF acoustics and microwave/millimeter wave electron beam devices to enable smart artillery rounds, improved IFF, improved acquisition of slow moving targets and portable chemical sensors.

Technical Point of Contact: Mr. Michael Patterson, e-mail: mike.s.patterson@us.army.mil , (301) 394-0923.

2.38. Hyperspectral/Multispectral Imaging. The ARL is engaged in the research and development in the design and development of high performance hyperspectral and multispectral imaging systems from the vacuum ultraviolet (UV) to the long wave infrared (LWIR). The present approach is based on using no-moving-parts acousto-optic tunable filters (AOTFs) with high sensitivity focal plane arrays. Developing high performance hyperspectral/multispectral imager technology is critical for the Army's needs in target detection including buried mine detection as well as for chemical and biological agent detection. Technologies based on diffractive optics, Fabry Perot etalon, liquid crystal, and other promising approaches are also of interest. The particular area of interest is research of novel collinear and noncollinear AOTFs operating from UV to LWIR. The range of applications includes spectroscopic remote sensing of biological and chemical agents, pollution monitoring, detection of plumes, condition-based management, and polarization imaging for detection of targets and backgrounds, etc. Growth of a variety of nonlinear birefringent materials with high acousto-optic figure-of-merit useful for designing broadband AOTF cells is also of considerable interest. System designs for compact automated AOTF spectrometers from UV to long IR incorporating suitable detectors, optics, and processing software and spectropolarimetric imaging systems incorporating electronically tunable variable retarders, suitable focal plane arrays, image collection and processing and on chip preprocessing capabilities that would improve the noise equivalent spectral radiance (NESR) of such imagers are of critical interest. Research in automatic processing algorithms for spectroscopic and spectropolarimetric imaging data including data storage techniques and data compression is encouraged for detection of biological and chemical agents, and target and backgrounds. Parameters of interest include efficient spectral dispersing elements, more efficient transducer designs, AOTF cell designs, design of AOTF cells and transducers to facilitate operation over two or more octaves in frequency, and design and fabrication of electronically tunable compact polarizing elements, higher sensitivity focal plane arrays, dynamic range, readout speed, compact packaging of such imagers, etc.

Technical Point of Contact: Dr. Neelam Gupta, e-mail: neelam.gupta@us.army.mil (301) 394-2451.

2.39 Luminescent Materials and Devices for Displays. The ARL requires research investigations into luminescent materials, devices, and components, and relevant basic physics studies that couple luminescence, electrical, optical and mechanical properties of these materials and devices. Research and study are needed to ensure that the displays available for the current and new systems will provide improved performance that is required to carry out complex military missions. The SEDD is interested in receiving novel proposals that address the technical barriers associated with improving the current state of the art in luminescent materials, devices, and components used as the basis for the display technology in Army systems. Technical areas of interest include, but are not limited to, the following:

a. Theoretical and experimental studies of luminescence including electroluminescence, (organic and inorganic) cathodoluminescence, and photoluminescence.

b. Investigations on the materials, devices, and tools that will lead to the development of displays on flexible substrates.

c. Studies of micro-mechanics that impact display devices.

d. Investigation of light modulation materials and devices.

Technical Point of Contact: Dr. Dave Morton, e-mail: david.morton1@us.army.mil , (301) 394-1916.

2.40. Nonlinear Optics. The ARL requires research investigations and proposals in nonlinear optical (NLO) materials, components and devices that can reduce their optical transmission across the visible and NIR (400-900nm) wavelength range passively when subjected to an incident laser beam within that wavelength range. Reductions of optical transmission on the order of 1000X or greater is desired. The speed at which such materials, components, or devices switch from transmissive to non-transmissive states needs to be on the order of <1ns. Materials and devices must be highly transmissive in the initial state. Concepts need to be able to be incorporated into low F/# optical viewing systems, yet must not greatly impact the normal performance of those systems. Technical areas of interest include, but are not limited to, the following:

a. Development of optical materials with large nonlinearities and a broad wavelength and/or pulsewidth response. This can include molecular modeling, material synthesis, and characterization of nonlinear parameters as well as nonlinear transmission studies.

b. 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.

c. Development of optical viewing systems and components that incorporate the materials and devices above.

Proposals utilizing solutions other than NLO materials that suggest novel methods of reducing transmission will also be considered.

Technical Point of Contact: Mr. Andy Mott, e-mail: Andrew.mott@us.army.mil , (301) 394-0942.

2.41. Micro-Devices and Micro-electromechanical Systems (MEMS). Topics of interest include research in material growth, processing, fabrication, and analysis of advanced electronic devices. Proposals are requested on scientific and applications studies as well as modeling, simulation and integration of these devices into circuits and arrays for low cost miniature battlefield sensor and communication systems. Device applications include ground/foliage penetrating and all-weather radar, electronic intelligence, navigation and countermeasures, light weight power sources and high temperature operation. Specific areas of interest include:

a. Micro-electromechanical Systems (MEMS).

b. Advancement of device fabrication technology for MEMS devices with Army applications, i.e., acoustic, pressure sensing, fusing, inertial guidance, and others.

Technical Point of Contact: Dr. Madan Dubey, e-mail: madan.dubey@us.army.mil , (301) 394-1186.

2.42. Environmental Monitoring Utilizing Biological/Biomolecular Processes Cellular and Subcellular Bioelectronics. With the advent of modern advances in biotechnology based on biochemistry, cellular and molecular biology, processes and functions that are normally associated with living organisms are being exploited for practical applications in fields as diverse as electronic devices and the computer technology. ARL seeks to research this interfacial technology for biomedical, biopsychophysical, biocomputation, and biodefense applications for the soldier. Bio-machinery and bioprocesses provided naturally by a cell or a sub cellular component are not only the most efficient, but their end results are also physiologically relevant, and these attributes cannot be matched by present-day inorganic devices and/or digital information processing technology. The goal of this BAA objective is to exploit these bioprocesses for applications such as using them as a central processing unit for intelligent

analysis and computation, and to interface these bioprocesses with microelectronic systems comprising micro-fluidic input of environmental factors, multi-array microelectrodes, micro-patterned biocomponent networks, and electrochemical assays of responses to the stimuli for the output of the system. Integration of these subcomponents will be assisted by recent advances in Bio-Micro/Nano-Electro-Mechanical Systems (Bio-MEMS and Bio-NEMS) technology. Constructing the sub-systems for the final architecture of a bioelectronic device (for example: a physiomic chip) may include researching for a viable, physiologically relevant, and multi-capacity (for sensing and analyses) cellular or subcellular component ranging from whole cells to organelles to biomolecular complexes, developing modes of inputs utilizing micro-fluidics technology, developing modes of outputs based on assay methods and modes of signal integration carried out by novel electronic circuitry (for example, VLSI technology), and developing bioprocess-compatible computational algorithms.

Technical Point of Contact: Dr. Tommy Wong, e-mail: tommy.wong@us.army.mil , (301) 394-0060.

2.43. Electrochemical Power Production and Energy Storage. The areas of technology of interest to ARL are:

2.43.1. Active and Reserve Primary Batteries for Munitions Applications: Research of battery chemistries and battery designs capable of supplying power densities from 20 to 400 W/liter after 10 or more years of storage. Storage and use are required over the full military temperature range.

2.43.2. Electrochemical Capacitors: Research of chemistries for capacitors capable of supplying specific power and energies upwards of 1 kW/kg and 4 Wh/kg in small sizes for man portable applications and in large sizes for vehicular applications.

2.43.3. Primary Lithium Batteries: Research of battery chemistries for cells and stacks of cells for man-portable applications, using environmentally-friendly materials and capable of providing better service than the Army's present general-purpose Li/SO2 battery. Emphasis on modification of commercially-based chemistries to permit soft-packaging and all-weather storage and use.

2.43.4. Rechargeable Li (Li Ion) Batteries: Research of chemistries for cells and stacks of cells using liquid or polymeric electrolytes and capable of providing specific energies greater than 120 Whr/kg, steady specific power greater than 50 W/kg, continuous and greater than 1kW/kg pulse, over the full military temperature range. Development of manufacturing technology for such batteries.

2.43.5. Fuel Cells: Research of improved protonic membranes and electrocatalysts for use with methanol-fueled systems, hydrogen generators and fuel reformers for use with hydrogen-fueled systems. Development of hydrocarbon fuel reformers and reformer components to provide hydrogen for fuel cells. Development of medium and high temperature fuel cells and components for the direct utilization of hydrocarbon fuels or of impure hydrogen.

2.43.6. Fast-Rise Pulse Power Capacitors: Research of film capacitor technology including the development of high energy dielectric films, impregnants, metallization and manufacturing technology for capacitors that can provide energy densities > 1 J/cc. And rise-times in the microsecond range.

Technical Point of Contact: Dr. Sol Gilman, e-mail: sol.gilman@us.army.mil, (301) 394-0339.

2.44. Electric Field Sensor Technology. Research proposals are desired that are related to small, rugged, low-power electric 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).

They 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, UAV/MAVs, 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 signal processing and communications capabilities, and should operate unattended for weeks or months after deployment. 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 related to the subject technology are also desired, to the extent that they are applicable to standalone sensors that can be used in proximity fuzes, small-unit training and simulation devices, etc. In this case, sensors may operate for a much shorter period of time (typically seconds to hours), so extremely low-power operation is less important, and the final sensor output may be qualitative (yes/no).

Proposals will be accepted in five areas:

a. Research on novel electric field sensor concepts leading to quantification of detection distance(s) for various classes of targets.

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

c. Research related to filtering and/or signal processing techniques, which are expected to improve the detectability of targets in a battlefield environment.

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

e. Research of prototype design(s) of individual electric field sensors suitable for detecting tactically significant targets in battlefield environment.

There are several related topics in this BAA that are intended to complement each other. Proposals that focus on magnetic sensing should be submitted against the "Magnetic Sensor Technology" topic. Proposals that focus on low-cost sensor systems should be submitted against the "Disposable Sensor Technology" topic.

Technical Point of Contact: Mr. David M. Hull, e-mail Hull@ds.arl.army.mil 301-394-3140.

2.45. RF Wide Band Gap Semiconductors/Devices. We are interested in understanding the modeling requirements for heterojunction devices, such as HBT's and pHEMTs. The modeling issues involve high-field transport and space charge effects to predict intermodulation products and noise issues (in particular 1/f noise). The research is both theoretical and experimental, leading to the understanding of device parameter limitations. The tasks involve microwave CAD, microelectronics fabrication and microwave instrumentation and measurements. We are also interested in high temperature/high power electronic devices in SiC or other wide band gap materials. Devices support electric drive applications for Army vehicles operating in extreme environments.

Technical Point of Contact: Dr. Stefan Svensson, e-mail: Stefan.svensson@us.army.mil , (301) 935-6969 or (301) 394-5429.

2.46. Millimeter Wave (MMW) Phenomenology. The Army has an interest in the basic phenomenology of targets and clutter at MMW frequencies for passive and active sensors. Concepts for the precise measurement and characterization of clutter and targets are sought. Some of the problems to be solved are the rejection of multipath, calibration issues, ground truth issues, measurement clutter rejection, polarization purity, near field issues and other

measurement issues.

Technical Point of Contact: Mr. Edward Burke, e-mail: Edward.burke@us.army.mil , (301) 394-4375.

2.47. Electronically Scanned Antennas. The Army has an interest in the low cost, high performance electronically scanned antennas at MMW frequencies. Specific areas of interest are broadband antenna elements, low loss phase shifters, low loss delay lines, true time delay architectures, low loss splitters and combiners, planar technologies, issues associated with polarization switching, low loss, high performance switches, simultaneous multiple beam formation, and high performance design tools.

Technical Point of Contact: Mr. Edward Burke, e-mail: Edward.burke@us.army.mil , (301) 394-4375.

2.48. RF Radiometry. The Army has an interest in RF radiometry for the detection of military vehicles, mines, obstacle avoidance, wire detection and navigation. Specific areas of interest include MMW radiometry, synthetic aperture radiometry, interferometric radiometry, low noise amplifiers, calibration techniques, super resolution techniques, sparse antenna arrays, motion compensation, signal processing and target and clutter models.

Technical Point of Contact: Mr. Edward Burke, e-mail: Edward.burke@us.army.mil, (301) 394-4375.

2.49. Multi-Function Radio Frequency Technologies. The Army has an interest in researching affordable shared aperture, single system architectures which implement radar, radiometric, combat ID, command and control, target acquisition, communications, and signals intelligence (SIGINT) functions. Supporting technologies include, but are not limited to, wide bandwidth antennas, e-scan antennas, multi-beam antennas, wide-bandwidth RF components and modules (LNA's, PA's, Mixers), digital receiver technology, high performance A/D converters, high performance filters, programmable synthesizers, signal processing architectures, signal processing algorithms, innovative waveforms and waveform management. Ka band solutions are of particular interest.

Technical Point of Contact: Mr. Edward Burke, e-mail Edward.burke@us.army.mil:, (301) 394-4375.

2.50. Power Conditioning and Sources. 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 Army applications. High efficiency and high temperature operation (for reduced cooling) are also critical requirements. Some specific areas of interest include:

a. Novel power converters such as matrix converters.

b. Novel dielectric and insulating materials.

c. Intermediate energy storage devices and techniques.

d. High performance components such as switches and capacitors.

e. PFNs for electric guns, directed energy, electromagnetic armor and other high power loads.

f. Novel power sources.

Technical Point of Contact: Dr. Al Kehs, e-mail: r.kehs@us.army.mil , (301) 394-2291.

2.51. Antimonide Materials Research. The antimonide materials research program includes R&D efforts aimed at developing interband cascade lasers emitting in the 3 - 5 micron band, and interband IR detectors in both the 3 - 5 and 8 – 12 micron region. Present efforts are based upon MBE-growth of InAs/InGaSb/AlSb heterostructures on GaSb substrates. Proposals that address specific goals relating to the research of these devices are welcome and will be seriously considered. We are particularly interested in proposals that involve device fabrication and testing. We are also interested in theoretical work aimed at optimizing device designs.

Technical Point of Contact: Dr. Richard Tober, e-mail: richard.tober@us.army.mil, (301) 394-5756.

2.52. Environmental Sensing of Chemical and Biological Substances. The ARL is exploring new detection technologies for environmental sensing. The ultimate goal is to develop research that leads to sensors (both point and standoff) of chemical and biological substances for field use. The areas of potential application include, but are not limited to, chemical and biological substances in the atmosphere, natural and background interferents, water and food quality monitoring, chemical and biological agent detection and identification, medical surveillance, infrastructure protection, electronic nose development, and battlefield applications, such as mine detection. 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 two key components of any sensor are transduction of the probe response and biologically or chemically specific recognition probes. Our current research interests include development of both point and remote sensing for chemical and biological species using optical transduction. The desired sensor technology is not limited to optical methods, but may use electrochemical, mechanical or other detection methods. The crucial element of the sensor technology is in the specificity of the biological or molecular recognition of the target material. Recognition technologies include, but are not limited to, spectroscopic identification, molecular imprinting, immunoassay, DNA hybridization methods, and molecular beacon methods. Optical technologies include, but are not limited to, new sources for sensors, novel detectors, fiber optics, interferometry, non-linear optics, photonics devices, Raman techniques, and fluorescence. Other aspects of environmental sensors of interest are: aerosol sampling research, coatings for sensor elements, and modeling—to include systems performance modeling and simulation modeling for detection of chemical and biological substances.

Technical Point of Contact: Dr. James B. Gillespie, e-mail: james.gillesp@us.army.mil , (301) 394-1880.

2.53. Countermeasures to Biological and Chemical Threats. The perception by a military unit that chemical or biological agents have been deployed by an adversary seriously compromises their combat capability. Developments in the continental US (CONUS) and the international scene have alerted the defense community to the threat of biological and chemical agents on civilian and military populations. Operation Desert Shield and Desert Storm yielded new understanding regarding the effect of a perceived chemical/biological (CB) threat on social and military organization. The events associated with the Aum Shin Rykyo movement in Japan revealed the potential capability of non-nation state terrorist groups to mount a serious threat. The need for an organizational structure that effectively and seamlessly provides coordination among the response agencies (local community first responders, DoJ, FEMA, DoD) was identified for further development.

In the event of an actual CB attack, the components needed for a successful response include persons with expertise in the scientific validation of an incident (e.g. development of tools to capture and concentrate air and liquid samples, rapid multi-array sensors, establishing a relevant data base, data fusion, data presentation); physical and medical countermeasures (technologies for the rapid diagnosis of infected people, plants, and animals in exposed environments, novel compounds that can defeat bacterial, viral and fungal agents, health care and triage related to the care of affected persons using antibiotics and vaccines, medical evacuation utilizing telemedicine capability); communication (informing appropriate governmental persons, health care persons, the media, and the general public about the incident, effectively communicate and fuse data from distributed sensors); and integrated systems (to efficiently manage detection data, fuse data and develop useful iconographic displays).

a. The objectives are:

(1) Develop sensors for the detection of biological and chemical warfare agents that have low energy requirements and will rapidly detect and identify the agents of military concern.

(2) Develop physical and medical countermeasures to the threat agents including vaccines, antivirals, antibiotics, binding agents.

(3) Develop new methods of communication that serves to alert, in a seamless manner, the security forces (Army, CBRIM, RAID), first responders (police, fire, EMS), medical community and general public that an agent release has occurred or is anticipated.

(4) Develop new communications paradigms that serve as sentinels for a rapid development of clinical

symptoms associated with biological agent release (e.g. purchase of non-prescription analgesics, student absence from public schools).

(5) Develop mechanisms for the integration of data from these various data sets.

b. The four research concentration areas will require development and integration:

(1) Scientific validation of a possible biological/chemical incident and the determination whether identified sites in threat nations contain chemical/biological agents (including air/fluid sampling, determination of pathogen virulence factors/pathogenicity islands and signatures, multi-array sensors);

(2) Physical and medical countermeasures for use on a regional/national scale or on small groups of affected persons (e.g. rapid diagnosis, pharmaceuticals, vaccines, triage, quarantine, epidemiology and transport);

(3) Communication so that appropriate action is taken by authorities with minimal social disorganization; and,

(4) Integrated system development (integration of sensors into systems; conversion of data to information including data fusion and iconography).

These four areas are congruent with the requirements for biological warfare defense identified by the Department of Defense and with JV 2010 identified by the military services. With the above thrusts it will be possible to develop novel education and training with on-site, virtual reality capabilities, distributed information systems (DIS) and advanced distributed systems (ADS), as well as operational needs evaluation.

c. The anticipated impact: the realization of these objectives will provide an early warning system, CONUS and OCONUS, that agent has been released or that endemic outbreak of a disease associated with an Australia group agent has occurred and will enable treatment modalities to be initiated. This will permit effective deployment of forces in contaminated areas with assurance that these forces will be resistant to the diseases of concern thereby enhancing the combat and survival capability of the unit.

Technical Point of Contact: Dr. James B. Gillespie, e-mail: james.gillesp@us.army.mil :, (301) 394-1880.

2.54. Disposable Sensor Technology. Research proposals are desired that can lead to a complete sensor system consisting of several disposable sensor nodes that can communicate with a remote display. Each disposable sensor node should include one (or more) transducer(s), a signal processor, and a communication device, all in a single package. Disposable sensor nodes should be extremely small, lightweight, and consume extremely low amounts of power. The projected unit cost for individual nodes should be less than $10 each, based on production quantities in the millions.

The primary performance goal is the detection of personnel and/or human activities, especially in confined areas; e.g., buildings, caves, bunkers, tunnels, sewers, etc. False-alarm rates must be kept low, even in a dynamic battlefield environment. In general, overall network performance is more important than performance metrics for individual nodes: “the network is the sensor”. Other desirable performance goals include detection and/or classification of other targets and/or threats, including gunshots, mortar, artillery, and rocket launches and/or explosions; power line activity; telephone activity; chemical and/or biological threats; unattended air vehicles, micro-air vehicles, and other robotic or autonomous vehicles; etc. Low-bandwidth information, including context-oriented location information, should be exfiltrated via the sensor network to the end user in near-real time. Sensor modalities are not specified in this topic, but could include acoustic, seismic, magnetic, electric field, non-imaging passive infrared, passive RF, chemical/biological, and/or any other transducer(s) that could be used to detect any targets or threats of military significance. Sensors should be chosen and/or configurable for a wide variety of Intelligence, Surveillance, and Reconnaissance (ISR) missions, including self-protection for individual soldiers, surveillance by small groups of soldiers, perimeter security, and border monitoring.

Node-level computations are needed to reduce relatively high-bandwidth raw sensor data to immediately usable information that can be transmitted over extremely low-bandwidth *ad hoc* sensor networks. The sensor output should be as concise as possible, but include a node ID, timestamp, target type, and confidence level. Development

of sensor fusion algorithms, including multi-modal algorithms that are independent of particular transducers, can be considered under this topic.

The communications source may be acoustic/ultrasonic, RF, or IR, or it may resonate or reflect "on command" from an external receiver. One-way communication may be used to exfiltrate data to end-users and/or more capable sensors, gateways, etc. The network should be able to infer node location information from some combination of the ISR sensors, the network topology, and/or programming during emplacement. The node reports should include contextual location information; localization should not depend on GPS. The problem of exfiltrating data from confined areas, e.g., through robust multi-hop networking, should be addressed.

Sensors should be deployable by hand, via UAVs, helicopters, and/or cargo rounds (artillery); however high-G packaging techniques are not a focus of this topic. Similarly, proposals submitted under this topic should NOT focus on sensor information assurance, network-level information fusion, novel low-cost sensor technologies, low-power microprocessors, communications and networking theory, novel display technologies, haptic interfaces, low-cost packaging for high-volume production, and/or power and energy technology (i.e., batteries). These are important issues, and components using technology from all of these areas could be part of a proposed sensor system; however, funding to advance these technologies will generally not be funded under this topic.

Technical Point of Contact: Mr. Andrew Ladas, e-mail: Andrew.ladas@us.army.mil , 301-394-2622.

2.55 Passive Magnetic Sensor Technology. Research proposals are sought for work that can lead to small, rugged, low cost, low power, highly sensitive passive magnetic sensors for use as part of unattended ground sensor systems. The sensors can be deployed using artillery, scattered from the air or ground vehicles, or hand emplaced. Since it is desired that they will operate unattended for weeks or months at a time, they must consume very little power. To provide surveillance over an area of a few square kilometers, many low cost sensors will have to be employed. The sensors may detect ferromagnetic material on vehicles or carried by armed personnel or the low frequency signals generated by vehicles or underground facilities. For most applications, the sensor output should have a digital output that can be used in a tracking/classification algorithm. Magnetic sensors used in some application such as in proximity fuzes, small-unit training and simulation devices, etc. may consume more power. Other BAAs cover communications between sensors and to hubs.

Besides using stationary sensors, the sensors also may be employed on robotic platforms, UAVs, and UGVs. In these applications the requirement of low cost is less severe, but there is a need for coping with noise generated by rotational vibrations. Total field magnetic sensors may provide a solution to this problem. Proposals are sought for

a. Low cost, energy efficient, high sensitivity vector and total field sensors

b. Methods for reducing geomagnetic noise

c. New efficient algorithms for identifying and tracking targets

d. Methods for reducing the cost and power consumption of magnetic sensors

Technical Point of Contact: Alan S. Edelstein, e-mail: alan.edelstein@us.army.mil , 301-394-2162.

2.56. Emerging Technologies for Semiconductor Investigations. Army electronics systems for the twenty-first century will require a four-order-of-magnitude increase in real-time signal processing capability. These requirements translate to a better understanding of advanced material structures and miniaturization of devices with feature size to the sub-micron region of 0.1 micron and below. Innovative research is sought in the general areas of advanced electronic materials, processing and fabrication science, material processing technologies for semiconductor devices and integrated systems that are critical to Army applications. The major focus in this request includes high speed, non-contact characterization technologies that can be used to aid the understanding, development and fabrication of advanced materials and technologies for microelectronics packaging; fabrication and processing of semiconductors, interconnects and device structures, and the characterization and control of trace impurities, defects and interfaces in semiconductors and masks. Principal emphasis is on surface or interface control during processing of these materials, characterization of their near-surface transport behavior and surface properties, and modeling or theoretical predictions of their properties.

Objective / Approach: This research topic goes beyond the simple desirability of efficient devices and circuits. It is aimed at bridging the gap between research and implementation of new technologies that can be used to support the fabrication of these efficient devices. With the advancement of computers and communication protocols, research results can be better used if the requested effort is broadened to include the integration of these technologies into the overall manufacturing processes. For example, a new surface characterization tool can be used to validate the quality of the advanced material being processed. Its usefulness can be increased by many folds if it can provide real time feed back control to the previous and/or subsequent process equipment (such as thin film deposition process, wafer polishing machines or thermal cycling). Since the ultimate objective is implementation, preventive maintenance concerns for this new technology and its complimentary equipment should be addressed as well.

Conclusion: The work, although basic in nature, is focused on researching technologies to advance the fabrication of new materials, process and electronics that promise to significantly improve the performance, increase the reliability, or reduce the cost of future Army systems. With the need for shorter research-to-implementation cycles, program emphasis has increasingly shifted away from 'islands of technology' research to a more balanced approach with interests that cross a broad spectrum of integration requirements. The ultimate goal is higher speed and lower power consumption.

Technical Point of Contact: Robert Reams, e-mail: rreams@arl.army.mil (301) 394-3135.

RESEARCH AREA 3
SURVIVABILITY/LETHALITY ANALYSIS

3.1. Radio Frequency Directed Energy (RFDE)/ High Power Microwave (HPM)/Electromagnetic Effects/ Electromagnetic coupling phenomena. ARL SLAD mission is to provide survivability, lethality and vulnerability (SLV) analysis and evaluation support over the entire life cycle of major Army systems; and help acquire systems that will survive and be lethal in all environments against the full spectrum of battlefield threats. This is done by conducting survivability, lethality, and vulnerability (SLV) investigations, experiments, simulations, and analyses. SLAD develops tools, techniques, & methodologies to improve the SLV analyses.

ARL SLAD has a continuing interest in a broad spectrum of research in these areas, including:
Electromagnetic Coupling Phenomenology. There is ongoing interest in EM coupling to analog and digital systems, subsystems, components, boards, ICs, and components. Of interest are susceptibility levels and dependent parameters. Understanding coupling phenomena provides insight into the system effects and is useful for analyst projections. Additionally, a methodology (that can be validated in a laboratory or open air environment) is needed to analyze and understand the performance of communication/electronic/ADP equipment when deployed/operating in battlefield electromagnetic environments (EME). EME sources in the battlefield include radars dedicated to various warning functions (acquisition, track, etc.) covering broad frequency bands, communication transmitters, and accouterments of EM generating equipment used in the BM/C4I functions during a battle. Some of the sources encountered in the battlefield come under the realm of high power microwave (HPM) and the coupling phenomenon associated with the pulsed environment needs to be understood.

Ideally a HPM predictive tool would be developed and used for ADP equipment survivability assessments.
The RF coupling study can be approached by placing the equipment under test (EUT) and the ancillary equipment in an anechoic chamber:

a. To understand the low level RF coupling phenomenon associated with narrow-pulsed and/or transient EM environment.

b. To characterize its performance when exposed to out-of -band environment in the 100 MHz to 18 GHz range.

c. To diagnose/instrument digital EUT systems; e.g., computers, network devices, receivers, for RF effects. These measurements are conducted in an anechoic chamber to insure clutter free environment and facilitate cause and affect relationships observed due to RF environment.

The results from out-of-band radiated susceptibility measurements would be invaluable in characterizing EUT susceptibility profiles. This profile would define EUT system sensitive frequencies and the corresponding incident power density levels required to induce an electronic effect. The radiated susceptibility profile would provide information to protect friendly forces' equipment as well as provide insight on exploiting hostile forces equipment. This exploitation could result in interrupt/delay, corruption or denial of information/data.

System response against narrow-pulsed or EM transient pulsed environments would allow an analyst to project the performance behavior of the system in a tactical environment. If performed thoroughly, this effort may provide an insight into predictive tools for the system performance in presence of HPM/DEW environment.

Such a methodology also provides a more deliberate and an efficient effort in carrying out IW attacks via RF weapon by bounding the critical parameters effective in inducting performance degradation and/or system malfunction. Furthermore, this methodology would provide invaluable information in the design and acquisition process of fielding weapon systems. The radiated susceptibility data would then be used as the basis for defining/focusing technical parameters for HPM filed tests as well as RF hardening recommendations to improve system survivability.

Technical Point of Contact: Mr. Daniel Williams, e-mail: daniel.williams4@us.army.mil , (505) 678-4694.

3.2. RF Digital Models/Simulations. Developing theoretically based digital models and simulation tools for the analysis of RF electronic countermeasures (ECM) against radar/sensor functions. These tools would be mathematically defined in order to verify functionality. The tools would identify/quantify the information gained or lost by the radar's receiving/signal processing function and guidance function of the radar/sensor system. New techniques for modeling and simulation of radar functions and their interaction with the external environment, specifically ECM, are also being sought.

Technical Point of Contact: Mr. Jose Gonzalez, e-mail: Jose.marcos.Gonzalez@us.army.mil (505) 678-5309.

RESEARCH AREA 4
WEAPONS AND MATERIALS RESEARCH

4.1. Composite Materials. Proposals are requested involving fundamental and applied research of materials issues of polymer-, metal-, and ceramic-matrix composites and their hybrids and at extending theory and experimental methodology where current theory and techniques are not adequate for modeling, analyzing, or characterizing the synthesis, processing, microstructure, and properties of such advanced materials and material systems. The broad areas of interest include such issues as dissimilar material bonding and adhesion, interpenetrating networks, TS-TP adherend interfaces, multilayer composites, and hybrid fiber systems; synthesis and thermo chemical and mechanical analysis of constituent material forms; surface analysis techniques; energetic and chemical interphase/interface development/properties; cure behavior and modeling; transport and degradation properties including thermal, oxidation, electrical, and chemical; effects of additives and fiber treatments on formation and properties of the fiber-matrix and hybrid system interphase/interface; failure modeling and analysis; special thermoplastic composite issues including intimate and healing mechanisms and modeling; interactions of composite and hybrid systems with electromagnetic and radiative fields; modeling/analysis of void formation and effects of voids and other defects on strength, modulus, microcracking, etc.; composite-specific testing and analysis technique development and utilization including mechanical and electromagnetic property tests, fiber and matrix property tests, environmental exposure tests, etc.; statistical analysis of composite properties; assessment and analysis of industry-reported composite material property data; fundamental concerns and mechanisms for novel curing including electron beam, dielectric, microwave, etc.; physical property analysis; hygrothermal effects testing and analysis; thermal and oxidative stability; impact and delamination resistance; viscoelastic effects; analysis of process-induced properties; micro- and macromechanical analysis of fracture, buckling, delamination, etc.;

mechanics of laminated forms; numerical analysis; material durability and performance; and fundamental research in new material developments including fiber forms and surface modifications, low-density core materials, low-viscosity thermosetting resins, and processable phenolic resins, etc. Special emphasis should be placed on composite materials supporting personal and vehicular armor; on low-observable and lightweight, multi-functional materials for aircraft, flight body, ground vehicle, and soldier systems; on materials for munitions, ordance, cannons, armaments, and their sub-components, and on the characterization of polymer/hybrid materials surfaces and interphase phenomena, adhesive bonding, durability/life extension, and smart/intelligent material systems. Reporting of scientific results and conclusions may be incorporated into scientific meetings and publications including general literature (conference proceedings, journals, etc.), technical reports, and standardization documents.

Technical Point of Contact: Dr. C.P.R. Hoppel, e-mail: christopher.hoppel@us.army.mil , (410) 306-0755.

4.2. Advanced Materials and Materials Processing. The WMRD is seeking proposals for high quality research and development in advanced materials and materials processing approaches that are critical to Army applications. The Army needs are being driven by the need for lighter weight, lower cost, environmentally friendly, and more reliable materials for the Objective Force. Reduced weight is a goal for all weapon systems and logistics support items including ground and air vehicles, missiles, munitions, etc. Major future weapon systems include the Future Combat System and the Future Transport Rotorcraft. There is an interest in materials and manufacturing processes that will reduce the cost of the weapon systems, or increase capability at no additional cost. Army weapon systems are being extended beyond original design life. Accordingly there is an interest for materials and processes that will help lower the operating and support costs of weapon systems. Environmentally friendly materials and processes can reduce disposal and cleanup costs. Processing technologies of interest include those that will be applicable during high rate production and also for rapid prototyping. The objective of rapid prototyping is to reduce lead-time and where possible to make cost independent of order size. Proposals may impact materials currently in use within existing systems or look forward to future systems, subsystems, or support items. Some examples of areas of interest include (i) materials such as bulk and composite amorphous materials, nanomaterials, advanced metal matrix composites, polymer materials, etc. Some goals are to discover, synthesize and process bulk and amorphous metallic alloys for potential applications such as kinetic energy applications; novel processing for refractory metal and alloy warhead liners for shaped charge and explosively formed projectile applications; other example uses include structural, armor, coatings, multifunctional, etc. applications, (ii) processing methods include joining, bonding, laser processing, shaping, etc. Example objectives include joining difficult to weld materials, dissimilar metals; rapid prototyping, direct metal deposition techniques, processing to enhance surface properties, etc.

Technical Point of Contact: Mr. Fred Stenton, e-mail: fred.stenton@us.army.mil, (410) 306-0807.

4.3. Electromagnetic (EM) Technology. The Army requires significant advances in the state-of-the-art electromagnetic technology for broad application to advanced future weapon systems. Research interests include conducting formal studies, technical assessments and critical evaluations for the Army; providing essential scientific research; and addressing the critical scientific, engineering and technical issues associated with the development of electric armament technology. Specific research interests include, but should not be limited to the following areas:

a. Electrodynamics/electromechanics:

(1) Conduct basic and applied railgun research.

(2) Methods and materials to suppress hypervelocity gouging, a destructive high-speed phenomenon that precludes multiple firing on a set of rails.

(3) Rail and cladding materials that simultaneously maximize performance of armature and survive in-bore environment.

4) Development of a fundamental understanding of mechanisms by which metal on metal contact is lost, and techniques to operate without a transition to arcing contact.

(5) Fundamental research into what it takes to operate a railgun in a low signature mode.

(6) Development of mass efficient novel armatures.

(7) Development and testing of Integrated (armature/sabot) launch packages and EM-launched, war-like rounds.

(8) Identification, evaluation and development of materials that would enhance the performance and affordability of future fielded EML systems.

(9) Experimental research into railgun technology and development of pulsed rotating machines, including computational effort.

(10) Development, distribution, and of a 3D FEA code that includes that ability to model high-speed, high-current density sliding electric contact.

(11) Development of scalable parallel algorithms and methods to provide a path toward addressing problems of increasingly greater size. Development to include PC-based clusters as well as parallel supercomputer platforms.

(12) Development of a hybrid boundary-element/finite-element approach to eliminate model-building complexity associated with meshing air regions.

(13) Coupling to high-deformation, thermo-plastic, transient structural analysis.

(14) Computational and laboratory research into railguns, development of pulsed power sources, and other pulsed power weapon applications such as EM armor and EM driven plate launch systems. This work should be tightly coupled to an experimental effort so that insights gained from computations are a critical factor for making efficient experimental progress.

b. Pulsed power technology:

(1) Conduct basic and applied research in battlefield/pulsed power to reduce development risk while enhancing opportunities for high payoff performance for electromagnetic gun weapons development.

(2) Develop and use state-of-the-art codes to design and evaluate the electromagnetic, mechanical and thermal performance of high performance power systems for individual soldier and unit performance enhancement.

(3) Design, build, test and analyze data from test fixtures that provide critical electric, mechanical and thermal data relevant to the development of compact high power batteries having very high energy- and power-to-weight capabilities.

(4) Develop, test and analyze fuel cell technologies that will support near- and far-term high power systems for battlefield class power supplies, including auxiliaries such as potable water production.

(5) Develop and analyze alternate novel concepts that may offer potential future benefits for battlefield armament and communication systems.

(6) Identification, evaluation and development of materials that would enhance the performance and affordability of future fielded EML systems.

c. Electromagnetic lethality, including hypervelocity physics, and novel kinetic energy penetrators:

(1) Develop and evaluate novel kinetic energy penetrator designs/concepts that take advantage of elevated impact velocities to defeat targets that represent present and future states-of-the-art in passive, reactive and active armor with lower striking or launch kinetic energy than can ordnance velocity long rod penetrators.

(2) Investigate dynamics of projectiles undergoing in-flight deployment by development and exercise of multiple degree of freedom models of hypervelocity flight trajectories including the effects of EML launch, inflight extension and segmentation, and subsequent flight to the target; and, employ these validated models to assess the performance of advanced hypervelocity projectiles.

(3) Investigate hypervelocity aerothermodynamics by developing models for tip and stabilizer ablation and erosion for materials of interest.

(4) Investigate all fundamental issues and technical challenges relevant to active dispersion control of HV projectiles.

(5) Conduct research to improve the fidelity and broaden the applicability for numerical simulations of hypervelocity impact and penetration.

d. Technology integration:

(1) Investigate vulnerability of electric vehicle components to obtain essential data for vulnerability assessments.

2) Develop computer models for simulation of the dynamics and system performance of advanced weapons systems such as EM gun system, electric/hybrid electric combat vehicles, and unmanned vehicles.

Technical Point of Contact: Edward Schmidt email Ed.Ed.schmidt@us.army.mil (410) 306-0663.

4.4. Weapons Dynamics and/or Sub-Component Simulations. The WMRD and other Directorates in ARL conduct an extensive applied research program in support of the development of materiel that support a diverse spectrum of weapons. Research interests include numerical modeling and experimental research addressing propulsion mechanics and thermodynamics, flight dynamics, structural dynamics, impact physics, and subsequent weapons effectiveness.

Technical Point of Contact: Dr. Edward Schmidt, e-mail: Ed.schmidt@us.army.mil (410) 306-0646.

RESEARCH AREA 5
HUMAN RESEARCH AND ENGINEERING

5.1. The Human Research and Engineering Directorate (HRED) plans, manages, and conducts a comprehensive, multi-disciplinary program of scientific research directed toward defining human performance in perceptual, cognitive, and psychomotor domains. HRED research provides the scientific foundations for militarily relevant databases on human performance and associations among enhancers, distracters, and stressors, which affect that performance. Those data and associations are then embedded in modeling and simulation tools, which in turn serve to guide optimal design of human-system interaction in battlefield environments.

Discussion of potential proposal ideas with the HRED POC are expected prior to white paper or proposal preparation.

Point of Contact: Ms Wendy Leonard, e-mail Wendy.leonard@us.army.mil 410-278-5813.

5.2. HRED has research interests in modeling effects on cognitive and team performance of different time-scales and other factors operating in a multi-echelon battle-management environment; defining and modeling effects of humans in automation, such as (a) effect of the automated system's interruption of ongoing human-in-the-loop tasks, (b) characterizing the nature and extent of an automated or semi-automated system's tolerance for neglect of human input; modeling interactions among cognitive, perceptual, and psychomotor performance of unmanned aerial and ground vehicles.

Discussion of potential proposal ideas with the HRED POC is expected prior to white paper or proposal preparation.

Points of Contact: Dr. Rene de Pontbriand, email: rene.depontbriand@us.army.mil, 410-278-3824, Mr. Michael Barnes, email: michael.barnes@hua.army.mil ,520-538-4702.

RESEARCH AREA 6
VEHICLE TECHNOLOGY

6.0. The Vehicle Technology Directorate (VTD) develops the technologies needed to extend the life of current combat vehicles, to provide components for future systems, and to shorten the design and development cycle by enabling flexible, affordable manufacture of the next generation of equipment. VTD is focusing its research towards development of lighter, faster, and more fuel-efficient vehicles. VTD topics shall be included in this BAA as funding is programmed.

Technical Point of Contact: LTC David C. Meyer, email: d.c.meyer@larc.nasa.gov 757-864-3091.

B. ARMY RESEARCH OFFICE (ARO)

RESEARCH AREA 7
MECHANICAL SCIENCES

7.0. Research supported in the mechanical sciences portion of the Mechanical and Environmental Sciences Division of the Army Research Office is concerned with a broad spectrum of fundamental investigations in the disciplines of fluid dynamics, solid mechanics, structures and dynamics, and propulsion and energetics. Though many creative and imaginative studies concentrate on a particular sub-discipline, increasingly, new contributions arise from interdisciplinary approaches such as the coupling between aerodynamics and structures, combustion and fluid dynamics, or solid mechanics and structures as in the structural reliability areas. Additionally, several common themes run through much of these four sub-disciplines, for example, active controls and computational mechanics. Research in such areas is addressed within the context of the application rather than as a separate subject of study. Fluid dynamics research is primarily concerned with investigations in the areas of vortex-dominated flows, unsteady aerodynamics, and the thermal science of micro/meso-scale devices. Solid mechanics include a wide array of research areas such as high strain rate phenomena, penetration mechanics, heterogeneous material behavior, and reliability of structures. The structures and dynamics area is focused on investigations in vehicle structural dynamics and simulation and air vehicle dynamics including rotor aeromechanics. Research in the propulsion and energetics area is concentrated on processes characteristic of reciprocating (diesel) and gas turbine engines and the combustion dynamics of propellants used for gun and missile propulsion. The following narratives describe the details of the scope and emphasis in each of these sub disciplinary areas. Potential offerors are encouraged to contact the appropriate TPOC for preliminary discussions on their ideas. The TPOC may invite the offeror to submit a preproposal. Some TPOC's have provided specific instructions for timing of submittals, see below.

7.1. Fluid Dynamics. Research in fluid dynamics supports the development of improved or new technology for advanced helicopters, small gas turbine engines, improved airdrop (parachute) systems, maneuverable high-speed missiles and high performance gun-launched projectiles. While basic research studies that address the fundamental flow physics underlying these devices are solicited, innovative research in the specific topical thrust areas listed below is especially encouraged.

7.1.1. Vortex-Dominated Flows. In contrast to fixed-wing aircraft, rotorcrafts always operate under the influence of their own wakes. The prediction of rotor performance, vibratory loads, and blade-vortex interaction noise depends strongly on the accurate prediction of the rotor wake, and the prediction methodology of this wake remains one of the major challenges in fluid mechanics. Current computational fluid dynamics (CFD) approaches are computationally intensive, especially for Eulerian methodologies where the vorticity diffuses numerically through the grid points and makes predication inaccurate. The process by which vorticity is shed by the blade and rolls up to form vortex filaments is not now adequately simulated for rotorcraft load distributions. In fact, under certain flight conditions, multiple vortices are observed to form due to negative lift over the blade tip. The application of non-intrusive optical diagnostic techniques should yield new phenomenological understanding for the study of multiple vortices, wake structures, and wake development. New numerical algorithms or different techniques to increase accuracy and reduce the computational requirements are required.

7.1.2. Unsteady Aerodynamics. A high level of unsteady flow, which cannot be adequately predicted by steady or quasi-steady approaches, can characterize the flow field around many modern Army weapons systems. One classical example of very high Army relevance occurs on the retreating blade of a helicopter rotor, where the high angles of attack experienced by the retreating blade of the helicopter rotor leads to boundary-layer separation followed by load and pitching-moment overshoots. Mild separation causes increased vibration and reduces performance, while severe dynamic stall leads to unacceptably large vibratory loads and limits forward flight speeds, load, and maneuver capabilities. The physics of this flow phenomenon are known to depend on the Mach and Reynolds numbers of the flow, and hence future research in this area needs to be performed under realistic flight conditions. Improved theoretical and numerical simulation is needed for understanding the unsteady separation process and evaluating concepts for separation control. The simulations must be capable of accounting for transition of the boundary layer (and under some circumstances, the transition in the separating free shear layer). Detailed experimental measurements of velocity and pressure are needed in the separating region for the fundamental understanding the separation process, the development of new turbulence models valid during the stall process, and the validation of numerical simulations: here, the current focus is on quantitative flow field measurements rather than merely quantitative measurements on the airfoil surface. These measurements will probably require the use of new non-intrusive optical methods. Combined experimental and numerical efforts towards control of unsteady separation using passive and active flow control (including the emerging field of Micro-adaptive Flow Control) are also sought.

A second example of the importance of unsteady aerodynamics occurs on maneuvering missiles and projectiles. As future emphasis in flight vehicle control and "smart" systems pervades munitions design, advances in aerodynamic phenomena, such as dynamic high alpha separation, vortex shedding, control surface/vortex interaction, divert thruster/vehicle interaction, roll control stability, and propulsion system integration will be required. New composite material vehicles will have stringent thermodynamic limits and enhanced nonlinear aero elastic response to maneuver forces. Smart structures and MEMS technology will redefine control strategies, control surface shape and control surface dynamics, consequently driving fluid dynamics into new areas of research. All of these developments require the prediction and experimental verification of complex nonlinear transient flow fields. This will require improved CFD for turbulent flow separation prediction, large eddy simulation, vehicle vortex interactions, and accurate computations of gross flow field response to MEMS boundary layer flow perturbations. Parallel developments in experimental techniques will be required to measure these complex flow fields to help verify and guide the predictive technology.

7.1.3. Thermal Science of Micro/Meso-Scale Devices. Over the last decade the same micro fabrication techniques originally developed for the production of electronic integrated circuits have been used to develop miniature mechanical devices (known as Micro Electrical Mechanical Systems, or MEMS). In fluid dynamics applications, the small size and mass of these devices have enabled the production of sensors and actuators with outstanding temporal and spatial bandwidth, enabling multiple applications for micro-flow control. Here the philosophy is the insertion of very small control forces at crucial spatial and temporal locations in order to obtain significant changes

in system performance. The application of this micro-flow control technology to Army systems offers the promise of significant performance enhancement at reasonable life-cycle cost.

More recently, the sophistication of these micro fabrication technologies has improved to the point where entire miniature machines can be developed. These miniature machines have a wide range of applications that have high relevance to the Army and specific application to the dismounted soldier. Examples include the development of micro-turbine power generators, air and water purifiers, compact cooling systems, and miniature unmanned aerial vehicles. The physics of these miniature devices can be significantly different than their macro-scale counterparts due to the very small scales involved, the two-dimensional nature of micro fabricated flow channels, and the limitations imposed by the materials used by these fabrication techniques.

As with all ARO-funded programs, the Army uniqueness and relevance of the proposed research should be explicitly addressed. Specifically, in this thrust proposals that seek funding for generic technology development (such as the development of new micro-flow actuators or micro-electronic chip cooling concepts, or the investigation of fluid flow and heat transfer in micro-channels) are discouraged: what are sought are broader technology solutions with specific Army relevance.

Technical Point of Contact: Dr. Thomas Doligalski, e-mail: Thomas.Doligalski@us.army.mil , (919) 549-4251.

7.2. Solid Mechanics. The light, lethal, survivable, continental United States (CONUS)-based modern Army with quick power projection capabilities around the globe has abiding interest in building fixed and mobile assets in the most efficient manner with advanced materials. Weapons, platforms, ammunition, and ground structures are designed with severe weight and volume restrictions. Innovative use of material combinations for specific applications necessitates understanding of the behavior of materials and structures under complex and severe constraints. Solid mechanics provides the link between material properties and structural response. The program focuses on *high strain rate phenomena* including *impact, penetration, and shock*, *mechanics of heterogeneous systems*, and *fracture and failure*. In this program, relations between material behavior, deformation, fracture and failure under physical constraints and loading conditions are examined. Complete understanding of the behavior of structures made of combinations of advanced materials permits the predictive capability to optimize structural response and is useful in the development of design methodologies. In situations that are ballistic in nature, the Army faces unique constraints of very high strain rates, large deformations, high pressures, and rapid changes in temperature. Interrelated analytical, experimental, and computational formulations are needed to solve multidisciplinary problems. Predictive models, validated by well-characterized experiments, are needed to identify dominant mechanisms at relevant scales. Though imaginative and promising research investigations in all these general areas are of interest, innovative research studies in the specific topical areas outlined below are especially encouraged.

To establish the suitability of proposed research topics, direct contact by telephone or electronic mail with the Program Manager and submittal of informal preliminary proposals (not to exceed five pages) are strongly encouraged. For the Solid Mechanics Program, preliminary proposals should be submitted no later than 15 October of each fiscal year. These preliminary proposals will undergo technical evaluation in terms of scientific merit and Army relevance. Offerors whose preliminary proposals are assigned a high priority rating by the committee will be invited to submit a complete, formal proposal.

7.2.1. Impact, Penetration, Shock and High Strain Rate Behavior. This research topic addresses the need to understand the response of Army hardware to impact or nearby explosive detonation and integrates fundamental work in finite deformation, high pressure and high strain-rate response, damage, and failure mechanics. It should be carried out through a combination of physically based experiments, theoretical studies, and computations and addresses a wide variety of materials including metals, ceramics, composites, and energetic materials. Since the complex interactions between the shock and release waves usually initiate the damage mechanisms in the target, accurate modeling of the target behavior will require controlled, high fidelity experiments. Because penetration involves erosion and sliding of both the projectile and the target, explicit modeling of these processes with friction-based theories and computational techniques are essential. Innovative research on processes and phenomena in materials and structures that absorb energy, deflect penetrations, and/or laterally disperse momentum is encouraged.

Paramount to this effort is a better understanding of the mechanics of interfaces and impact mechanisms, such as high velocity sliding that might occur at the penetration/target interface or within developing cracks at macroscopic and microscopic scales. To this end, innovative experimental techniques that incorporate high-speed data acquisition or imaging are necessary to capture the deformation processes and relative motion between surfaces. Computational methods for treating discontinuities in a three dimensional context are required. These methods must concentrate not only on the techniques required to track a moving boundary, but also on the relevant physics and mechanics associated with those surfaces. Examples might include boundaries between dissimilar materials, shock fronts, elastic/plastic boundaries, phase boundaries, shear bands and cracks, as well as penetration/target interfaces.

Penetration into brittle materials presents special challenges due to cracking and comminution of material ahead of the penetrator, high-speed granular flow of comminuted material, and the mixing of eroded penetrator material and comminuted target material. Ceramics and geologic materials exhibit extreme sensitivity to loading histories, which may manifest in apparent rate dependence of failure strengths and the propagation of failure waves. All of this requires greatly improved understanding, effective modeling, and efficient computational schemes. Penetration into composite materials presents still another set of challenges. Careful experimental techniques are required to delineate the nature, timing, and evolution of damage and failure in composite targets. Analytical models at multiple scales validated by carefully designed experiments are needed. Future ultra-lightweight armors will involve a combination of layered and graded structures that are highly anisotropy and heterogeneous. Linearized homogeneous isotropic conventional theories will not be adequate to describe the shock and penetration response of such material combinations.

Another important aspect of this area of research is the deformation and fracture of materials under high strain rates (up to 10^7 s^{-1}), large strains (up to 500%), high temperatures (up to melting), and high pressures (up to 5 GPa). Constitutive models should be three-dimensional and should allow for system nonlinearities. Models of behavior for combinations of ductile and brittle solids that encompass coupled deformation and failure modes are sought. These models should be based on new uniquely defined benchmark experiments. An important aspect of this area of research is the development of innovative experimental techniques that can be used to generate data for the wide ranges and combinations of strain rates, strains, temperatures, and pressures of interest. These experiments should provide for quantitative measurements of variables and parameters related to failure.

7.2.2. Mechanics of Heterogeneous Systems. The mechanics of heterogeneous structures involves the development of integrated analytical, computational, and experimental approaches to investigate the response of hybrid structures that may include combinations of high strength and lightweight engineered composites, ceramics, and functionally graded materials. Heterogeneity at all scales should be considered, from nanomaterials to systems created through combinations of different materials at larger scales. Experimental and computational techniques are needed to optimize material microstructure as well as the topology of systems to provide the desired structural response for specific boundary and loading conditions. Physically based structural design guidelines for energy absorbing structural systems comprised of tailored combinations of materials and heterogeneities at different length and time scales are sought. There are continuing technology barriers that need to be overcome if reliable Army structures such as helicopters, ground vehicles, bridges, and weapons systems are to be designed, manufactured, and maintained over a long period of time. Of special interest to the Army is the thermo-mechanical response at strain rates encountered in high-speed impact or explosive loading. Probabilistic as well as deterministic approaches are encouraged. Phenomena of interest are wave propagation, scattering, dispersion, damage evolution, and failure.

At appropriate length and time scales, the quantitative prediction and measurement of parameters related to dominant heterogeneities and mechanisms are needed for specific material systems in order to relate nano and micro effects to the macro scale. Deterministic and statistical scaling methodologies for toughness, strength, and geometrical effects that account for the multitude and variability of heterogeneities such as interfaces, interphases, particulate dispersion, fiber volume fraction and distribution, constituent shape, and their combined effects on failure are needed. Innovative methods and models to control material properties and damage by graded interfaces, coatings, and mechanical impedance mismatches are required. Constitutive relations for multi-scale mechanisms should include failure and damage criteria, which are mechanism-based and experimentally verifiable. The determination of universal scaling laws that can be used to bridge physical scales would greatly enhance our understanding and prediction of phenomena such as inelastic deformations, localization, distributed damage and failure, and fragmentation. Advances and approaches based on analyses of physically representative model

problems related to specific phenomena are needed for scaling laws corresponding to an underlying physical universality.

7.2.3 Fracture and Failure. Fundamental research in damage initiation and progression, failure mechanisms, and life prediction is essential for the development of new structural systems for the Army. New theories are needed that can overcome the limitations of traditional continuum fracture models arising from crack tip singularities. Interrelated theory, experiments and computations are required to understand and predict crack nucleation, branching and coalescence and should be used to develop accurate failure theories that can be used by designers for a variety of complex material systems. Methodologies that explore fracture processes at the microscale and relate them to the meso and macroscopic levels should be investigated. Computational models for the creation of free surfaces that are mesh independent and that incorporate evolving time-dependent boundary conditions and physically based failure initiation criteria need to be developed. These computational models should capture the complex interactions of failure processes and defects in three dimensions. Experiments have to be designed to delineate the effects of failure initiation, interaction, and rupture. Necessary and sufficient conditions are needed to determine when to follow failure from initiation to rupture. A better understanding of the effect of damage on a system's operating performance and its remaining life is needed.

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7.3. Structures and Dynamics. A significant challenge facing Army laboratory engineers is the determination of the influence of inertial, thermal, electrical, magnetic, impact, damping, and aerodynamic forces on the dynamic response of adaptive armament systems, ground vehicles, rotorcraft, missiles, projectiles, gears, parachutes, and shelters. Its resolution is of fundamental importance to the design and construction of affordable, reliable, durable, and maintainable Army equipment with acceptable levels of personnel safety and comfort. Consequently, the ARO is supporting basic research in these areas, with emphasis on air vehicle dynamics, including missile and rotorcraft dynamics; the dynamics, non-linear vibrations, structural control, and simulation of land vehicles and weapon systems; and the dynamic response of structural components and systems fabricated from advanced composite materials, with or without embedded actuators and sensors. Submittal of fundamental research proposals on the general topics described above is encouraged, keeping in view the paramount importance of Army relevance. More specific details of the program's predominant thrust areas are described in the following paragraphs.

To establish the suitability of proposed research topics, direct contact by telephone or electronic mail with the TPOC and submittal of informal preliminary proposals (not to exceed five pages) are strongly encouraged. For the Structures and Dynamics Program, preliminary proposals should be submitted not later than 15 October of each fiscal year. These preliminary proposals will undergo technical evaluation in terms of scientific merit and Army relevance. Offerors whose preliminary proposals are assigned a high priority rating by the TPOC will be invited to submit to ARO a complete, formal proposal in early March of each fiscal year.

7.3.1. Structural Dynamics and Simulation. This topic consists of six thrusts: smart structures, structural dynamics, structural damping, active structural control, structural health monitoring, and inflatable structures. Advances in these areas are required to improve capabilities of modeling, computing the dynamic response, reducing noise levels, suppressing vibrations, detecting the presence of damage, and assuring the integrity and performance of structural components used in military systems.

Adaptive structures are currently being considered for application in helicopter rotor systems, missiles, projectiles, electromagnetic antenna structures, land vehicles and weapon systems. They offer opportunities, for example, to realize structural vibration suppression or isolation in rotorcraft and weapon systems, unsteady load control on rotor blades, reduction of blade/vortex interaction noise, airfoil shape change, gust load alleviation, aeromechanical stability augmentation, beam shaping and steering in antennas, and structural health monitoring. Research areas include sensors and actuators, formulation of suitable constitutive relations, modeling and optimal design of smart composite structures, finite element formulations and control algorithms. Concepts for novel actuation techniques, based on micro-electromechanical systems (MEMS), nanotechnology or other innovative concepts, are encouraged. New active damping techniques, based, for example, on combinations of viscoelastic and active materials, combined with shunted electric circuits and non-linear adaptive control strategies, have emerged as candidates for improving structural performance and reliability. Topics of interest include the role of viscoelastic materials, constitutive equations, elastomeric dampers for missiles and rotorcraft, magnetorheological fluid dampers, modeling and design,

actuation of missile flight control surfaces, non-linear control techniques, and techniques for including damping effects in mathematical and computational models.

The trend toward the increasing use of composite materials in the fabrication of military vehicles to reduce their weight and augment fuel efficiency requires that Army engineers have the tools necessary to predict the static and dynamic response of composite structures. During the course of service, virtually all-composite structures should be monitored to assure their condition of health and integrity to prolong their life span or to prevent catastrophic failure. Recent developments in sensor and actuator technologies have opened the way to develop new diagnostic technologies particularly suitable for composite materials. Such enhancements might involve approaches such as wavelet transforms, neural networks, fuzzy logic, probabilistic estimations, system identification, electro-mechanical impedance methods, electric impedance tomography, etc. The development of the associated software will have to include the presence of distributed sensors, actuators, and controllers based on fiber optics, piezoelectric materials, (MEMS) devices, or other concepts. The development of new active materials, such as relaxor ferroelectrics and alkaline-based piezoelectric materials has recently been reported by the materials science research community. These materials appear to offer significant opportunities to create improved actuation devices that will deliver greater authority (force, stroke) than do the conventional piezoelectric materials. The potential of new actuators in Army applications should be energetically pursued.

The assurance of structural reliability of military air and land vehicles and weapon systems will greatly enhance confidence in their safety, reduce the probability of mission failures, and diminish the costs of operation and maintenance. An important element in achieving reliable systems is a strong capability of inspecting and assessing the physical condition of critical structural components. Significantly improved techniques for inspection, analysis, and interpretation are urgently needed to facilitate the assessment of the health of a structure and to promote the design, fabrication, and reliable operation of future and current military systems. Inability to detect damage in heterogeneous structures that may comprise combinations of composites, ceramics, and metals is a limiting factor to their use in practice. The application of active materials to the development of novel sensing techniques, such as MEMS, and the ability to interpret sensor signals effectively and accurately in nearly real time are fundamental for improving the reliability of physical systems. Miniaturized sensory devices could be incorporated into heterogeneous structures to signal the presence, location, and extent of local and global failure modes, such as fiber breakage, fiber pull-out, delamination, and large matrix structural cracking. Accordingly, new design and maintenance technologies are critically needed for military systems. An idea that shows considerable promise in reducing operating costs while enhancing system safety is the concept of condition-based operation. This is a concept that encompasses maintenance, system characteristics, scheduling, and operations. Condition-based operation attempts to enhance the reliability and survivability of the system under adverse conditions, such as battle damage and critical system failures, using on-line system identification, health monitoring and failure detection, and adaptive fault-tolerant reconfigurable operational control. With advances in micro-sensors (including MEMS devices), piezoelectric actuator technology, system identification, information technology, adaptive control theory for sensor nets and wireless telemetry, condition-based operation of military systems will lead to enormous gains.

7.3.2. Air Vehicle Dynamics. Rotorcraft aeromechanics analytical prediction capability must be improved to increase military effectiveness of rotorcraft through better mission performance, improved availability and dependability, and reduced life cycle costs. Advanced comprehensive analyses must address rotor blade control surface devices that use aerodynamic forces to excite structural response in order to minimize blade and fixed system vibratory loads and/or to improve the vehicle's aeroelastic stability characteristics. Of great importance in helicopter dynamics is the development of numerical analysis tools that are applicable to the special challenges associated with moderate to very large systems of equations (typically finite element based) that are needed to determine solutions for rotorcraft trim, periodic response, and transient behavior. The types of numerical analyses that are needed include: (i) the determination of the periodic solutions to the equations (both stable and unstable orbits) and of the unknown parameters that are associated with a specified flight condition, (ii) traditional constant and periodic coefficient eigenanalysis of these system orbits and limit cycle or chaotic behavior of unstable orbits, and (iii) determination of optimal design, optimal trim, and optimal control of such systems. The dynamics and control of micro-aerial vehicles is also of interest to the program.
Smart structures concepts offer the Army the potential to address critical problems in helicopter systems including vehicle vibration suppression, control of rotor blade vibratory loads and fatigue stress, reduction of interior and exterior noise, gust load alleviation, enhancing rotor aerodynamic efficiency and performance, and augmenting aeroelastic/aeromechanical stability. These advances may be achieved by using smart structures approaches, for

example, to twist the rotor blade along its length, to actuate a flap or elevon control surface at the blade trailing edge, or to change the airfoil camber or leading edge shape. The development of control algorithms is needed to tailor the inputs to multiple actuation sites, integrate information from multiple sensors, and optimize overall controller architecture including the development of appropriate data processing and software techniques.

The Army's requirement to deploy soldiers and equipment rapidly and safely dictates the use of parachute insertion usually at high speed and low altitude to minimize detection and exposure to enemy fire and maximize the drop accuracy. Parachute deployment and inflation is a challenging problem in aeroelasticity requiring multi-disciplinary modeling for coupling the structural deformations of the parachute material with the three-dimensional and highly unsteady aerodynamic environment. Prediction of a parachute system's response to user control and environmental factors once deployed also requires a coupled approach. For instance, an airdrop problem for which no three-dimensional coupled simulation capability currently exists is that of predicting the aerodynamic performance of fully deployed airdrop systems such as a steerable parafoil or a steerable round or cross canopy. Issues include: determination of (i) the lift to drag ratio of such systems, (ii) the outcome of a control input, and (iii) the system response to environmental inputs such as winds.

7.3.3 Weapon System and Land Vehicle Dynamics. The overarching goal of weapon system research is the improvement of firing accuracy. Improved weapon system accuracy reduces the number of rounds required to complete a mission; thus the ammunition logistics requirements of a unit are reduced. Vehicle generated disturbances (environmental or internal) and firing disturbances excite the structural dynamics between the sighting system and the weapon mount and the dynamics of the weapon itself. Innovative, unique, and far reaching research is required to explore fundamental issues in simultaneous control and structure design, ultra-high performance hybrid weapon drive systems, smart structures for vibration suppression and micro-positioning of gun barrels, high speed emplacement mechanisms and non-traditional barrel structures. Specific areas include mechanism theory and optimization, vibration, multi-body dynamics, smart materials, distributed servo control, software development tools for mechanical design and optimization.

Numerous large, complex mechanical systems used by the Army consist of interconnected multi-body structures, e.g., heavy machinery, wheeled/tracked military land vehicles, machine tools, rotorcraft, weapon systems, etc. These complicated systems often consist of numerous combinations of rigid and flexible elements. New and innovative approaches are needed for the efficient analysis, design, and control of large vehicles that consist of interconnected flexible bodies. Recent advances in computer and graphics hardware and software capabilities are stimulating recent advances in motion based simulators with computer generated imagery that interfaces vehicle dynamic models and their physical environments. Innovative approaches for modeling the deformation of vehicle system components based on the finite element method and experimental identification techniques are needed to develop more detailed models of complex vehicles. Examples of potential research areas are automatic formulation of the constrained equations of motion, symbolic equation processing, generation of computational methods and associated computer codes, algorithm optimization for computer architectures, model reduction and error quantification techniques, fluid payload dynamics, suspension systems and control, weapons positioning control, optimization techniques, and non-linear control algorithms.

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7.4. Propulsion and Energetics. Propulsion and energetics research supports the Army's need for higher performance propulsion systems. These systems must also provide reduced logistics burden (lower fuel/propellant usage) and longer life than today's systems. Fundamental to this area are the extraction of stored, chemical energy and the conversion of that energy into useful work, for vehicle and projectile propulsion. In view of the high temperature and pressure environments encountered in these combustion systems, it is important to advance current understanding of fundamental processes as well as to advance the ability to make accurate, detailed measurements for the understanding of the dominant physical processes and the validation of predictive models. Thus, research in this area is characterized by a focus on high pressure, high temperature combustion processes and on the peculiarities of combustion behavior in systems of Army interest.

7.4.1. Engines. Research on combustion in engines is focused on intermittent, reacting flows encountered in diesel combustion chambers and on continuous combustion characteristics of small, gas turbine combustors. Optimizing engine performance, through understanding and control of in-cylinder combustion dynamics, while retaining high

power density, is a major objective. This focus leads to a strong emphasis on fuel injection processes, jet break-up, atomization and spray dynamics, ignition and subsequent heterogeneous flame propagation. Research on heterogeneous flames requires supporting study into kinetic and fluid dynamic models, turbulent flame structure, soot formation and destruction, flame extinction, surface reactions, multiphase heat transfer, and other factors which are critical to an understanding of engine performance and efficiency. An additional consideration is the high pressure/temperature environment, encountered in advanced engines, which influences liquid behavior and combustion processes at near-critical and super-critical conditions. Of particular interest are investigations of fundamental characteristics related to highly stressed engines such as elevated temperature combustion, accelerated mixing, and transient heat transfer. Engine performance degradation under low temperature conditions, due to reduced fuel volatility, high oil viscosity, poor atomization and vaporization, etc., is a major concern. Fundamental research is needed in many areas, including low temperature physical and chemical rate processes, instantaneous friction and wear mechanisms, and combustion instability effects at low temperatures. With advances in sensing, modeling and control architectures, it is becoming possible to further optimize the performance of combustion systems. Providing the foundations for such active control is also a major goal of the program.

7.4.2. Propellant Combustion Processes. Research on propellant combustion processes is focused on understanding the dynamics of the planned and inadvertent ignition and subsequent combustion of energetic materials used for propulsion in gun and missile systems and in ordinance. The program is also addressing the characterization of advanced energetic materials, e.g. those based on nano-scale structures and/or ingredients. Basic research is needed in several areas, including, plasma- and laser-induced ignition; thermal pyrolysis of basic ingredients and solid propellants; flame spreading over unburned surfaces (particularly in narrow channels); surface reaction zone structure of burning propellants; chemical kinetics (including possible ion kinetics in the presence of plasmas) and burning mechanisms; propellant flame structures; characterization of physical and chemical properties of propellants and their pyrolysis products; and coupling effects among the ignition, combustion, and mechanical deformation/fracture processes with or without the presence of a plasma. The use of advanced combustion diagnostic techniques for reaction front measurements, flame structure characterization and determination of reaction mechanisms is highly encouraged. This includes characterization of radiative and convective stimuli delivered by plasma injection sources as well as the thermal, kinetic, and mechanical responses of the propellant. Complementary model development and numerical solution of these same ignition and combustion processes are also essential. There is also need to understand the unplanned or accidental ignition of energetic materials due to stimuli such as electrostatic discharge, impact, friction, etc. This requires, for example, research on the processes of energy absorption and energy partitioning in the materials, the effect of mechanical damage on the ignition events, and other topics relating to the safety of energetic materials.

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RESEARCH AREA 8
ENVIRONMENTAL SCIENCES

8.0. The Environmental Sciences Division of the Army Research Office supports fundamental research in the Atmospheric and Terrestrial Sciences, i.e. research in the physical sciences of planet Earth in support of Army requirements. The need for research in the environmental sciences stems from the impact that the environment has upon virtually all aspects of Army activities. As military technology become ever more complex and sophisticated, both systems and operations are increasingly influenced by the natural environment and variability in environmental conditions. Despite continuing Army efforts to develop an all-weather/all-terrain capability, environmental conditions still constrain Army operations. Thus, the potential impact and leverage of environmental factors must be clearly understood in order to increase existing system capabilities and performance, take advantage of environmental weakness within adversary systems, and optimize the design of new systems. The ability of the Army to function properly and efficiently in all these environments requires equipment and tactics designed with full knowledge of the potential effects of the environment. Intelligent planning for the battlefield must take advantage of the environment. An in-depth understanding of individual environments on micro- to macro-scales and capabilities to predict environmental effects and behavior for places and times differing from the “here and now” are required. Advanced simulators for training and mission rehearsal require realistic behavior of atmospheric processes and terrain. Domains of specific interest range from the shallow subsurface, the land surface and the

earth-air interface, to the lower atmosphere and cover surficial environments which vary from the polar regions to the tropics under all weather conditions, both favorable and adverse.

The Army is also committed to be a national leader in environmental and natural resource stewardship for the present and future generations as an integral part of its mission. Responsibilities in this arena include the restoration of sites contaminated through prior Army activities, as well as achieving a state of environmentally sustainable operations on all military installations, particularly those utilized for training and testing. Cost-effective land use and restoration requires in-depth knowledge and understanding of the physical principles and processes operating in the terrestrial and atmospheric domains across a variety of scales which range from the microscopic to megascopic.

The natural environment is, by nature, a multifaceted and dynamic system so that there is an increasing need for multidisciplinary approaches to address the complex research issues that presently characterize the atmospheric and terrestrial sciences. Because of limited resources, not all subjects that fall within the broad interest areas defined below can be included in the current ARO Environmental Sciences research program at any point in time. Emphasis areas are reviewed periodically and funding concentrated in specific areas on a 3-5 year time frame. The submission of white papers is strongly encouraged. For Terrestrial Sciences funding consideration, white papers should be submitted in November of each fiscal year. Offerors whose pre-proposals are evaluated and are found to have significant technical relevance and merit will be requested to submit a complete proposal during the April-May time frame of each fiscal year.

Potential offerors are encouraged to contact the appropriate TPOC for preliminary discussions on their ideas. The TPOC may invite the offeror to submit a preproposal.

8.1. Terrestrial Sciences. In general, the Terrestrial Sciences program is concerned with the impact of the Earth's surficial environment on Army activities. Program interests cover a broad spectrum, ranging from terrain characterization and analysis, mobility considerations under combat conditions and military engineering, to the management and stewardship of its installations as regards the impact of Army activities on the natural environment. Primary emphasis is directed toward understanding the behavior of the land surface and the near-surface environment, understanding the natural processes operating upon and within these domains, and modeling these environments for predictive and simulation purposes. Special emphasis is given to the need to better understand, model/simulate, and predict those environments/conditions that are most extreme, dynamic, or restrictive to systems performance or military operations. The three areas of current interest to the Terrestrial Sciences program are:

8.1.1. Terrain Properties and Characterization. Terrain affects all aspects of Army operations. The effective understanding and use of terrain is critical to military success on the battlefield. It is in effect a force multiplier, affecting mission planning, system performance, unit mobility and effectiveness, and training readiness. At present, the Army cannot rapidly and efficiently perform the terrain analysis that is required before personnel, vehicles, and weapons are deployed. A 'rapid mapping' capability to remotely sense and interpret the features of and upon the earth's surface and an automated capability/methodology for handling and analysis of large aggregates of remotely sensed data are critical for the 21st Century Army. Terrain information may be considered elevation data, soil and environmental characteristics, natural terrestrial features and man-made structures, and urban environments. A capability to remotely sense and interpret the features of and upon the earth's surface, together with an automated capability/methodology for handling and analysis of large aggregates of remotely sensed data, are critical for the for the improved terrain characterization capability required for most of the technology areas important to the *Army Objective Force*. Research related to terrain characterization is directed toward fostering the development of advanced geoscience-based capabilities for the rapid post-acquisition generation, analysis, and utilization of terrain data acquired through remote sensing technology. Characterizing terrain features and conditions from sparse data plus the accurate detection of short-term dynamic surface conditions and terrain feature change are high priority research issues. A problem of particular importance is the accurate remote sensing measurement of soil moisture at the scales of Army operations (*e.g.* 10^2-10^3m). Knowledge of the properties and phenomenology of the surface and near-subsurface is critical to support military operations on land, ranging from operational mobility, the detection of landmines and unexploded ordinance, natural material penetration/excavation, military engineering activities, to training and testing land sustainability. Effective military action requires a rapid and accurate assessment of the influence of soil and rock properties. Strength and deformation properties of geomaterials are highly variable due to the intrinsic heterogeneity of bedrock geology and soil formation processes and moisture content over variable spatial scales, rock mass competency, and groundwater pressure over small spatial scales. A thorough

understanding of the behavior of geomaterials under different environmental and dynamic loading conditions is a critical need for mobility prediction and as input for projectile penetration prediction to destroy hardened and deeply buried targets. Also of concern is the issue that soil and rock properties and behavior measured in the field are typically much different than observed in the laboratory. This dilemma has profound consequences for predicting geomaterial behavior. Specific research is need to provide new approaches to (or techniques for) the non-intrusive geophysical characterization of subsurface materials and their spatial distribution; the prediction of location, frequency, and scale of subsurface heterogeneity; the detection and discrimination of buried objects (particularly landmines, unexploded ordinance, hazardous wastes, and contaminant plumes), tunnels and underground structures; and high-resolution field data sets for non-intrusive measurement validation. The ability to discriminate subsurface features and objects in the presence of surface roughness, natural geologic heterogeneity, and anthropogenic clutter requires advanced signal processing and analysis techniques.

8.1.2. Terrestrial Processes and Landscape Dynamics. Environmental factors can directly affect the Army's strategy, mobility, field operations, and logistics. With the expected increased sensitivity of the future *Objective Force* to these factors, the importance of this information will become even more critical. Therefore, the focus of this research area is the development of an improved understanding of surficial processes within the terrestrial environment that can affect Army operations. The dynamics of natural processes and systems operate over a wide range of scales and are only poorly understood at the time and space scales required by the Army; hence much of what is needed is a fundamental understanding of the appropriate ways to couple processes of highly differing scales and types. A continuous dynamic interaction takes place between solid earth materials and the most abundant fluids, water and air. A variety of dynamic environmental parameters and conditions affect the performance of geophysical sensors. Fluvial processes are dominant in shaping the continental surface through both erosion and deposition. In more arid regions, eolian processes can give rise to both erosional and depositional landforms. Military problems arising from these interactions include localized flooding in battle areas, deterioration of trafficability, and obscuration from blowing dust and sand. The nearshore zone is a complex boundary region where air, land, and sea interact over a wide range of space and time scales. It is also a region in which incident energy is often dissipated or transformed to motions at other scales. The result is a highly non-linear, coupled, dynamic system. Surface waves, coastal circulations, and sediment transport all have important impacts on Army operations within this region; however, information on these processes is essentially nonexistent for most areas around the globe. At 0°C, water changes from the liquid to solid phase, resulting in the formation of snow, ice, and frozen ground. Such conditions dramatically alter the battlefield environment and affect the performance of systems and materiel. Icing is a particular issue for aircraft, rotorcraft, optical sensors, and antennas. An improved understanding of the fundamental character and dynamic nature of the surface environment and its evolution through time, as well as the consequences of military interaction with this environment, is essential for the continued development, improvement, and sustainability of Army training and testing activities. In particular, there is a need for the development of first-principle physical/chemical process models and computer-based techniques for monitoring, modeling, and simulating the natural environment, as well as improved technologies and methodologies for environmental characterization and prediction. Special emphasis is given to the need to better understand, model/simulate, and predict those environments/conditions that are most dynamic or restrictive to systems performance or military operations. The development of an improved understanding, physical representation, and quantification of terrestrial processes affecting Army operations are of particular interest to this research area. Improved measurements and theoretical treatments are needed to treat the complex, often nonlinear dynamics governing these processes, which are a result of both physical and biologic processes and the interaction of these processes with terrain evolution. Such processes operate over a wide range of discontinuous time and space scales, which make them extremely difficult to characterize, quantify, and model. Explicit consideration of these processes and their interactions will lead to critically needed improvements in the ability to predict environmental effects on Army operations. Important in this context is research that seeks to the response of landscape to modification by Army use and the fundamental nature of subsurface flow and mass transport and then numerically model these complex processes. Critical to developing an engineering-scale understanding of the properties and behavior of surface environments is a fundamental knowledge about the natural processes that operate on surficial materials at a variety of scales. Field observation, laboratory experiments, and computational modeling must be integrated to solve well-formulated problems. Predictive geotechnical models, based upon well-characterized constitutive relationships, are required to identify controlling processes and parameters across a spectrum of scales. Extreme environments (hot, cold, dry, and wet, or combinations thereof) pose unique challenges to future Army systems and personnel because deserts, tropics, and cold regions are extremely hostile environments that dramatically affect human and materiel performance, thus inducing a negative effect on the performance of military systems and operations. Extreme

environments also are important because they can exhibit unusual recovery rates following disturbance. Within the US, approximately 70% of DOD lands occur in highly sensitive arid and semi-arid environments. The character of terrain in arid environments can determine how military operations are conducted on these lands and military activities can directly impact the terrain in a manner that causes both short-term and long-term stresses on the surficial environment and ecosystem. The repeated use of such lands for military purposes, particularly training and testing activities, increases the risk of soil disturbance, damage to vegetative cover, degradation of water quality, and the disruption of animal populations and archeological sites. These impacts can be particularly adverse over the long term as battlefield readiness and sustainable training requirements place significant demands on the delicate terrains that characterize arid and semi-arid environments.

8.1.3. Terrestrial System Modeling and Model Integration. One the objectives of research to characterize the natural environment and understand terrestrial processes is to better prepare the soldier for combat through the development of the next generation of battlefield decision aids. An important application of this research is to develop or enhance integrated system models and simulators. A vision of terrestrial system models for the *Objective Force* includes products that enhance mission success through improved decision-making. The future battlefield will generate massive amounts of data that describe this space. Synthetic models will be essential to supporting leaders in the real-time analysis of battlespace terrain data and in selecting the best courses of action for a particular terrain or environmental situation. The Army maintains various modeling and simulation systems, such as the and the SYNTHERM cold climate energy balance model, NATO Reference Mobility Model, the Engineer Obstacle Planning System, the Surface Water Modeling System, the Groundwater Modeling System, the Watershed Modeling System, the Army Training and Testing Area Carrying Capacity Model, and the Integrated Dynamic Landscape Analysis and Modeling System to name but a few. These current systems allow for the computation of a variety of outputs, including mobility analyses, watershed response, groundwater flow and transport, military reservation land use response, and prediction of winter specific engineering effects. The Army is continually developing new features for existing numerical models and, in some instances, new environmental model systems, such as the emerging Land Management System. Research products, to be fully useful, must be integrated into modeling systems. This is often a non-trivial undertaking. The integration of the output from existing models offers many challenges related to different computational domains, resolution, and time scales. The ability to integrate advances in fundamental theory and process understanding is necessary to fully exploit these advances. The Army also faces a host of management and logistical issues, ranging from traditional training and testing to installation range management and coastal logistics, which require the coupling of models and analysis tools of highly contrasting scale for more effective decision making and long-term planning. Not atypically, differing processes exist at often radically different, but interrelated time and space scales. A fundamental understanding is needed of the appropriate ways to consider heterogeneous and dynamic terrain properties, couple natural processes of highly differing spatial scales, and the most efficient methods to model interrelated physical and ecological phenomena.

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8.2. Atmospheric Sciences. The Army has the responsibility to provide fundamental knowledge of the atmospheric boundary layer over land to all US armed services since that boundary layer is the primary theater for Army operations. Intelligence preparation of the battlefield depends on a full knowledge of atmospheric conditions and their effects on operations, weapon systems, and the soldier. It requires an ability to estimate atmospheric details at specific locations and at present and future time to maximize strategic weather advantages. Knowledge of the atmosphere and its effects on soldiers and sensor systems are essential for command and control as well as visualization of the battlefield at all echelons. The Army lead responsibility for chemical and biological defense requires detailed knowledge of the threat once it is induced into the air. In garrison, Army training and preparedness depend on accurate representation of atmospheric test conditions and on physically correct portrayal of atmospheric processes and effects in simulations.

The research program is broadly based to address the wide spectrum of conditions and influences of the atmospheric boundary layer on Army operations and systems. It is divided into three general research areas of the boundary layer problems: atmospheric effects on sensors and systems, characterization of the atmosphere at high resolution, and management of atmospheric information

8.2.1. Atmospheric Effects on Sensors and Systems. The Army depends heavily on propagation of electromagnetic and acoustic signals through the atmosphere for detection, ranging and operation of smart munitions as well as

reconnaissance and information dominance of the battlefield. Atmospheric turbulence can severely impact the performance of optical and infrared sensors as well as acoustic detection systems by affecting the propagation, imaging, and coherence of the received signals from active or passive systems. Furthermore the effects of surface and natural environmental conditions on propagation of images and signals must be considered because of the near-ground operation of many Army systems.

8.2.2. Characterization of the Atmosphere at High Resolution. Research efforts concentrate on increasing Army knowledge of physical processes in the atmospheric boundary layer at the engagement scale of the battlefield. This scale, characterized by horizontal distances to 20 km at resolutions at 10's of meters and times of seconds to hours, is the most inhomogeneous and changeable portion of the atmosphere.

The principal research concern is the diurnal evolution of the turbulent and stable atmospheric boundary layer. Research topics span a full spectrum of atmospheric boundary layer dynamical conditions including, but not limited to: parameterization and scaling of boundary layer processes for micro scale and mesoscale predictive models; surface conditions from simple to heterogeneous terrain elevation and slope, vegetation, and moisture; surface energy budgets; scale interactions; temperature and moisture fluctuations, especially as they affect the atmosphere as a medium for propagation of acoustic and electromagnetic signals; and natural or induced obstructions to visibility. A principal focus of the boundary layer dynamics is their application to prediction of the mean and fluctuating concentrations of chemical and biological agents in realistic terrains on appropriate scales.

Comprehensive measurements of wind velocity, temperature, moisture, surface energy exchanges and fluxes at resolutions showing their scales of variability in the atmospheric boundary layer are essential for advancing understanding of boundary layer processes affecting Army operations and systems. The variables should be measured in space and time to clearly define the evolution of three-dimensional physical processes within a volume of interest. Such measurement programs should highlight both the instrumentation development and the interpretation of the physical processes from the sensed data.

These topics are considered from perspectives of theory, field experiments, and analyses of the faithfulness and validity of models and simulations of these processes. The research results are expected to contribute to improved models of boundary layer processes for visualization and field use through strong interactions with appropriate Army laboratory scientists.

8.2.3. Management of Atmospheric Information. Providing useful atmospheric effects information to the soldier and decision maker is the focal point of the Army's atmospheric sciences effort. The information needs of each user may be very different. Furthermore, the information must be in a form that is readily understood in light of the user's needs. At the same time, the path from data to information must have a fundamental scientific basis. The science issues behind the information management include an ability to obtain data from multiple sources, friendly or adverse, quantitative and qualitative; fusing the data into a comprehensive representation of the present and future atmospheric state; understanding of the uncertainties of the data and their effects on the application; and communicating the complex four dimensional atmospheric in the language and application of the user. To accomplish the goals of information management, improved computational methods are needed to assimilate and integrate the data, assess the atmospheric present and future state, and disseminate the user's needed information in a timely and effective manner.

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RESEARCH AREA 9
MATHEMATICAL SCIENCES

9.0. Mathematical and computational methods pervade research, development, testing, and evaluation problems encountered by the Army. Furthermore, increasing demands are being placed on research in the mathematical sciences because of their fundamental role in the analysis and modeling issues that arise in military science, engineering and operations. Although these problems are often and quite naturally stated in terms of their system or

operational implementation, their solutions are usually dependent on a number of mathematical subdisciplines. For example, some promising approaches to computer vision for automatic target recognition (ATR) require research in a wide range of areas including constructive geometry, numerical methods for stochastic differential equations, Bayesian statistics, tree structured methods in statistics, probabilistic algorithms, and distributed parallel computation. Another example is furnished by simulation. Here improvements depend on a large number of research areas including large scale scientific computing and real time computing for embedded systems. Similarly, recent research on dynamical systems, control theory, logic and concurrency is being applied to the extraction and verification of digital control programs for continuous systems.

In this announcement, the Army Research Office areas of interest will be described to the potential researcher and user mainly by means of research topics within mathematical sciences. This procedure has the benefit that our program managers can amplify the worth of their programs by funding research topics that have impact on many different problems.

To be able to respond to the increasing demands on the mathematical sciences, the ARO attempts systematically to advance fundamental knowledge that focuses on the needs of the Army. To accomplish this objective, the Division supports extramural basic research in the five areas that follow. A program represents each of these five areas. The research supported by the Division does not cover all or even the majority of topics in these areas. Rather, it covers only certain sub areas that are of strategic importance for the Army. Programs typically have two to four foci. There are unavoidable overlaps between programs. The sub disciplinary boundaries within the Division and the disciplinary boundaries in the ARO are not rigidly drawn and there is strong interest in and appreciation for multidisciplinary research in which the mathematical sciences play a major role.

Potential offerors are encouraged to contact the appropriate TPOC for preliminary discussions on their ideas. The TPOC may invite the offeror to submit a preproposal.

9.1. Modeling of Complex Systems. The Modeling of Complex Systems Program is a program of fundamental mathematics-oriented research the objectives of which are to develop quantitative models of complex phenomena of interest to the Army, especially those for which current models are not based on first/basic principles, and to develop new metrics, preferably those based on first/basic principles, for these models. The complex phenomena of interest to the Modeling of Complex Systems Program include (1) physical phenomena, (2) abstract phenomena in information theory and networks and (3) behavioral phenomena. Complete and consistent mathematical frameworks for the modeling effort are the preferred context for the research, but research that does not take place in such frameworks can be considered if the phenomena are so complex that the frameworks are not feasible. Metrics are part of the mathematical framework and are of great interest. Traditional metrics, when they exist, often do not measure the characteristics in which observers in general and the Army in particular are interested. For many complex phenomena, new metrics need to be developed at the same time as new models. Just as is the case for the modeling effort, these metrics should preferably be in a complete mathematical framework. The research in modeling of and metrics for complex phenomena of interest to the Modeling of Complex Systems Program may include numerical/computational work as a subordinate component. However, research that focuses mainly on numerical/computational issues should be directed to the ARO Computational Mathematics Program. The investment in the Modeling of Complex Systems Program is in the following seven areas.

9.1.1. Advanced Complex Materials for Structures, Armor and Sensors. The analysis, design and manufacture of advanced materials is an interdisciplinary area in which the basic principles are often known. However, the current models for meso and macro behavior of materials are often not based on these principles because implementation of the basic principles in the models results in inordinate complexity and because principles on intermediate levels are not well known. The Modeling of Complex Systems Program supports research oriented toward optimizing properties or performance characteristics of highly nonlinear materials, including advanced composites for structures and armor and smart materials for sensors. Lightweight, high-strength structural components, including advanced composites, contribute to attaining mobility and protection requirements for U.S. Forces (as well as to the fuel efficiency and safety of the U.S. automobile fleet). Advanced composites are challenging to analyze and design because of the presence of many interacting length scales. Smart materials, the functional ingredients of actuators, sensors and transducers that have a load- or field-dependent (crystal or other) structure. Such materials may undergo a phase transformation when some mechanical, thermal, electrical or magnetic factor changes and vice versa. Advanced composites and smart materials are typically highly nonlinear. In seeking to understand the

relationship between the microscopic and macroscopic length scales of these materials, fundamental issues in nonlinear modeling arise. The program invests in research on these fundamental issues, including development of basic equations and constitutive laws.

9.1.2. Inverse Scattering in Complex Media. Inverse scattering is of interest to the Army for detection and identification of landmines and unexploded ordnance with low false alarm rates. This is an area involving the interaction between the propagation of various types of waves in cluttered soils and the inverse problem of detecting location, shape and material properties of solid objects having various waveform signatures. Currently available techniques often have high false alarm rates, which impede mine clearance. Additional Army interests include electromagnetic sensing through cluttered battlefield atmospheres, including smoke, fog, flames, etc. Application of inverse scattering techniques for standoff detection of chemical and biological agents is of interest. One of the directions of research is that of creating models for currently unused sources of information, validating these models and integrating them into larger models or systems. Traditionally, imaging by ground-penetrating radar and by x-rays has utilized information only from singly scattered waves, that is, waves that are scattered by a collision with only one object and then return to the detectors. For such imaging, multiply scattered waves that arrive at the detectors create error, because they are erroneously presumed to have resulted from a single scattering event. However, multiply scattered waves contain information, not just error. Creating models that are able to access the information in multiply scattered waves is of considerable interest. Integrating these models into models/systems that also use the information in singly scattered waves is of interest. Research on multiple scattering in complex media includes research on models for utilizing other sources of information that are ignored by current models.

9.1.3. Modeling of Multiscale Objects and Functions. Representation of complex, multiscale/mulitresolution geometric objects and of complicated, often high-dimensional, abstract phenomena and functions is fundamental for Army, DoD and civilian needs in modeling of terrain, geophysical features, biological objects (including humans and their clothing), computational learning and many other objects and functions. Real-time visualization of huge terrain databases with glitch-free zoom-in/out cannot be achieved with current techniques. Progress in automatic target recognition, robotic vision, representation/compression of data in general and many other areas depends on advances in approximation theory. A key to achieving these goals is data compression at ratios and with accuracy that exceeds what is currently known. A multitude of variants of piecewise planar surfaces (including those on triangulated irregular networks or "TINs"), splines, multiquadrics, kriging, wavelets, neural nets and many other techniques developed in the past perform well on many types of data. However, none of these procedures are able to provide, without human intervention, representation of geometry and data with the accuracy and compression that is needed. To achieve such representation, new types of approximation theory appropriate for complicated multiscale/multiresolution surfaces and phenomena need to be developed. In these cases, the objects/functions being approximated are not consistent with the assumptions of classical approximation theory. Approximation theory research that results in highly compressed, loss-free or minimally lossy representation is of particular interest. Approximation theory for information flow and other abstract items in large communication and computer networks is an area of interest. The approximation theory developed under support of this program is expected to provide building blocks for computational geometry, pattern recognition, automatic target recognition and visualization systems. However, research that is focused on these areas rather than on approximation theory is beyond the scope of the Modeling of Complex Systems Program and fits best with the Image Fusion, Processing and Circuits Program of the ARO Computing and Information Sciences Division and with the Discrete Mathematics and Computer Science Program of the ARO Mathematical Sciences Division.

9.1.4. Nonlinear Dynamics for Communication. Enhanced capability in digital communication is recognized as a pivotal element in a modern economy and in national security. At present, digital communication is carried out mainly by linear devices, that is, by transmitters and receivers operating in the so-called linear regime. The option of creating digital communication systems based on transmitters and receivers operating in the nonlinear regime is already under investigation. One type of nonlinear behavior on which these transmitters, receivers and codes can be based is chaos, that is, the deterministic but complicated behavior of physical systems in which arbitrarily small changes in the input produce large changes in the output. The potential advantages of nonlinear digital communication devices include increased power and bandwidth efficiency, light weight, compactness, increased information-bearing capacity, greater number of channels, low-cost manufacturing, low probability of interception (LPI) and low probability of detection (LPD). The Modeling of Complex Systems Program is interested in the nonlinear modeling that needs to be done to create new, nonlinear transmitters, receivers and codes. Research in controlling chaos, which is inherently unstable, is ways suitable for these devices and codes is important.

Investigation of the information theoretic and symbolic dynamic properties of the signals produced (for example, size of alphabets, grammatical constraints on symbol sequences and entropies) is of interest. This research should be carried out in the context that leads to simple, inherently nonlinear devices. However, the engineering design of such devices is outside the scope of the Modeling of Complex Systems Program and fits best with an appropriate program in the ARO Electronics Division. Soliton theory for fiber optics communication is an important area of research but is beyond the scope of the Modeling of Complex Systems Program.

9.1.5. Data Fusion in Complex Networks. Enhanced capability in distributed sensing by organized or self-organizing networks of large numbers of geographically dispersed sensors, often microsensors (acoustic, infrared, magnetic, etc.), of various modalities is increasingly recognized as a pivotal element in the ability of defense forces to accomplish their mission. Such networks are a potential replacement for landmine fields. Over the past generation, great progress has been made in research and development of low-cost sensing devices. When networks contain small numbers of sensing devices, issues of network organization and topology and issues of information processing can often be addressed in known scientific/engineering frameworks. However, when networks contain large numbers of sensing devices, issues of information flow and information processing are a challenge for which basic principles remain to be created. Such basic questions as how to measure "goodness" or optimality are still open. As the number of devices in distributed sensing systems increases from hundreds to thousands and perhaps millions, the amount of attention paid to information flow and processing must increase sharply. The Modeling of Complex Systems Program is interested in research on information flow and information processing in large, dynamic networks of sensors, primarily microsensors with limited capabilities and power. Development of metrics, preferably based on first principles rather than ad hoc, for measuring goodness is a topic of concern. Developing models (more likely nonlinear than linear) for linkage of scales in the information processing system for large networks is of interest. Research that leads to improved information processing under strong constraints on power and communication bandwidth is of particular interest.

9.1.6. Dynamics of Distributed Networks of Embedded Sensors and Actuators. Low-cost wireless networking, which is now becoming common, may be the catalyst that will lead to networking of embedded devices in Army and DoD sensing and weapons platforms, vehicles, soldiers and command and control organizations. The analysis and design of networks of embedded sensors and actuators will involve modeling at much deeper levels than that of bit flow. This design and analysis requires a solid mathematical foundation focused on issues of stability, robustness and performance not merely of the sensors and actuators but also of the people and objects in which they are embedded.

9.1.7.. Additional Areas of Opportunity. Behavioral modeling is an area of nonlinear modeling for which few basic principles are currently known. Research in this area is critical for military and civilian decision-making, training and rehearsal. The nonlinear modeling of information flow and other abstract issues in large communication and computer networks is of interest. Approximation theory research mentioned above under *Modeling of Multiscale Objects and Functions* may be a component of this modeling. Modeling information flow and other dynamics in large networks is important research that is required for information assurance, that is, for protecting networks from unforeseen catastrophes and from deliberate attack. Analytical procedures that provide new ways to "image" networks, such as "network tomography" (deduction of network topology or other network properties from measurements at a limited number of nodes and/or over a limited number of paths) will be required for the maintenance and protection of networks. The interests of the Modeling of Complex Systems Program include these areas and also include mathematics-oriented research for other complex phenomena of interest to the Army that may be proposed by researchers.

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9.2. Computational Mathematics. The Computational Mathematics program supports basic research on innovative, efficient and accurate numerical methods, optimization techniques and scalable scientific software tools. Since quantitative predictions based on most modern theories require extensive computation, new methods and tools are needed to assure that mathematical models can be translated into realistic simulations. Such simulations are needed to understand, design and optimize the solution to the more complex problems faced by the Army. The overall focus of the Computational Mathematics program is on algorithmic problems which arise with new applications and on the exploitation of common features from different application areas to define problem classes and develop general solution methods.

9.2.1. Numerical Methods. The primary interest in this subarea is on finding solutions to algorithmic problems associated with currently intractable computational problems and new applications. Among the barriers that need to be addressed are interacting subsystems, multiple scales and the effects of uncertainty. Different mathematical models at different scales may describe different parts of a numerical simulation. New methods are needed to couple different types of models, simplify the complexity of systems and accurately compute small-scale effects in a large-scale simulation without brute force. Algorithms need to be designed to take advantage of the mathematical structure of potential applications. It may be advantageous to develop stochastic algorithms for deterministic problems or deterministic approaches for stochastic problems. Rigorous analysis is needed to determine structure, predict algorithm performance and drive adaptivity. Design, control and optimization require that simulations be performed many times. To accelerate such repeated simulations, reduced order models and fast algorithms in core areas such as linear algebra, ordinary differential equations and partial differential equations become important. Considerable progress has been made on the numerical treatment of interfaces, singularities and difficult boundary conditions but new applications may generate new difficulties. Uncertainty arises in models, parameters and interactions among components. Systematic methods are needed to evaluate and quantify the effects of these and other sources of uncertainty.

9.2.2. Optimization. As computing power increases, optimization will replace trial and error as the approach of choice for the solution of DoD problems. Problems of interest to the Army in science, engineering and operations are usually large, nonlinear and global with many local minima. A single problem may contain continuous, discrete and integer variables. The primary interest in this subarea is in mathematically sound methods for solving such problems. The emphasis is on methods rather than specific applications. Rigorous mathematical analysis is an essential part of this effort.

9.2.3. Software Tools. As numerical computations become larger and more complex, non-numerical issues become important. Computers have different architectures, multiple processors and complex memory hierarchies. Data is distributed among multiple computers connected to each other over networks with different bandwidths. Without mathematical tools that map algorithms to architectures with minimal input from programmers and users, computation on such systems is very difficult. In addition, large-scale computations produce huge data sets. Thus tools are needed to extract useful information from such data sets and to present results in ways that are easily understood. Progress has been made in grid generation, adaptivity and load balancing but new applications may generate new problems. Some tools have been developed but are not widely used. Therefore it is important to determine why this is so and what can be done to make such tools more useful for programmers and users. This subarea overlaps with the Discrete Mathematics and Computer Science program.

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9.3. Stochastic Analysis, Applied Probability, and Statistics. The Stochastic Analysis, Applied Probability and Statistics Program support critical Army needs in decision making under uncertainty.

9.3.1. Stochastic Analysis and Applied Probability. Army research and development (R&D) programs directed toward system design, development, testing and evaluation problems generate a need for research in the field of stochastic processes, including stochastic differential equations. Special emphasis is placed on research into methods for the analysis of observations from phenomena modeled by such processes and to numerical methods for stochastic partial differential equations. Research areas of importance to the Army in probability and its applications include stochastic optimization and approximation, stochastic control, large deviations, simulation methodology, spatial processes and image analysis. Ideas are needed from Markov random fields, renormalization of the state space, scaling of time, nonlinear stochastic analysis and infinite-dimensional stochastic differential equations. The techniques required include Brownian flows, infinite-dimensional stochastic processes driven by Poisson noise and Levy noise.

9.3.2. Statistical Methods. There is great interest in statistical methods for very large data sets or very small data sets, sampled from nonstandard, poorly understood distributions. The extraction of more information from small data sets requires improved methods for combining information from disparate sets, as in meta-analysis. Useful statistical models should be based on a thorough understanding of physical processes combined with sound statistical theory. Thus, it is important to integrate statistical procedures with scientific and engineering information

about mechanisms as exemplified by a probabilistic methodology that describes the nature of the growth of cracks in different media and the associated statistical analysis. More research is required in several statistical areas including Bayesian methods, Markov random fields, cluster analysis, change point methods, and Markov chain Monte Carlo methods. It is important to bring novel statistical thinking into resource management and optimization in very large communication and logistics networks.

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9.4. Discrete Mathematics and Computer Science. As suggested by the title, the Discrete Mathematics and Computer Science Program supports Army needs in discrete mathematics and theoretical computer science.

9.4.1. Discrete Mathematics. The interests in discrete mathematics are the development and analysis of solution procedures for discrete problems in computational geometry, computational algebra, logic, network flows, graph theory and combinatorics. Specific areas of emphasis include robust geometric computation, solid modeling, multi-resolution methods, parallel and distributed computing and dynamic interactive visualization techniques. Other areas of interest include distributed algorithms for network flows, randomization in computing, computational algebraic geometry techniques for solution of polynomial systems, discrete methods for combinatorial optimization, symbolic methods for differential equations, mixed symbolic-numerical methods for applied problems, parallel symbolic sparse matrix methods, and algorithmic methods in symbolic mathematics arising in, for example, automated reasoning systems, mathematical logic and formal language theory.

9.4.2. Theoretical Computer Science. The interests in this subarea include fundamental issues in parallel computing such as advanced data structures for parallel architectures, parallel algorithms, graph theoretic methods applied to a parallel and distributed computation and models and algorithms for the control of heterogeneous concurrent computing. Also of interest is research on tools for the development of parallel algorithms and expert systems for computation and visualization of solutions to partial differential equations. Exploring fundamental techniques that optimize I/O communication is a research area of great strategic importance.

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9.5. Cooperative Systems The objective of this work-package is to study and take advantage of the combined power of collaborative systems pertaining to groups of robots and other complex systems. An example is the cooperative activity of robots or communication systems with changing relative topology in the battlefield. Research areas include the mathematical foundations of system theory, communication nets, the swarming phenomenon, game theory, large data set manipulation, decision-making, and data processing related to intelligent systems.

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RESEARCH AREA 10
ELECTRONICS

10.0 Electronics. Electronics is widely recognized as a key force multiplier, underpinning the Future Combat System, as well as the Objective Force as an essential means to achieve technological superiority. The U.S. Army Research Office's Electronics Division seeks to support scientific and engineering endeavors in research areas that possess the potential to define new electronic capabilities or to enhance future electronic performance. The Electronic research sub-areas are Solid State Devices, Optoelectronics, Quantum Electro-Magnetic Devices, Sensors and Detectors, Electromagnetics and RF Circuit Integration, and Terahertz Science and Technology. We invite proposals for research to advance our understanding of electronic devices, materials, and processes with a strong prospect for use in future Army technology. Potential offerors are encouraged to contact the appropriate TPOC for preliminary discussions on their ideas. The TPOC may invite the offeror to submit a preproposal or white paper.

10.1. Solid State Devices. This research area emphasizes efforts to establish a new and comprehensive base of knowledge for the electronic, photonic, acoustic and magnetic properties of solid-state materials, structures and devices. Functions such as very intelligent surveillance and target acquisition; command, control, and communications; electronic warfare; and reconnaissance, must be accomplished with the high data rates and real-time capability that are essential for these applications. To support the U.S. Army vision of Objective Force and Future Combat System of Systems (FCSS), these systems will need to operate at much higher speeds and frequencies, have greatly increased functionality, and have much higher levels of integration than present day technology provides. Therefore, fundamental research in the area of Solid State Devices is the corner stone and an essential requirement in the development of these future systems for military defense.

To establish the needed science base for future Army battle-space capabilities, innovative research is sought in the general areas of; novel electronic materials for advanced devices, nanoscale processing and fabrication science, nano/molecular electronic science and technology, nanoscale physical modeling and advanced simulation, ultrafast electronics, advanced device concepts, mixed technologies (electronic, photonic, acoustic & magnetic), heterogenous devices and technologies, micromachined devices and ultra-low-power technologies. Therefore, the program currently emphasizes fundamental research in, (1) Nanoscale Growth and Processing Science, (2) Nanoscale (Semiconductor) Electronics, (3) Molecular Electronics and (4) Advanced Device Concepts, with a focus towards identifying and overcoming existing scientific barriers. Important science and technological barriers include, but are not limited to, the discovery and implementation of new and revolutionary growth techniques for engineering materials and for mixing and matching diverse material systems; the development of novel processing, fabrication and self-assembly techniques for realizing effective integration of diverse materials and devices into ultra-dense and complex solid-state electronic systems; the establishment of a theoretical base of knowledge into conventional and non-traditional (molecular) nanoscale electronics for bridging the gap between today's microelectronics to the future where molecular devices will be integrated with nanoscale semiconductor devices and components; the development and implementation of accurate physical models and robust simulation tools for identifying novel ultra-small device concepts and complexly-coupled nanosystems and accurately predicting their behavior; the development of a comprehensive science base that will provide fundamental insights into quantum-confined structures with time dynamic, nonequilibrium, dissipative electronic processes that are imbedded in practical circuits with realistic interconnects; and the development of new and effective integration techniques for realizing complex heterogeneous devices (i.e., devices utilizing different materials and operating on different physical principals) and mixed technology systems.

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10.2. Optoelectronics. Research in this subarea includes novel semiconductor structures, processing techniques, and integrated optical components. The generation, guidance and control of optical/infrared signals in both semiconductor and dielectric materials are of interest. The Army has semiconductor laser research opportunities based on quantum dot and quantum well semiconductor materials operating in the eye-safe (>1.55), 3-5, 8-12, and 18-24 microns regions for various applications, such as ladar, IR countermeasures, and free space/integrated data links. Research is necessary in semiconductor materials growth and device processing to improve the efficiency and reliability of the output of devices at these wavelengths.
High performance devices and components will be optimized for applications including high-data-rate optical networks. Interfacing of opto-electronic devices with electronic processors will be investigated for full utilization of available bandwidth. Electro-optic components will be studied for use in guided wave data links for interconnections and optoelectronic integration, all requirements for high speed full situational awareness. Optical interconnect components are needed in guided-wave data links for computer interconnection and in free-space links for optical switching and processing. For optical processing of images, research leading to two-dimensional (2-D) arrays of surface-emitting lasers is necessary. Research addressing efficient, novel optical components, such as optical micro-electro-mechanical systems (MEMs) is needed. Emitters and architectures for novel display and processing of battlefield imagery are important.

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10.3. Quantum Electro-Magnetic Devices. The Army has a need for devices and components that exploit multi-field interactions in suitable materials leading to a new class of quantum-effect devices for sensing, display, data storage, and information handling. Research on the generation, detection and control of electronic, optical, and magnetic signals in both semiconductor and dielectric materials is of interest. In particular, novel electro-magnetic processes leading to greater manipulation and increased sensing/data handling capabilities are to be considered. Crystalline and amorphous wide bandgap semiconductor materials are of interest as host materials for rare earth and transition metal ions. Typical applications for these materials include robust, multicolor, multi-layer thin film displays and spin-polarized sensors for chem.-bio detection. Such devices will be especially critical in the development of miniature, unmanned platforms operating in hostile environments. In order to realize such devices it is necessary to explore the electrical, optical, magnetic, and acoustical multi-field interactions in advanced materials, such as AlGaInN, AlGaP, and ZnO. Novel structures, at the micro- and nano-scale level, need to be developed to optimize the multi-field quantum-effect interactions. Device concepts that exploit these interactions for enhanced sensing, display, data storage, and information handling need to be explored. In order to establish the science base for this new class of quantum-effect devices, innovative research is sought in the general areas of:

a. Methods for altering the electronic, optical, and magnetic properties of semiconductor materials

b. Rare-earth and transition metal doping of semiconductors and dielectrics,

c. UV-visible photonics in III-V nitride compound semiconductors,

d. Efficient, eye safe lasers leading to high power operation,

e. Control of photonic-magnetic interactions in nanostructures.

Research is to include demonstration of proof of principle devices employing novel phenomena and interactions. Research issues relating to design, modeling, and fabrication of these devices are of interest. Characterization of materials and devices at the nanoscale is to be performed to determine the electrical, optical, magnetic, and piezo-electric properties of prototype devices. This knowledge is to be used to understand the limitations of such quantum-effect devices and to establish the basis for unique sensing, display, data storage, and information handling opportunities. These investigations are necessary to determine the ultimate performance ranges of field-controlled, quantum-effect nano-devices and to provide increased functionality and capabilities for the Objective Force.

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10.4. Sensors and Detectors. The Army requires high resolution, high sensitivity, but also affordable, multi/-hyperspectral and polarization sensitive, active and passive, IR sensors for target acquisition, recognition, and identification in the digital battlefield. Research opportunities include components based on quantum confined devices and semiconductor materials operating in the infrared 1-24 microns regions, as well as ultraviolet (UV) detectors. Studies involving growth, defects, interfaces, doping, and other electronic characteristics will be considered. Efforts aimed at raising the operating temperature of conventionally "cooled," high performance, infrared detectors (to >120K for TE cooling in vacuum and >190K for TE cooling w/o vacuum), as well as, increasing the performance of "uncooled" infrared detectors are also sought. Research involving novel multispectral structures including adaptive spectral selection will be considered. In addition, the next generation IR imaging systems will use large area, multispectral, staring arrays with considerable front end processing to provide multi-wavelength spatial and temporal detection. Development of the necessary architectures and the optical processing components provide additional research challenges. New device concepts are needed for all the above applications.

The sensing of vehicles, personnel, chemicals, landmines, and biological agents is critical for battlespace deconfliction, and new or improved sensing methods to increase battlespace situational awareness are needed. Sensing technologies currently include acoustic; seismic; radar (RF to millimeter wave) and passive electromagnetic; hyperspectral, etc. Other, novel, sensors will be considered, as well as, sensor fusion and networking that results in a sensor system for Army applications.

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10.5. Electromagnetics and RF Circuit Integration. The Army Transformation to the network-centric Objective Force is driving the need for basic research supporting mobile, multifunctional, reliable, and high-performance communications and sensor systems. The increasing need for high data rate communications and all-weather operating capability is pushing design frequencies into the millimeter wave regime, where the unique propagation characteristics of short wavelengths can produce system size reduction, high-resolution imaging, and large bandwidth. The proliferation of radio systems has increased the need for rugged, compact, multifunctional, low signature, lightweight, low-cost, and electronically steerable antennas. High average energy efficiency and low instantaneous operating power are required to reduce the logistics burden on deployed forces. Extensive modeling and simulation of the systems and their interaction at close proximity and at long range over varied terrain is required for design, analysis, and optimization. In Electromagnetics and RF Circuit Integration, research falls into the following general technical areas: computational electromagnetics, antennas, RF component development, RF circuit integration, and mine detection.

Problems of interest in computational electromagnetics can be divided into two regimes: device, circuit, package, and antenna modeling at short length scales, and radio wave propagation modeling at large length scales. Advanced models and simulations tools must be developed to accurately predict device, circuit, package, antenna, and system performance. Of special interest are physically-based models that enable the simulation of integrated circuits and modules as the levels of integration become higher and higher, as the circuits become denser and more complex, and as new circuit types such as leaky wave, quasi-optical, and active antennas must be addressed. The coupling of radiation into and out of complex structures is a problem of special interest. For increasingly complex systems, new analysis concepts, techniques, and methodologies are needed with improvements in algorithm speed and efficiency including order reduction and design for inherently low computational dispersion. The human interface for these tools should simplify the problem setup, data presentation and analysis process, possibly including knowledge-based tools, and allow the integration of multiple computational engines.

Propagation effects have a major impact on communications and radar systems. Research is sought leading to innovative and efficient techniques for near-real-time propagation modeling, capable of point-to-point calculations over paths that include urban, rural, and foliated environments with natural and man-made structures including tunnels, validated with appropriate experimental data, with effective interactivity and information delivery to the user.

Innovative approaches are needed to increase the performance and decrease the size and signature of tactical antennas operating from the HF to W frequency bands. Novel and new materials, configurations, and fabrication techniques for multifrequency, multiband operation are of interest. Broad impedance bandwidths and pattern bandwidths are required for spread spectrum systems. Fast frequency switching circuits and techniques for tunable antennas that minimize nonlinear effects over a wide band of frequencies are required for frequency hopping systems. Efficient coupling of electromagnetic energy into the ground is required for ground penetrating radar antennas. In addition, radically innovative approaches are needed to increase the performance and reduce the cost of electronically steerable apertures (ESA), including novel feed networks that improve antenna performance and reduce the cost of support circuitry. Furthermore, completely new approaches are sought for a new class of antenna elements that are efficient, point sensors and radiators of the vector electromagnetic fields with little or no mutual coupling for highly oversampled antenna arrays giving improved direction finding capabilities and radiation pattern control.
The electronic systems of the future will operate in an increasingly dynamic and complex spectral environment. This drives the need for innovative concepts that will produce devices and components with extremely high dynamic range, extremely wide instantaneous bandwidth, extremely high linearity, and multi-channel phase tracking. The requirements for dynamic range, bandwidth, and linearity apply to active devices such as power amplifiers and low-noise amplifiers, as well as to passive components such as filters, mixers, couplers, etc. Because these devices and components will be used in mobile systems and because energy storage technology has not kept pace with developments in electronic technologies, the active components must also be energy efficient with low instantaneous peak power requirements and the passive components must have low losses. Optimal partitioning between digital and analog technology combined with new circuit topologies will be critical.

Integration technologies provide millimeter-wave/microwave circuits at small size, lightweight, low cost, and high reliability. Novel techniques for integrating circuits are of special interest at higher frequencies in order to overcome loss, coupling, and spurious radiation problems. Hybrid techniques that combine high performance from

component optimization with low fabrication cost due to compatibility with high volume production processes are needed. Fabrication and integration techniques including dense 3-D and heterogeneous integration must be developed that give the system designer access to transmission lines with constant impedance over wide frequency range, inter-layer high-frequency and optical interconnect, hermetic self-packaging, and ease of assembly and handling. Thermal/mechanical effects must be analyzed and minimized. Innovative approaches such as micromachining will provide significant advantages for circuit integration and the production and integration of passive components, including integrated antennas.

Innovative electromagnetic and hybrid approaches are needed for the detection of mines and buried ordinance. Radar, acoustic electromagnetic induction, gravitometers, nuclear and infrared techniques have been applied in traditional approaches. Innovations on the traditional approaches and hybrid combinations with potential improvements in usability and probability of detection with significant reduction in false alarm rate are of interest to this program.

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10.6. Terahertz Science & Technology. This research area emphasizes efforts to establish a new scientific foundation for understanding and utilizing terahertz (THz) frequency sensing as a new tool for the detection, identification and characterization of chemical and biological (CB) agents on the battlefield. This research area also includes a parallel thrust to identify and develop advanced device concepts that are suitable for realizing THz-frequency sensors and sensor systems that are militarily useful (i.e., compact, robust, cost effect, etc.) in realistic battlefield scenarios.

To establish the needed science and technology base for future Army battle-space capabilities, innovative research is sought in the general areas of THz frequency sensing science and advanced device concepts that facilitate robust functionality at frequencies within the submillimeter-wave or THz frequency regimes (i.e., the part of the electromagnetic spectrum between approximately 1 mm (300 GHz) and 100 μm (3 THz). To improve device performance, the Army is interested in new device and circuit concepts, including quantum transport devices such as resonant tunneling structures, and quantum-transition devices in which photon emission can occur through intersubband transitions between quasi-bound states. It also includes traditional devices with revolutionary circuit and packaging techniques to improve performance. The components of particular interest are electrically-driven room-temperature sources, cw or pulsed, operating between ~ 0.3 and 3 THz. Innovative and novel methodologies should be explored until an effective approach is discovered or developed. Here, the development of efficient sources and integrated semiconductor-based components and systems is a priority.

In addition, a key application of interest for terahertz and ultrafast electronics is battlefield remote sensing of biological agents. Another second class of application is point detection of biological/chemical agents and explosives, such as RDX and TNT that also interact with THz radiation via low-frequency vibrations and rotational modes. Rapid, unambiguous identification of chemical agents, precursors, and degradation products is required in many areas of the DoD including treaty verification and counter-terrorism. The ultra-high resolution offered by THz spectroscopy may provide this rapid identification even when the substance is in a complex mixture. A final, and possibly even more far-reaching application of THz electronics, is in the development of concepts for extending ultra-wideband sensing and communications. Indeed, the fusion of an advanced THz-frequency sensing capability with conventional sensor-network communications and high-speed data processing has the potential for significantly enhancing the network-centric capability of the Army's Future Combat System of Systems (FCSS) concept. Here, THz electronics will collectively impact spectroscopic sensing, radiometric imaging and data transmission/ processing. Furthermore, commercial local-area-wireless networks can already be envisioned at frequencies as high as 400 GHz, therefore, THz electronics has a strong duel use potential and the potential for significantly impacting the high-frequency electronics of the future.

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RESEARCH AREA 11

COMPUTING AND INFORMATION SCCIENCE

11.0. The Army has determined from its experience in Gulf Wars that it needs a force that can be deployed rapidly to any conflict area in the world. The delay incurred in deploying a heavy force with 70 ton tanks is no longer acceptable nor is the logistics tail needed to support them. The Army has embarked on a transformation to a lighter more rapidly deployable and supportable force. This, according to The Army Vision, will be a strategically responsive force that can deploy combat-capable forces anywhere in the world.

The operational concept of the Objective Force includes smaller units with higher mobility and weapons of greater precision and lethality. Since forces will not be highly massed and vehicles will have less physical protection, the key to providing survivability of this force is real-time information on the friendly and enemy situations available continuously so that decisions can be made and actions taken within the decision cycle of the enemy.

Information processing on the move is critical to the success of operations of the Objective Force which will be almost constantly moving. Information must be communicated; and, since the force is mobile, the communications required is unique mobile wireless communications networks that are adaptive and operate without any geographically fixed infrastructure. There will be numerous unmanned robotic and tele-operated aerial and ground vehicles serving as sensor, communications relay, and weapons systems platforms. Information sources on the battlefield will grow rapidly. Computing and information processing research will have to provide the technology to process this information in real-time and to insure that soldiers and commanders are not overburdened with data, rather than succinct information, to a degree that adversely affects their performance and victory in battles.

The transformation of the Army to the Objective Force will require investment in science and technology, especially computing and information science (CIS). The research topics described in this section of the BAA are those needed to provide the Objective Force with the information processing and communications needed to achieve the vision of future Army operations.

The CIS research at the Army Research Office required to support the characteristics of the Objective Force and the Future Combat System (FCS) center around techniques to gather, disseminate, and act upon information about the enemy's location, movement, and intention. Information from many different information sources will have to be fused to produce an incisive total picture of the battlefield. This composite of information must then be communicated quickly to both men and machines. Methods to aid the commander in using this information effectively must be developed. Decisions generated by the commander must result in unified action plans communicated quickly by electronic systems. CIS also will play a key role in providing an increased efficacy in both range and kill probability of weapon systems while effectively protecting our own forces. For this reason, CIS is a key technology, underpinning the FCS and the Objective Force. While advances in electronic technology have played decisive roles in recent successful military engagements, such as Desert Storm; the ambitious goals of these new warfighting concepts require major additional progress in the computing and information science discipline. Prospective investigators for this research should contact the technical points of contact (TPOCs) for the following research areas to determine if their research ideas are appropriate for full proposal submission.

11.1. Mobile, Wireless Communications and Networks. The mobile, wireless communications and networks research program is concerned primarily with establishing the fundamental understanding necessary to support the Army's future mobile, wireless tactical battlefield communications needs. The research in this program primarily targets the tactical battlefield at brigade and below. The Army is interested in communication systems operating in frequency bands traditionally occupied by narrowband radios high frequency (HF), very high frequency (VHF), and ultrahigh frequency (UHF) as well as systems operating in frequencies extending into the millimeter wave region. These systems must support broad-based and highly mobile communications and must perform in environments of impressive diversity, from dense foliage to dense urban obstructions, and unintentional and intentional jamming. Future Army tactical communication systems for the digital battlefield will consist of many different types of networks and must be capable of communicating on the move. These systems will be highly mobile creating highly dynamic network topologies (mobile ad-hoc networks) and routing multimedia (voice, data and video) data. Unlike commercial systems, the communications infrastructure must be mobile. In addition to the highly mobile communications, there is interest in algorithms for small, very energy-limited, stationary, unattended ground sensors.

11.1.1. Research is required in broad thrust areas including end-to-end admission, flow and congestion control; adaptive routing protocols; channel access protocols; adaptive transmission techniques for power and spectral efficiency; and signal processing for robust communications. Adaptability at all levels and cross layer design should be considered to meet quality of service (QoS) requirements where possible and optimize performance. Cross layer design may be the key to meeting the various QoS requirements and priorities of the network.

11.1.2. Research in multimode transport layer to be able to adapt to different networking environments. Unlike traditional TCP, the transport layer must be robust to packet errors as well as congestion. Admission, flow, and congestion control must be performed in the context of different QoS requirements and priorities. Network control must be distributed to avoid single points of failure and the system should be self-organizing with peer-to-peer capability.

11.1.3. Routing protocols must be able to adapt to the constantly changing environment caused by mobility, propagation conditions, interference environment, and traffic load changes. In contrast to classical routing, that sends all traffic over the "best" path, adaptive tactical routing protocols should utilize all network resources, optimizing the route for the QoS of the particular packet. Routing protocols must be designed to handle point-point, multicast, broadcast, and possibly anycast multimedia traffic. Mathematical and simulation models are desired to evaluate routing protocols for use in tactical military communications.

11.1.4. Channel access is expected to play a central role in providing efficient QoS. Of particular interest are channel access protocols that are distributed, scalable, adaptive, survivable, secure, and energy efficient. Novel protocols are needed for link scheduling to support directional antennas, steerable arrays, and space time coding; protocols permitting low-latency access for a mixture of multi-media traffic types; protocols incorporating adaptive power control techniques for purposes of energy efficiency and to reduce interference; and methods providing diverse QoS guarantees.

11.1.5. The physical layer will utilize some form of spread spectrum packet radio. Research is sought which supports spread spectrum, multiple access, anti-jam and covert (low probability of detection/interception) capabilities, and adaptive antenna array processing. Research in adaptive data compression and adaptive error control coding is also relevant.

11.1.6. Research in smart antenna techniques for communications is of interest. This includes array processing for null and beam steering adaptive antennas, direction of arrival estimation, diversity combining techniques, as well as multiple-input multiple output (MIMO) techniques.

11.1.7. There is an interest in basic research to develop theory to support the design of advanced highly mobile, multi-band multi-mode communications receiver and transmitter architectures with special emphasis given to techniques, which minimize power dissipation for near optimal performance over a wide range of channels. Survivability in an electronic/ information warfare environment is a requirement.

11.1.8. Realistic simulation of future battlefield communications with hundreds or thousands of nodes is computationally unwieldy. Modeling and simulation techniques to facilitate these simulations are highly desirable. In particular, modeling of ultra wideband channels, channel parameter estimation, signal design, and coding for multiple access channels with interference are important. Many military communication systems signals have unknown or time-varying characteristics, motivating the need for research in both the theory and modeling of stochastic signals in noise and interference.

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11.2. Information Processing and Fusion and Circuits.

11.2.1. Image Analysis and Processing. Of paramount importance is the understanding of image background, including target-competitive clutter, and of how image background compounds the difficulty of target detection and recognition. Available models for background and clutter are currently inadequate. Objective measures of clutter and modeling paradigms that enable the quantification of image properties are needed for effective comparison of scenes, evaluation of algorithm performance, validation of synthetic imagery, and strategies for data fusion.

Research is needed which addresses: (i) modeling of background and clutter, (ii) definition and assessment of clutter metrics, (iii) the manner in which clutter degrades the discrimination processes, and (iv) interaction between image background and targets.

The three dimensional (3-D) to 2-D projection process causes object recognition from images to be an ill-posed problem. The detection, recognition, and identification of an obscured, concealed, or partially occluded object in an image of a scene cluttered with other target-like objects is a difficult and challenging task. The problem may be aided by the knowledge of the context, the nature of the ambient conditions (weather, terrain, clutter environment), and other relevant parameters. Algorithms for detection and classification of targets with small numbers of pixels in images with substantial background clutter, such as in forward-looking infrared (FLIR) images are important. Algorithms to examine images with objects which have motion and can be observed over a number of sequential image frames is appropriate.

Research is needed which addresses: (i) the object recognition issues in general, (ii) how the use of a priori and emerging knowledge and alternative data representations may contribute to the solution of the recognition problem, and (iii) how the performance of the resulting algorithm/system may be evaluated.

The development of algorithms for automatic target recognition (ATR) must address highly variable target signatures in highly variable scenes and a variety of sensor types, both imaging and non-imaging. Simulation is the only economical and practical means for providing large amounts of data for parametric studies upon which the underlying theoretical foundation of ATR depends. There is a need to develop methods and metrics for validating the accuracy of simulated data. Simulation produces images which may be realistic to the eye but contain artifacts that could cause difficulty for algorithms. The methods and metrics must detect and represent these differences. In particular, performance quantification based on synthetically generated data lacks creditability without a "validation data set" within every group of environments. Environments consist of meteorological states, target operational states, and target distortion ranges. Metrics to quantify data states and ranges for synthetic data calibrated using real data are needed to create "validation data sets" to enhance the credibility of test results.

Currently, there are no effective methods for predicting the performance of an Image Analysis and Processing system, given the input signal or parameters of the scene such as time of day or nature of clutter. There is a need to both understand the sensor and to represent the information content in the signal and how it affects the algorithm performance. As part of this effort, it is necessary to develop metrics that predict theoretical performance bounds and estimate how close the actual performance is to the predicted and optimal performance. Methods for characterizing the complexity of data/signals are required so that performance metrics can be used to compare different algorithms across different data sets.

There is a need for development of fast ways to perform such computations, especially for applications which demand closed loop execution, such as missile guidance. If fast implementations of such algorithms require special purpose computing architectures, then such architectures may be considered a component of the research. However, it is preferred that algorithms be developed for architectures that can be upgraded or improved at least every 18 months. The challenge for the future is to implement a modular, cost effective, embedded signal processor that is "incrementally" upgradeable and not anchored to a particular vendor or processing element, and that can be optimally configured for specific applications and algorithms.

There are multiple sources of data being transmitted for many diverse uses, e.g., ATR, mine detection, telemedicine, tele-maintenance, visual display, cueing, etc. The coordination of the source coding compression methodology used and the application requirements are paramount. Compression methodology must be matched to data characteristics and application needs. There is a need to develop compression approaches that fulfill the multiuse requirements.

Model-based target detection, classification, recognition, and identification rely on databases consisting of models of target signatures, clutter signatures, etc. In real-world mobile scenarios, algorithms have to take into account thousands of potential target types, many of which are poorly characterized due to lack of training data, some of which may even be previously unknown. Algorithms also have to deal with continuously changing clutter and/or occlusion characteristics. The databases necessary to support model-based target identification are unlikely to be small enough, or well-characterized enough, to support real-time mobile applications. Some means of constructing and refining models "on the fly" from the input data stream is required. A sound theoretical basis is needed for such

"agile" or "adaptive" modeling. For example, just as a conventional nonlinear filter is capable of extracting a low-observable target from the background and recursively refining an estimate of its state thereafter, so the desired "modeling filter" would initiate and recursively refine an estimate of the model of each target type (and perhaps also of clutter/occlusion processes) as they are encountered in a continuously evolving scenario. This research enables more efficient utilization of model databases and dynamic environments for the purpose of multi-source, multi-target, detection, classification, recognition, and identification.

11.2.2. Information and Data Fusion. Multisensor and multidimensional data acquisition systems are becoming increasingly prevalent with sensing platforms remotely distributed on the battlefield. Processes such as target detection, classification, recognition, identification, and tracking often require fusion of information, much of which takes increasingly diverse forms and which is increasingly supplied by remotely distributed sources. To date, approaches to this general fusion problem have been addressed in heuristic, piecemeal, and disjoint fashion. Rigorous and heuristic approaches which have been used in this process include classical or Bayesian statistics, Dempster-Shafer, fuzzy logic, rule-based inference, plausible reasoning, rough set theory, and statistical capacity theory. A variety of information-quality measures are associated with these approaches: likelihood, possibility, belief, entropy, etc. Further progress in data fusion requires that the following four aspects of the fusion problem be addressed in a more systematic, unified, and theoretically sound fashion: (i) data representation, (ii) data encoding and transmission, (iii) pooling of diverse data into a coherent picture, and (iv) measurement of the informativeness of both data and the fusion system. Ideally, a systematic, tractable framework is needed that will allow diverse input data streams to be transformed into a unified information fusion space for processing using more unified and tractable procedures, and which will permit performance to be measured with greater confidence. This framework must be open (i.e., permit growth in an emergent or epistemological process) and should provide systematic, tractable measures of information quality.

First, much information is corrupted by forms of ambiguity more extreme than those addressed by conventional statistical analysis: imprecision, vagueness, indiscernability, partial contingency, etc. Image data, in particular, presents unique difficulties. It is important that information from sources such as images, signals, voice messages, geographical information, natural language text, features and attributes, and rules from knowledge bases be presented/modeled in a unified framework (especially multidimensional data representations that are scalable in spatial and temporal resolution). For heterogeneous image and video data, it is known that scalable data representations offer advantages for fusion processes.

Second, current data fusion systems separate the problem of data transmission (from sensors to fusion processing) from the information needs of the fusion algorithms or human end-users. Since much of this data is accessible only via a communication network, fusion systems require variable amounts of data compression depending on such factors as congestion, mission, target priority, algorithm needs, end-user requirements, etc. (facilitated by a scalable data representation).

Third, mathematical methods for representing and fusing information from multiple sensors are fundamental (especially multidimensional data representations that are scalable in spatial and temporal resolution). Effective means are required to fuse diverse information originating from many sources into a single composite picture. A common example is track-to-track fusion, in which existing and possibly correlated or conflicting estimates/ decisions must be fused into a valid composite picture. Another example is that of fusing the (possibly correlated) decisions and/or estimates provided by a number of experts or fusion sources, each employing different evaluation criteria and using possibly overlapping data sources.

Fourth, a mathematical framework is essential for tractable means of measuring information content in diverse and ambiguous data. Evaluation of fusion system performance requires techniques capable of representing preferences, expert credibilities, weights of criteria importance, and data dependences in qualitative terms that lead to an aggregated choice of alternatives which are preferable or admissible but not necessarily optimal. Such measures should enable prediction of the level of system performance based upon the information content of sources available, knowledge gained from previous experience, tasks to be performed, and constraints in the context of the task to be performed.

Threat assessment is the process of estimating the current threat status of a target. Battle Damage Assessment (BDA) refers to determining the threat status of a target after an attempt has been made to destroy or disable it.

Issues which require further research include: more systematic approaches to threat assessment and BDA which permit effective post attack evaluation. A common methodology should be developed that would support the optimal determination of current threat state based on reports gathered from multiple information collection resources.

11.2.3. Information and Signal Processing. Information and signal processing research is oriented primarily toward infrared image analysis for target detection, classification, identification, and tracking and sensor fusion. Interest exists in high performance multi-dimensional and concurrent signal processing architectures and novel and hybrid implementations such as fuzzy and neural networks, discrete event dynamical systems, and non-linear systems using electronic, biological, optical, acoustical, electro-optical, or acousto-optical techniques. Important aspects of this research include the development of design methods, architectures, and implementations to minimize power dissipation, to increase processing speed and concurrency, and to increase modularity to aid implementation of incremental upgrades.

11.2.4. Circuits. There is a need for original research on novel circuit designs which utilize new integrated circuit, acoustic wave, and/or photonic technologies to improve operating performance. Improvements are sought in performance parameters such as reduced noise, reduced power dissipation, and increased speed. Extending the bandwidth, time-bandwidth product, and upper frequency limits of circuits is included. Design tools for integrating RF devices and components, such as inductors and optics, on chip are needed to reduce size, weight, power, and cost. Circuits such as mixers, oscillators, amplifiers, phase-locked loops, voltage-controlled oscillators, digital-to-analog and analog- to-digital converters, correlators, and convolvers may benefit from this research. Typical goals may be to develop technology for implementing monolithic transceivers on single integrated circuits and processors capable of multiple gigahertz operation.

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11.3. The Systems and Control Program is concerned with modeling, analysis, and design of complex real-time systems, especially as they relate to Army problems in distributed command, control, communications, and in guidance and control of complex autonomous and semi-autonomous systems. The program invests in fundamental control theory, intelligent systems, sensors and actuators, and design and control of smart structures. Additionally, the program seeks to invest in issues related to new and emerging interdisciplinary areas of control such as control in quantum systems, nanotechnology, and biological systems.

11.3.1. Control Theory. Topics of interest include multivariable control for robust performance in the presence of measurement and model uncertainties including adaptive, nonlinear, optimal, stochastic, and hybrid control. Additional areas of interest relate to new and novel applications of control such as control in quantum systems, nanotechnology, and in biology.

11.3.2. Intelligent Systems. An intelligent system seeks to configure assets to achieve goals or to replan objectives in a fault tolerant fashion, either autonomously or for intelligence augmentation of human-centered systems. Intelligent control is the avenue by which regulatory control systems will be expanded to more general functions of decentralized decision making, goal selection, mode switching, assistance to human operators, scenario identification, and system adaptation. Topics of interest include computational vision, computational geometry, cognitive issues in man-machine systems, hierarchical sensing and control, frameworks for representing and reasoning with uncertainty, soft computing and evolutionary approaches to the design of complex systems, and novel modeling and computational paradigms for large intelligent systems.

11.3.3. Net-Centric, Distributed, Autonomous and Semi-Autonomous Systems. Topics of interest include integrated agent-based decision and control architectures, dynamic resource management, and fault-tolerant operation, especially under bandwidth communication, and computational constraints. One application area that is of particular interest is coordination between and among groups of unmanned aerial and ground vehicles. Another application is the need for ground vehicles that interface with battlefield database information systems to assist a vehicle operator in achieving maximum lethality on the battlefield. Related work includes differential gaming for missile and unmanned ground/aerial vehicle pursuit-evasion.

11.3.4. Control of Hybrid and Embedded Systems. A hybrid controller may be defined as a conventional analog controller that changes states or control modes at discrete times. Design of such systems requires analysis of the effects of random delays and investigations into issues of autonomy, hybrid dynamics, and discrete event and hybrid system supervisory control.

11.3.5. Modeling and Control of Logistic Systems. Robust logistic policies are needed that can withstand intelligent adversarial attack. This area includes a need for rapid-response, reconfigurable supply chain designs with guaranteed stable transition dynamics; analyses of the interaction of command and control networks and materiel distribution systems; closed-loop control of force deployment and battlespace management; and stability and performance analyses of large-scale networked systems under uncertain and incomplete information.

11.3.6. Design and Control of Smart Structures. The Army is interested in developing a capability that includes a combination of mathematical theories of design, control, analysis and visualization that would aid in the search for an optimal or near-optimal design of smart and adaptive structures. Topics of interest include advancing the state of the art in active control of materials and structures via first principles modeling, analysis and computation, enhancing the theoretical foundations of controlled fluid-structure interactions at various length scales, developing the communications and hierarchical control theory needed for controlling very large arrays of sensors and actuators and developing engineering tools for design and fabrication of controllable materials.

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11.4. Software and Knowledge-Based Systems. The program in Software and Knowledge-Based Systems (SKBS) addresses the integration of the theoretical bases for the analysis, design, development, and evolution (sustaining) of advanced information-based systems. The research in this program is focused on research that is deemed critical to enabling technology-development that supports a modern system/software engineering capability. The following topics/sub-topics are of particular interest concurrent system design (hardware/software), embedded systems, modeling and simulation, machine learning, knowledge/acquisition/ representation/ synthesis, intelligent agents, and knowledgebases/databases. The four major foci of the program are explained below.

11.4.1. Software Prototyping, Development and Evolution. The "Software Prototyping, Development and Evolution" (SPDE) area addresses the scientific/engineering advances needed for the implementation of iterative/adaptive graphically-driven interfaces (for engineering design, etc.); rapid prototyping; software generation; system evolution and software reuse; system/software simulation; distributed software change/evolution; software engineering for domain-specific architectures; tools and toolset integration; software/system documentation (requirements/design); and system validation and verification. Formal models and methods (FMM) are addressed separately because of traditions of research and the importance of FMM to the overall analysis and design concerns. Advances in SPDE technologies are expected to contribute to the development of capabilities for engineering robust, safety-critical, real-time and high assurance systems.

A summary of FMM research interests is provided below. The combination of the SPDE and FMM efforts are synergistic and are expected to facilitate the development of a modern basis for a principled "end-to-end" system/software technology-supported engineering capability.

11.4.2. Formal Models and Methods for Software Engineering. The scope of this foci (FMM) includes the concern for network-centric/distributed information-systems and the global dependencies intrinsic to many of these modern systems. However, many aspects of these type of systems can be treated as parameters of a general, overall, design-space. The resolution of issues related to these concern/design-parameters is expected to be addressed via the emerging capabilities the SPDE and FMM techniques. Included in the scope of the FMM foci is interest in research on real-time software issues and the investigation of formal frameworks, deductive methods, and tools for the implementation of provably correct (reactive, real-time and hybrid) systems. As part of a near-term strategy, to demonstrate the "value-added" of the nascent technologies being developed in the FMM element of the SKBS program, there is a strong emphasis on the application-domain of embedded systems. In a broad sense the critical-technology-needs issues, that in part define a critical-research path, include the recognition of the need for coupled technologies enabling the rapid capture/validation of requirements, the semi-automated translation of languages (from development languages to analysis/design languages), scaleable formalisms for analysis/design, code

generation, content-based retrieval of archived information, engineering level interfaces, and requirements/design documentation.

11.4.3. Knowledgebase/Database Science. Complex reasoning in a real-world environment requires the ability to integrate data from multiple databases (relational databases, object-oriented databases, geographical information systems, etc.) and data structures as well as to adopt and integrate multiple modes of reasoning such as inconsistency, time, planning, scheduling, reasoning under uncertainty, reasoning under incompleteness and reasoning about pictures, images, and sound. Much of the data/information in the world does not (and will not) reside in any conventional database but rather resides in data exchange (DX) formatted files. Only a few DX formats and their application programming interfaces (API) have database management features. This fact along with other characteristics of DX files leads to a number of research issues such as concurrency control, support of behavioral components and query languages. There is interest in these several areas as well as in content-based retrieval, complex reasoning and machine learning. Agent technologies and the enablement of the many decision-support application needs (facilitated by information fusion) are also of interest to the SKBS program.

11.4.4. Virtual Parts Engineering Initiative. This is a critical application of the generalized SKBS program technology-enablement objectives. At present there are numerous CAD tools; however, they generally cannot be used together. As importantly, while we have enabled CAD we have not facilitated CAD/CAM. It is the objective of this thrust to not only contribute to solving the interoperability problem, but to facilitate the coupling of CAD and CAM. Part of this effort is attempting to build on the emerging international data standard for physical-systems (STEP). At present STEP has some significant features and utility; however, the emphasis in this initiative is to enhance STEP thru research that addresses the many non-physical dimension concerns of designers. Of particular interest are the issues of reverse-engineering, reengineering, and redesign capabilities. The "Legacy System/ System-Part" engineering and procurement concerns/costs give this area a particularly high potential return on investment.

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11.5. Information Assurance. From the Army perspective, Information Assurance must address the delivery of authentic, accurate, secure, reliable, timely information, regardless of threat conditions, over the distributed and heterogeneous computing and communication system. The computing system may range from a hand held mobile unit to a centralized high performance information processing system. Heterogeneous communication systems consist of both tactical (mobile, wireless) and fixed (wired) communications infrastructures.

11.5.1. Supporting Army Mission Characteristics. The objective of this research is to enable dynamic management of communities of interest (COI) by the battlefield commander. The commander needs the ability to alert the membership in a specific COI based on issues ranging from classification of the data to specifics of the battlefield situation. If, for example, the information device of an individual war fighter is captured by the adversary, the commander must recognize that change in status and deactivate that node to protect subsequent transmissions. Individual war fighters may simultaneously be members of multiple COI's depending upon battlespace specifics. Research is needed in the areas of protocols and techniques which support reconfigurable, survivable and self-healing, efficient, and mobile computing and communication environments that would allow for the dynamic creation of Communities of Interest as well as to assure delivery of trustworthy data within reconfigurable, mobile network environments. Reconfigurable, survivable and self-healing systems allow a combat unit to dynamically establish and maintain its command and communication capability under diversified and extreme battlefield situations. Efficient computing and communication is another important aspect of information assurance that needs to be addressed. Most likely, the battleground system (both attended and unattended) relies heavily on limited energy resources to perform its functions. New computing and communication protocols and techniques need to be developed so that critical information delivery and critical infrastructure functions can be assured, while maximizing the longevity of such systems under the resource constraints.

11.5.2. Supporting Battlefield Technology: Information Protection for Wireless Networks. The Army requires a fully mobile, fully-communicating, agile, and situation-aware force that operates in a highly dynamic, wireless, mobile networking environment. This force consists of a heterogeneous mixture of individual soldiers, ground vehicles, airborne platforms, unmanned aerial vehicles, robotics, and unattended sensor networks that operate in a complex wireless environment. The objectives of this initiative are to 1) develop techniques and a quantitative basis

for intrusion or anomaly detection and vulnerability assessment of mobile wireless networks that is automated, efficient, scalable, adaptive, and secure; 2) develop security services and wireless security infrastructures for highly mobile tactical and unattended sensor networks that are distributed, scalable, and extremely resource efficient, and, 3) develop a fundamental understanding of the trade-offs and limitations on detection performance, coverage frequency, adaptation rate, wireless capacity, security, complexity, and parameter sensitivity under bandwidth, energy, processing capability, bit-error-rate, and mobility constraints. Research areas include tools and techniques for automated wireless intrusion and anomaly detection, automated wireless vulnerability assessment, mobile wireless security infrastructures and sensor network security infrastructures, as well as secure and trustworthy mobile code in tactical operations.

11.5.3. Evaluation Metrics and Risk Mitigation Methods. Information Assurance metrics are scarce and qualitative. Given the need to determine the information assurance posture for a given organization under given conditions, commanders in the field require a means to determine the relative degree of assurance associated with the information assets under their control. Likewise, developers of Army systems require metrics to measure the degree to which they are employing security engineering practices during the system development process. The use of IA metrics would permit establishing trust in a system built from untrusted components, determining sufficient levels of security for the specific tactical situation and condition, and assessing system vulnerabilities.

11.5.3.1. *Information Assurance Metrics in the Tactical Environment.* IA metrics development should focus on measures of assurance for specific in-place systems and for systems development activity. These metrics are intended to be used to guide commanders in understanding the security posture of the systems they depend on in information operations and to guide Army developers in determining the degree to which they are adhering to good security engineering practices. These metrics are particularly important when systems are formed from other systems or many COTS products are tied together. A goal is to discover a means of providing sufficient security to meet present threat and provide operational flexibility to the commander in the field. Finally, solutions are sought to the human factors problem associated with security of Army systems (e.g., unintentional compromise, security relevant error, intentional insider attack). Research is encouraged in the area of measures and metrics associated with assurance determination of existing systems (particularly when the existing security perimeter has been modified operationally) and for the security engineering process associated with new development (which includes new code and COTS composition). Means of matching the security protection mechanisms to the existing threat and modifying this set of factors as the threat changes are sought. Research into processes and procedures that minimize human error and vulnerability introduction is encouraged.

11.5.3.2. *Testing, Assessing, and Mitigating System Vulnerabilities.* The objective of this research strategy is to develop the technology necessary to test, assess, and minimize system vulnerabilities, particularly in the Objective Force environment. This environment will consist of technologies not yet established, such as dynamic, wireless networks. Nevertheless, it is essential that testing, assessment, and risk mitigating technologies be researched *a-priori* so that as these new technologies emerge, the capability will exist to test and assess the security of these systems. This will certainly include finding new vulnerabilities of existing technologies, developing new security attacks and attack countermeasures, and adaptive risk mitigating technologies. These testing, assessment, and risk mitigating techniques must be adaptable to the new technologies as they emerge. Research concentration areas include: (1) System security and vulnerability assessment framework and methodology, (2) Novel security and vulnerability assessment methods, (3) Adaptive countermeasures to attacks and to system vulnerability exploitation, and (4) Framework and methodology for building secure, intrusion immune host and network systems.

11.5.3.3. *Correlation, Fusion, Analysis, and Visualization of Systems Security Information.* The objectives are to (1) develop techniques and a quantitative basis for the correlation, fusion, and analysis of multi-source infrastructure protection data to reliably and adaptively provide attack indications and warning, and (2) develop a scalable, modular, and open visualization and analysis environment that correlates, aggregates, prioritizes, and displays situation awareness data from multiple sources in a way that significantly increases the ability of an analyst to recognize and react to incidents. Research concentration areas include: (1) Multi-Sensor, Multi-Site Event Correlation, Analysis, and Fusion, (2) Methodology and techniques to improve the quality of attack indications or warnings, and (3) Visualization and Presentation.

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RESEARCH AREA 12
PHYSICS

12.0. The objective of the Physics Program of the Army Research Office is to develop and exploit the physics knowledge base for new Army needs and capabilities. The future promises dramatic changes in military capability as a result of physics research. In support of this goal, the interests of the Physics Division are primarily in the following areas: Condensed Matter Physics; Theoretical Physics and Nonlinear Dynamics; Quantum Information Science; Atomic and Molecular Physics; and Optics, Photonics, and Image Science. Physics disciplines which impact these areas include: (i) Condensed Matter Physics, (ii) Interface/Surface Physics, (iii) Atomic, Molecular, and Optical Physics, (iv) Materials Physics, (v) Cross-Disciplinary topics, and (vi) Classical Phenomenology. There is little direct interest in Relativity and Gravity Physics, Elementary Particles and Fields Physics, Nuclear Physics, Astronomy, and Astrophysics since they generally have no impact on the research areas of Army needs. Nevertheless, the possible relevance of topics within these other physics disciplines is not absolutely discounted and discussions of potential exceptions are welcome.

The disciplinary boundaries of the ARO are not sharply drawn as shown by the joint support of a number of efforts by the Physics Division and other ARO Divisions. In addition, it is not necessary that a potential chief investigator be associated with a Physics Department to receive support from the Physics Division.

Potential offerors are encouraged to contact the appropriate Technical Point of Contact (TPOC) for preliminary discussions on their ideas. The TPOC may invite the offeror to submit a preproposal.

12.1. Condensed Matter Physics. The properties of novel inorganic, organic, hybrid materials and composites are determined by the structure and composition of the constituent materials and the modified physical phenomenology within them. The condensed matter physics thrust investigates and exploits such phenomena to demonstrate new or enhanced functionalities that could be exploited for use by the Army. There are four major areas of interest within the condensed matter physics work package.

12.1.1. Nanometer-scale physics. Specific interest is in the experimental investigation of physical phenomena operative in nanometer-sized materials. The objective is twofold: to investigate and control nanoscale phenomena in well-defined nanometer-sized environments and to elucidate how these phenomena are modified and may be exploited when such nanostructures are assembled into novel composite materials. Related interests include collective and cooperative nanoscale phenomena, understanding the evolution of atomic to nanoscale to bulk behavior and phenomena at surfaces and interfaces such as film growth, Fermi-level pinning and quantum confinement effects. Emphasis of this program is on the demonstration of revolutionary capabilities that could be used in a broad variety of Army-relevant applications, including novel optical and infrared materials and innovative electronic and optoelectronic devices.

12.1.2. Electronic and Photonic Band Engineering. Interest continues in the use of electronic band engineering for the demonstration of militarily relevant device functionalities such as infrared emitters based on quantum cascade lasers and lasing without inversion in multiple quantum well semiconductors. Of greater interest is the continuing development and use of photonic band engineered materials for applications including novel microcavity lasers and LEDs, room temperature infrared sensors, enhanced microwave components, and low emissivity materials. The objective is to use electronic and photonic band engineering independently and together as adjustable design degrees of freedom to develop devices and materials with unique functionality. Methods of solving the inverse problem, finding optimal material and structural parameters based on prescribed functionality, are of particular interest. Applications include infrared emitters and detectors, low observables, and micro photonics for smart sensors.

12.1.3. Soft Condensed Matter Physics. Interest is in understanding the physical basis for structural, electronic, and optical properties of bulk, thin film, and nanoscale soft materials such as organic semiconductors, composites, and biological materials. Also of interest is the physical understanding of the interface between soft materials and inorganics, and between soft materials and nanostructures such as carbon nanotubes and nanoclusters. Although there is some interest in revolutionary synthetic techniques, the primary objective is to understand the underlying

physical properties of soft materials at the quantum level. This will support the development of applications relevant to the Army including but not limited to flexible electronics, novel organic-based electronic and optical devices, and biocompatible devices.

12.1.4. Multifunctional Probes and Control. In order to characterize and control phenomena in semiconductor heterostructures and nanostructures, it is important to combine the high spatial resolution of nanoprobes with the ultra fast temporal or adjustable spectral resolution of optical probes. The objective is to observe and control the dynamical evolution of physical phenomena in these materials at all relevant length- and time-scales. Although development of nanometer-scale pump-probe techniques and other probes of local behavior is still sought, the exploitation of such tools to demonstrate feedback and control of phenomena is of increasing interest.

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12.2. Theoretical Physics and Nonlinear Phenomena. The Theoretical Physics and Nonlinear Phenomena program is very closely coupled to experimental science as well as to ARO's programs in mathematics, chemistry, biological chemistry, materials science, and engineering sciences. The program thus encompasses a broad base including research in electron physics, photon physics, classical and quantum mechanical systems, and statistical physics. It includes first-principles derivations of thermomechanical strengths of alloys for armor and armor penetrations; electronic band structure calculations of materials for electronic, magnetic, optical, and optoelectronics applications, including those that result from quantum well and multiquantum well structures for signal generation, signal processing, propagation and detection of signals. Also of interest are many-body theoretic approaches that address the electron correlation problem in extended molecular and condensed matter systems to provide the means to predict reaction kinetics, nonequilibrium dynamics, and application to the "alloy problem." There is interest in quantum optics research to explore the role of coherent states, squeezed states, etc. which may provide new tools for improved information processing and means to control information. Statistical physics interests go beyond thermodynamics, into non-equilibrium structures and their metastability, into information theoretic formulations, and into decision algorithms to connect the underlying physics to real world applications via proper modeling, instrumentation and data analysis.

12.2.1. Theoretical Condensed Matter Physics. The program extends beyond the topical areas of conventional solid-state physics. It includes research in liquid crystals (for displays, information processing, etc.), atomic clusters, quantum well structures, superlattices, and metastable structures such as quasi crystals and alloys. It explores fundamental interactions such as electron-phonon coupling, spin-phonon coupling, and polaritons. In addition, it studies the role of elementary interactions such as spin-waves in ferrites and plasmons in multiquantum wells for coherent THz radiation generation. Also of interest are the experimental demonstrations and mathematical underpinnings of enhanced retro reflection and super-enhanced retro reflection of light, which may have unique applications for secure light-wave communication in the battlefield. Another area of interest is the study of "cooperative behavior" which appears in many different forms in solid-state physics, optics, and elsewhere. The program encompasses research in both classical and quantum domains, from macroscopic (phenomenological/ mean field) to microscopic levels of description of the mechanisms involved. In addition to analytical techniques, it includes the development of new computational methodologies. For example, the use of the principle of maximum entropy, functional integral methods in many-body physics for predicting electron dynamics in quantum well structures, and variants of the density functional method.

12.2.2. Nonlinear Dynamics. Nonlinear interactions that are useful for Army applications appear not only in optics but in other parts of physics, such as in magnetism in the form of magnetostatic solitonic waves for millimeter wave signal processing, in semiconductor multi-quantum well plasmas for generating coherent THz radiation, and in general when an interaction potential significantly deviates from a harmonic form. Defects, both unintentional and intentional, can play major roles. A general theory of "band structure" calculation that takes defects and defect structures correctly and accurately into account will be useful not only for semiconductor science but also for optics and even micromechanics. Many of the elementary excitations of solid-state physics could be investigated in light of information processing to increase S/N, density of information and speed of processing. The Theoretical Physics program makes an effort to develop these potentialities vis a vis realistic materials that can embody them, and thereby transition these studies to the Materials Science and Engineering Sciences Divisions for actual implementation.

12.2.3. Nonequilibrium Dynamics. Many aspects of the field of nonequilibrium statistical physics have significant unresolved scientific issues. These issues are not just of academic interest; they impact engineering sciences, from growth of new materials to implementations in neural nets, and also have potential implications for what is dubbed "smart" or "intelligent" systems that have adaptive learning capabilities. This is a vast area of investigation, but our Theoretical Physics program focuses on realistic goals in this area. The physics to be studied should be coupled with actual material mechanisms. In magnetism, this may translate into the study of the coupling of spins to phonons to provide a realistic relaxation mechanism and the associated resonant line widths. We are interested in magnetic superlattice type structures which can respond to mm waves by forming magnetostatic and magnetooptic waves that have sufficiently long lifetime and propagation distance for signal processing functions. Also, significant theoretical contributions can be made to the science of alloys, via a quantum mechanical calculation of the characteristics of the bonding charge between nearby atomic constituents. This would provide some guidance to "engineer" grain boundaries with specific brittle fracture characteristics needed for Army and civilian applications.

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12.3. Quantum Information Science. Quantum mechanics provides the opportunity to perform highly nonclassical operations that can result in exponential speed-ups in computation or ultra-secure transmittal of information. This work package seeks to understand, control, and exploit such nonclassical phenomena for revolutionary advances in computation and secure communication. There are three major areas of interest within this work package.

12.3.1 Fundamental Studies. Experimental investigations of the wave nature of matter, including coherence properties, decoherence mechanisms, decoherence mitigation, entanglement, nondestructive measurement, complex quantum state manipulation, and quantum feedback are of interest. The objective is to ascertain the limits of our ability to create, control, and utilize quantum information in multiple quantum entities in the presence of noise. Of particular interest is the demonstration of the ability to manipulate quantum coherent states on time scales much faster than the decoherence time, especially in condensed matter systems where scalability to many quantum bits and quantum operations is promising. Theoretical analyses of nonclassical phenomena may also be of interest if the work is strongly coupled to a specific experimental investigation, as may proof-of-concept demonstrations in atomic, molecular, and optical systems as described in the Atomic, Molecular, and Optical Physics program.

12.3.2. Quantum Computation. Quantum computing will entail the assembly and manipulation of hundreds of quantum bits. The objective is to demonstrate tremendous speed up of computations, and experimental demonstrations of quantum logic performed on several quantum bits operating simultaneously would represent a significant advance toward that ultimate goal. Demonstrations of quantum feedback and error correction for multiple quantum bit systems are also of interest. In addition to the algorithm for factoring, there is particular interest in developing algorithms for solving an NP-complete problem for use in resource optimization and in developing quantum algorithms to simulate complex physical systems.

12.3.3. Quantum Communication. The ability to transmit information through quantum entanglement distributed between spatially separated quantum entities has opened the possibility for an ultra-secure means of communication. Beyond quantum cryptography, the objective is to demonstrate quantum communication of information based on distributed entanglements such as in quantum teleportation. Of particular interest would be the demonstration of long-range quantum entanglements, entanglement transfer among different quantum systems, and long-term quantum memory.

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12.4. Atomic and Molecular **(**AM**)** Physics. Research in atomic and molecular physics will create fundamentally new capabilities for the Army, as well as providing the scientific underpinnings to enhance existing technologies. Topics of interest include laser, evaporative, and novel cooling and trapping schemes; quantum degenerate atomic gasses, their excitations and properties, including mixed species, mixed state, and molecular; matter-wave optics and matter wave lasers; nonlinear atomic and molecular processes; quantum control; novel forms and effects of coherence; and related areas. Applications range from ultra-sensitive detectors including improved inertial sensors and navigation aides; to sensor protection; to novel sources. In addition, areas of application include novel materials processing, e.g., by obtaining increasingly complex molecules, clusters, or patterned structures, as hybrid or composite materials, or through quantum control.

12.4.1. Matter-wave Optics. Matter waves offer new or enhanced capabilities in a number of areas. For example, cooling, trapping and coherent control of atoms and molecules may provide ultra-sensitive sensors, including gyroscopes for inertial navigation, or ultra-high resolution lithography. In addition to the sensitivity advantage of matter waves, they also have additional degrees of freedom such as mass and associated "external" quantum states (together with a richer internal state structure) that might provide handles for new sensing capabilities. The use of coherent matter waves and Bose condensates (e.g., as in a "matter-wave laser") requires basic research to better understand issues such a coherence and decoherence, trapping and out-coupling techniques, and "matter-wave optics" to collimate, diffract, split, combine, interfere and otherwise manipulate matter waves. Laser cooling and trapping of atoms and molecules also may provide proof of principle demonstrations of key components of quantum computing.

12.4.2. Molecular Physics. The molecular physics program is distinguished from programs in chemistry and in materials science. One distinguishing feature is its focus not on synthesis, but on the underlying *mechanisms*, such as electronic transport, magnetic response, coherence properties (or their use in molecule formation/selection), and/or linear and nonlinear optical properties. The systems of interest are well-defined molecules, generally small or of high symmetry, and their functionalized variants. The objective is to broaden the scope of atomic physics questions into the molecular regime. Cooling, trapping, and Bose condensing molecules fall into this scope. Recently seen coherent molecular superposition states, a novel form of matter, are another example.

12.4.3. Fundamental Atomic and Molecular Physics. The Division also has a general interest in exploring fundamental atomic and molecular physics topics that may have an impact on technologies of interest to the Army. For example electromagnetically induced transparency allows propagation of light through a medium that is normally strongly absorbing, and it also provides unique access to nonlinear effects that could lead to very efficient frequency multiplication and tunable sources of electromagnetic radiation. The understanding of the physical mechanisms behind long range, white light propagation of ultra-short, ultra-intense pulses is another example of a topic of interest with unresolved atomic and molecular physics issues. General issues of quantum coherence, quantum interference, and quantum control and their numerous potential applications are also of interest.

Technical Point of Contact: Dr. Peter Reynolds, e-mail: Peter.Reynolds@us.army.mil , (919) 549-4345.

12.5. Optics, Photonics, and Imaging Science. The Army of the 21st century will rely more on sensing, imaging processing, and autonomous target tracking and recognition than ever before. The objective of this work package is to investigate fundamental physical phenomena that will lead to revolutionary advances in these areas. The Physics Division emphasizes fundamental science that uses photons and their properties (e.g. coherence, wavelength, polarization) in ways that will significantly improve information processing capabilities for the Army in the coming decades. Much like the breakthroughs in integrated electronics that brought revolutionary changes to computing and signal processing, a key objective is to integrate elemental optical components into "integrated optics" or "photonics" for smart, adaptive, reconfigurable sensing and image processing. Another objective is to improve the imaging capabilities of the Army by extending beyond the visible and infrared regions to consider advantages of the THz and ultraviolet regions. The Division has an interest in the identification and resolution of basic research issues that would demonstrate the utility of these approaches.

12.5.1. Unconventional Optics and Imaging. The Division has an interest in extracting more information from emitted, scattered, and reflected electromagnetic radiation. Of particular interest is the exploitation of coherence and correlations in the electromagnetic field. The degree of coherence can affect or improve the ability to image objects, transfer information, and recognize targets. When a laser beam passes through a scattering medium, the degree of coherence is altered depending on the amount of randomness and the scattering processes involved. Multiple scattering and partial coherence depend on both volume effects and scattering from many interfaces. A number of such physical effects have been observed and explained, but many issues need investigation. Other areas of interest include hybrid optical/digital systems to minimize aberrations in classical optics, adaptive optics to mitigate against atmospheric distortions, new approaches to coherent or ballistic imaging through turbid and scattering media, and imaging enhancement technologies such as hyperspectral imaging, infrared polarimetric imaging, and THz imaging. Also of interest are other approaches that would increase the resolution or contrast of scenes, or otherwise improve the information quality of the images in the presence of noise and clutter.

12.5.2. Fundamental Optical Physics. A variety of topics in classical, nonlinear, and quantum optics are of interest. Photonic band engineering may be used to control the flow of light in fiber, optical materials, laser resonators, and integrated optical systems much more efficiently and compactly than today's component-based technologies. Investigations and utilization of novel nonlinear optical phenomena, such as solitons, vortices, and left handed materials, are of interest and show potential for optical information processing. Relativistic, extremely short and high intensity laser pulses show potential for a new frontier in optical physics, with applications including high harmonic generation, nanolithography, 3-D internal design, micromachining, particle beam acceleration and control, and light filaments. Theoretical and experimental research is needed to describe and understand how matter behaves under these conditions, from single particle motion to the effects in materials, and how to generate these pulses and use them effectively.

12.5.3. Photonics. The word "photonics" has been used in a broad sense by the optical science community to define the development of photon-based devices and circuits to perform certain imaging and information processing tasks in a manner superior to or impossible by their electronic counterparts. The Physics Division seeks revolutionary changes in ways photons can be used to perform a variety of such tasks, including signal processing, computation, imaging, and information display. Of particular interest are unique, niche applications for photonics that surpass or replace their electronically based counterparts and that are of direct relevance to the needs of the military. Any super parallelism promised by photonics needs to be demonstrated and exploited in order for photonic solutions to replace existing electronic ones. It is clear that the field of photonics is a very rich frontier for physics research with high potential for device and system technologies. Therefore, the emphasis of this work package is to explore the basic physics and to demonstrate proof-of-concept demonstrations that will ultimately find indispensable military and civilian application.

12.5.4. Image Science. The ubiquitous presence, especially in Army scenarios, of structured or target- like clutter is a major impediment to all target recognition systems, including both automatic systems and humans. In many Army scenarios and systems, the performance of image analysis systems is limited by the algorithms, signal processing strategies and models, rather than the sensors or processors. Even though there has been a large investment in automatic target recognition algorithms, significant shortcomings exist, leading to the need for a renewed emphasis on the theoretical underpinnings. To this end, the Division is interested in innovative research which addresses the following objectives: (i) development of a set of scientific metrics which quantify image content, image complexity, and the performance of image recognition and classification techniques, (ii) development of metrics for structured and target-like clutter, (iii) development of metrics for assessing and validating synthetic scenes. The ultimate goal is to develop image science to the point that the performance of automatic target recognition systems in arbitrary real-world scenarios can be predicted. The emphasis of the Image Science program is on the underlying issues of information science and image analysis. Other ARO programs are concerned with the development of the detectors and algorithms themselves.

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RESEARCH AREA 13
CHEMISTRY

13.0. Chemistry is central to the operation of the Army Research Office. Explosives, propellants, fuel cells, and batteries function by converting chemical energy into mechanical and electrical energy. Macromolecules, especially elastomers, provide materials for equipment. Protection of the soldier against chemical agents requires the detection, identification, and destruction of such chemicals, and the design and construction of barriers to their passage. The destruction of toxic wastes represents another chemical problem faced in the restoration of military real estate and the safe demilitarization of surplus munitions. We invite proposals for research to advance our understanding of chemical materials and processes with a strong prospect for use in future Army technology. Potential offerors are encouraged to contact the appropriate TPOC for preliminary discussions on their ideas. The TPOC may invite the offeror to submit a preproposal.

13.1. Chemical Kinetics. The Army's program in ignition and combustion processes associated with energetic

materials, explosives, detonation phenomena, the control of energy release and energy transfer processes will benefit from increase understanding of fast reactions of energetic species. We are especially interested in the investigation of chemical reactions using time-resolved techniques to observe transient species and infer reaction pathways and other experiments and calculations that enable modeling of the time dependent processes of ignition and combustion. Research on controlled transformation of toxic materials to relatively benign products in chemical reactors is also of interest.

Technical Point of Contact: Dr. Robert Shaw, e-mail: Robert.Shaw@us.army.mil, 919-549-4293.

13.2. Electrochemistry and Advanced Energy Conversion. The Army relies on compact power sources to support many different weapons systems, communications, and other devices. Power sources under development include batteries and fuel cells, microturbines, thermophotovoltaics, alkali metal thermal to electric converters. This program supports fundamental chemical studies of materials and processes that limit the performance of current or enable future power sources. Topics include ionic conduction in electrolytes, electro catalysis, fuel processing (particularly hydrogen), interfacial electron transfer, transport through coatings, surface films and polymer electrolytes, and activation of carbon-hydrogen bonds. Novel electrochemical synthesis, investigations into the effect of microenvironment on chemical reactivity, and quantitative models of electrochemical systems are also encouraged.

Technical Point of Contact: Dr. Richard Paur, e-mail: Richard.Paur@us.army.mil , (919) 549-4208.

13.3. Organic Chemistry and Organized Media. There exists a need for basic research in detection of toxic materials, decontamination of those materials, and protection of the soldier during those processes. This program seeks to explore fundamental research addressed at eliminating toxic materials in processing and protect the soldier from existing toxic materials. New, more efficient, and environmentally benign organic reactions, both stoichiometric and catalytic, are of interest, especially nitration, and oxidative and nucleophilic displacements at phosphorus and sulfur for destruction of toxic organic compounds. Selected mechanistic studies that promise new insights to the pathways of the above reactions are encouraged, as are new synthetic pathways with reduced production of waste by-products.

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13.4. Polymer Chemistry. The Polymer Chemistry Program seeks novel, fundamental polymer research that may lead to new materials that provide the soldier with critical protection and required materiel. Research of interest may be related to chemical and biological agent protective materials, ballistic protection, transparent materials for eye protection and sensors, including laser protection, materials that have tunable optical properties, and lightweight super-strong materials. Research areas of interest that may be relevant include synthesis of polymers, including polymers with novel architectures and compositions, new approaches to synthesizing polymers, organic/inorganic hybrid polymeric materials, creating light-weight polymeric materials with enhanced strength, and the design and synthesis of environmentally benign polymeric materials that may benefit the soldier. Also of potential interest is characterization of structure/property relationships, diffusion and transport, and fiber properties related to polymer chemistry.

Technical Point of Contact: Dr. Douglas Kiserow, e-mail: Douglas.Kiserow@.us.army.mil , (919) 549-4213.

13.5. Surfaces and Catalysis. This program supports fundamental research on the decomposition and interaction of molecules on well-characterized surfaces, and catalysts. The development of new experimental probes of these reactions is also of interest. The most important species are organo-phosphorus, -sulfur, and -nitrogen molecules, and reactions of organic functional groups on surfaces and catalysts. Research areas of interests include nanoparticle reactivity, the interface between nanostructures and biomolecules, the reaction mechanisms of hazardous materials with plasmas, and the fate of toxic materials on surfaces in the environment.

Technical Point of Contact: Dr. Stephen Lee, e-mail: stephen.lee2@us.army.mil , (919) 549-4365.

13.6. Theoretical Chemistry. Army requirements for insensitive munitions, for propellants and explosives with greater energy density, for the control of propellant burning rates, and controlled energy release from explosives

provide a continuing interest in a variety of theoretical explorations. Theoretical investigations may provide predictive capabilities relevant to the properties and behavior of a wide spectrum of energetic materials and their prototypes. More specifically: studies of energy transfer mechanisms in condensed phases, the prediction of molecular reactivities, the investigation of heterogeneous reactions, and the prediction of reaction pathways. Theoretical understanding of atoms, molecules, and clusters on surfaces may provide the basis for rational design of catalysts.

Technical Point of Contact: Dr. Robert Shaw, Robert.Shaw@us.army.mil , 919-549-4293.

RESEARCH AREA 14
LIFE SCIENCES

14.0. Extramural research in the Life Sciences is supported by the Army Research Office. For those proposals related to purely medical topics, the investigator is invited to contact the U.S. Army Medical Research and Materiel Command. For research in the behavioral and social sciences or in training techniques, contact the Army Research Institute for Behavioral and Social Sciences. The ARO Life Sciences Division research program is currently focused on four sub area work packages. The titles, scopes and points of contact for these work packages, each of which address general aspects of basic research in biotechnology, as well as the specific thrusts described, are listed below. A small number of symposia, conferences and workshops are also supported in part or in whole to provide an exchange of ideas related to ongoing programs in Army laboratories. Potential offerors are strongly encouraged to contact the appropriate TPOC for preliminary discussions on their ideas before any submissions. The TPOC may invite the offeror to submit a preproposal.

14.1. Biomolecular and Cellular Materials and Processes. Fundamental studies to define structure-function relationships and biochemical interactions for enzymes, receptors and other macromolecules exhibiting mechanisms and properties uniquely relevant to synthetic and degradative pathways of interest to the military, including establishment of the foundations for manipulation and exploitation of biocatalysis, ribosomal and non-ribosomal biosynthesis to enhance permissiveness toward elaboration of useful biomolecular structures and cellular systems designed with "metabolic engineering" in mind. Also, research to provide insight from nature on novel theoretical principles and mechanisms in sensory and motor function, as well as on materials with extraordinary properties, from biological sources. Includes not only initial molecular events, signal transduction pathways and integrated information processing for the powerful sensing capabilities exhibited in the biological world, but also self-assembly processes, hierarchical structure formation, and functional characterization of biomolecular materials such as those with potential "biomimetic" utility for nanometer scale fabrication or for energy and information transfer, among other possibilities.

Technical Point of Contact: Dr. Robert Campbell, e-mail: bob.Campbell@us.army.mil , (919) 549-4230.

14.2 Molecular Genetics and Genomics. This program emphasizes basic research in molecular genetics and genomics that will enable optimization of soldier cognitive and physical performance, soldier protection, and Army logistics. This includes human performance and protection under both normal conditions, and when affected by a variety of stressors that are likely to be encountered in battlefield situations, such as dehydration, heat, cold, sleep deprivation, fatigue, caloric insufficiency, microbial factors, and psychological stress. Genetic and genomic research areas include identification and characterization of gene function, gene regulation, genetic interactions, gene pathways, gene expression patterns, mitochondrial regulation and biogenesis, and nuclear and mitochondrial DNA replication, mutagenesis, oxidative stress, and DNA repair. Also molecular responses to pathogens, pathogen identification, and pathogen inactivation, as well as host-pathogen interactions, and host components of infection and resistance to infection. This program is also interested in the biotechnology of microarrays, including both genomic- and proteomic-based platforms, for real time detection of pathogens or physiological states that would reduce or interfere with human performance. This program also supports development of new biomaterials and bioproduction methods, and other advances in biotechnology methods and applications.

Technical Point of Contact: Dr. Micheline Strand, e-mail: micheline.strand@us.army.mil , (919) 549-4343.

14.3. Microbiology and Biodegradation. Biochemical and physiological mechanisms, underlying the biodegradative processes in normal, extreme, and engineered environments and fundamental studies on organisms in these environments, the properties of materials that make them susceptible or resistant to biological attack, basic concepts for anti-fungals, and studies of microbiological mechanisms with potential for contributing to the remediation of sites contaminated with toxic wastes. Included are research investigations in analytical microbiology (including microbial signatures), and in general microbial mechanisms with relevance to Army problems. Addressed here also is research into microbial communities and how to study organisms that cannot be grown in the lab, as well as research into methods to enhance the stabilization of military materiel, which would include methods to prevent microbial growth. Also included is the development of microbial systems for unique biotechnological applications and bioengineering processes with individual microbial species or consortia of microorganisms, emphasizing the control, stability, and mechanisms of the basic cellular processes involved.

Technical Point of Contact: Dr. Shirley Tove, e-mail: sherry.tove@us.army.mil , (919) 549-4344.

14.4. Neurophysiology and Cognitive Neuroscience. Research in the perception and cognition subfields of neurophysiology and the cognitive neurosciences, covering several or all areas of electrophysiology, psychophysiology, sensory and perceptual physiology, computational neurobiology, psychophysics, neuropsychology, and integrative neurobiology is of interest. Specific examples can include physiological, neuro-psychological and/or cortical/cognitive mechanisms underlying successful completion of complex task behaviors applicable to non-laboratory environments under non-ideal conditions, to include both amelioration of induced losses as well as enhancement in defined perceptual, cognitive and/or motor abilities. Investigations can span the gamut from multi-unit recordings through evoked potentials and neuro-imaging technologies to humoral and psychological correlates of both central and peripheral nervous system function. Non-medically oriented research designed to elucidate the fundamental physiology underlying cognition and possible non-invasive methods of monitoring cognitive states and processes during normal activity is appropriate. Perceptual and/or psycho physiological implications of mind-machine interfaces ranging from optimizing auditory, visual and/or somatosensory display and control systems based on physiological or psychological states through modeling of individual cognitive dynamics and decision making is appropriate to this research area.

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RESEARCH AREA 15
MATERIALS SCIENCE

15.0. The objective of research supported by the Materials Science Division of the Army Research Office is to discover the fundamental relationships that link chemical composition, microstructure, and processing history with the resultant material properties and behavior. The work, although basic in nature, is focussed on developing new materials, material processes, and properties that promise to significantly improve the performance, increase the reliability, or reduce the cost of future Army systems. With the need for lighter weight and higher performance systems in the future, program emphasis has increasingly shifted away from metals research to a more balanced program with interests that cross a broad spectrum of materials, including polymers, ceramics and semiconductor materials. Fundamental research that lays the foundation for the design and manufacture of multicomponent systems such as composites, hierarchical materials and "smart materials" is of particular interest.

Potential offerors are encouraged to contact the appropriate Technical Point of Contact (TPOC) for preliminary discussions on their ideas. The TPOC may invite the offeror to submit a preproposal.

15.1. Materials Design. The objective of the materials design program is to tailor material properties for application-driven property requirements. The research should investigate property interrelationships in materials growth, processing or characterization with the approach eventually leading to stronger coupling of experimental

research with theory or modeling (including phenomenological modeling). The goal is to predict and control material behavior during processing and operation, to predict property changes over time (based on science rather than statistics), to optimize performance and reliability, and to reduce cost and time to development. It would also be advantageous to develop strategies to define constraints imposed by the experiment and theory and to establish and populate open databases for processing-microstructure-properties-performance etc. These could be continually updated to enable design, simulation, modeling and theory to evolve and ultimately for property tradeoff in support of performance optimization to occur. In addition, this should also facilitate communication among researchers and engineers at the materials, subsystem, and system level. One area of emphasis will be surface and interface engineering in support of materials integration. There is particular interest in identifying new ways of combining similar and dissimilar materials which provide multifunctional capabilities, recognizing that functionality is often derived from properties very close to the interface. Processing models that build a solid theoretical underpinning will be a key to control/optimization of surface and interface properties. Surface and interface research in areas such as organic/semiconductor, bio/semiconductor, or bio/organic/semiconductor interfaces; dielectrics/semiconductor interfaces; transparent conductive thin films; dissimilar material and nano electrical contacts; and bonded or alternative substrates can be envisioned. Another area of emphasis will be development of in-situ and ex-situ analytical methods for analysis over the appropriate dimensions, that is, methods with appropriate spatial resolution or appropriate sensitivity. The goal is to understand and control material and growth parameters that affect a desired or undesired property within a particular property range. Other areas of interest are investigations of high temperature materials and their relevant degradation modes; development of adaptive materials capable of response to internal or external stimuli; study of self-repair or self-healing effects; growth and characterization of embedded nano-sized constituents designed for material and performance health monitoring; and investigations of novel methods leading to large-scale, large-quantity processing of nanomaterials. It is intended that in addition to promoting convergence, combination and integration of similar and dissimilar materials the program also promotes convergence of and cross-disciplinary concepts for materials design.

Technical Point of Contact: Dr. William V. Lampert; email: William.V.Lampert@us.army.mil, (919) 549-4325.

15.2 Mechanical Behavior of Materials: The Mechanical Behavior of Materials program seeks to establish the fundamental relationships between the structure of materials and their mechanical properties as influenced by composition, processing, environment, and loading conditions. The program emphasizes research with the potential to dramatically enhance the mechanical properties of known materials systems and research that seeks to develop innovative new materials with unprecedented combinations and formulations of mechanical, and other complementary, properties. Critical to these efforts is the need for new materials science theory that will enable robust predictive computational tools for the analysis and design of materials subjected to a wide range of specific loading conditions, particularly theory which departs from standard computer algorithms and is not dependent upon tremendous computational facilities. The primary research thrust areas of this program include: a) high strain-rate phenomena (e.g., experimental and computational analysis of the physical mechanisms which govern deformation in advanced materials, lightweight damage tolerant materials); b) property-focused processing (e.g., materials science theory to predict the range of properties attainable with advanced processing methods, novel approaches for enhancing specific toughness); and c) tailored functionality (e.g., innovative materials containing unique and specifically designed chemical and biological functionalities and activities while maintaining, or preferably enhancing, requisite mechanical properties).

Technical Point of Contact: Dr. David Stepp, e-mail: David.M.Stepp@us.army.mil, (919) 549-4329.

15.3. Synthesis and Processing of Materials. The program on Synthesis and Processing of materials focuses on the use of innovative approaches for processing high performance structural materials reliably and at lower costs. Emphasis is placed on the design and fabrication of new materials with specific microstructure, constitution, and properties. Research interests include experimental and theoretical modeling studies to understand the influence of fundamental parameters on phase formation, micro structural evolution, and the resulting properties, in order to predict and control materials structures at all scales ranging from atomic dimensions to macroscopic levels. Trends in this subfield include non-equilibrium materials processing (e.g., rapid solidification); powder synthesis and consolidation; novel processing of ceramics, polymers, metals and composites; welding and joining including composite materials; elastomers; fibers and fabrics; and utilization of micro structural, compositional, or other unique signatures which may provide non-destructive in situ feedback process control to enhance product reproducibility and quality. Supercritical fluid, shock-induced chemical processing and other innovative approaches

for processing materials are also of interest.

Technical Point of Contact: Dr. William Mullins, e-mail: William.Mullins@us.army.mil, (919) 549-4286.

15.4. Physical Behavior of Materials. The program of Physical Behavior of Materials seeks research directed at providing an improved understanding of the fundamental mechanisms and key materials and processing variables that determine the electronic, magnetic and optical (EMO) properties of materials and affect the reliability of EMO devices. Emphasis is on research that will facilitate the nanostructuring of materials to realize the materials-by-design concept where new and unique materials are constructed on the atomic scale with application-specific properties. This includes research on understanding the underlying thermodynamic and kinetic principles that control the evolution of microstructures; understanding the mechanisms whereby the microstructure affects the physical properties of materials; and developing insight and methodologies for the beneficial utilization and manipulation of defects and microstructure to improve material performance. Major trends in this subfield include: (i) electronic materials - materials for microelectronics and packaging; fabrication and processing of semi-conductors, interconnects and device structures, and the characterization and control of trace impurities, defects and interfaces in semiconductors, (ii) magnetic materials - bulk and thin-film processing of magnetic materials for electronic and high frequency communications; and fundamental studies on magnetic coercivity and spin dynamics, and (iii) optical materials - materials and processing methods for detectors, lasers, nonlinear optical materials, refractive and diffractive optics, and optical windows and coatings. Research to improve the long-term stability of EMO materials, develop multifunctional or smart EMO materials, and develop low observable materials is also being sought.

Other important areas of interest include new approaches for materials processing, new composite formulations, and surface treatments that minimize environmental impacts; and novel composite concepts, including multifunctional and hierarchical materials. Finally, there is general interest in identifying basic research in the area of manufacturing science, which will address fundamental issues related to the reliability and cost (including environmental) associated with the production and long-term operation of Army systems. The foregoing areas of research are not intended to reflect all of the activities of the Materials Science Division. We are always interested in new ideas and cross-disciplinary concepts in materials science that may have future applications for the Army.

Technical Point of Contact: Dr. John Prater, e-mail: John.T.Prater@us.army.mil, (919) 549-4259.

ARO SPECIAL PROGRAM AREAS 16

16.1. SHORT TERM INNOVATIVE RESEARCH (STIR) PROGRAM. The objectives of the STIR program are to fund innovative ideas in basic research. Proposed research may be for the continuation of or the natural outgrowth of experimental or theoretical explorations.

16.1.1. Eligibility. Research proposals are sought from educational institutions, nonprofit organizations, and commercial organizations. Prospective offerors of a STIR proposal are encouraged to contact the appropriate TPOC identified in PART I Research Areas 7-15 **only** of this BAA to ascertain the extent of interest in the specific research project.

16.1.2. Research Sought. Proposals in the amount of $50,000 or less are sought for research in the areas identified in PART I, Research Areas 7-15 of this BAA.

16.1.3. Proposal Preparation.

16.1.3.1. Organizations or institutions should submit proposals that are no more than twenty (20) pages in length, inclusive of the budget, transmittal letter, and attachments. Any proposal in excess of 20 pages will not be considered. No brochures or explanatory material should be submitted with the proposal. A one-page budget must accompany the proposal.

16.1.3.2. Proposed research efforts must be "stand alone" and not predicated on the use of any facilities other than those under the direct control of the offeror. Research must be completed within nine (9) months of award of the agreement. **Extensions of the nine-month performance period will not be granted.**

16.1.3.3. Proposals shall be submitted with a Proposal Cover Page (Form 51). Limited rights data should be identified as an attachment to the proposal. Otherwise, we will assume that the proposal does not contain limited rights data.

16.1.3.4. No capital equipment may be purchased. Travel costs must not exceed $500. Report preparation costs must not exceed $100. The assessment of indirect costs or fee is unallowable.

16.1.3.5. The principal investigator(s) should disclose and explain the relevancy of the proposal to the research interests identified in PART I, Research Areas 7-15 of this BAA.

16.1.3.6. A brief, final technical report must be submitted to the ARO within thirty (30) days of completion of the grant or contract. Please note that your award document will reference Form 18, "Reporting Instructions," as found at http://www.aro.army.mil/index.htm .You shall use these reporting instructions for format instructions only; the due date for receipt of a final technical report is thirty (30) days from completion of the award.

16.1.3.7. Submit electronic proposals to the address found in Part IV, Section 2, General Preparation and Submission Information, paragraph 3.

16.2. YOUNG INVESTIGATOR PROGRAM (YIP). The objective of the YIP is to attract to Army research outstanding young university faculty members, to support their research, and to encourage their teaching and research careers. Young investigators meeting eligibility requirements may submit a YIP proposal. Outstanding YIP projects may be considered for a Presidential Early Career Award for Scientists and Engineers (PECASE). PECASE awards are the highest honor bestowed by the Army on outstanding scientists and engineers beginning their independent careers.

16.2.1. Eligibility. This program is open to U.S. citizens holding tenure-track positions at U.S. universities and colleges who have held their graduate degrees (Ph.D. or equivalent) for fewer than five years at the time of application. Faculty at an institution of higher education which does not designate any faculty appointments as "tenure track" are eligible if that is so indicated in the proposal and the supporting letter from the university states that the faculty member submitting the proposal will be considered for a permanent appointment.

16.2.2. Research Sought. Proposals are invited for research in areas described in PART I, Research Areas 7-15 **only** of this BAA. Proposals may be submitted at any time. As is the case for the regular research programs, **we strongly encourage informal discussions with the cognizant ARO technical program manager before submission of a formal proposal**. An award in each topic area is not guaranteed. YIP awards not to exceed $50,000 per year for three years will be made based on research proposals and supporting material. These funds may be used to defray those reasonable costs normally allocable to the research effort (e.g., direct salaries, indirect costs, graduate student support, equipment, supplies, etc.).

16.2.3. Proposal Preparation.

16.2.3.1. An individual applying for a YIP award must submit a research proposal and a supporting letter, each through university officials. Any resulting agreement will be made to the institution, not to the investigator. The research proposal should follow the format set forth in PART IV of this BAA. The institutionally approved proposal and letter should be sent to the address found in Part IV, Section 2 with the attention line as ATTN: AMSRL-RO-RI-YIP.

16.2.3.2. The supporting letter must be from the applicant's Department Chairperson, Dean, or other official who speaks for the university regarding support for and commitment to the applicant. Strong university support for the applicant is essential. This support can include the applicant's 9-month academic salary, release time from administrative responsibilities, the purchase of equipment, support for the applicant's graduate students, waiver of indirect costs, departmental cost sharing, start-up funding, and so on. It must be clear that the university views the

applicant as a truly outstanding, potential leading faculty member and is making a long-term commitment to the application and the research.

16.2.4. Evaluation Factors. The evaluation factors to be used in determining which proposals are selected for funding are described in PART III of this BAA. In addition, proposals submitted for YIP funding will be evaluated based on a long-term commitment by the university to the applicant and the research. YIP proposals will be selected for award on a competitive basis after a peer or scientific review.

16.2.5. Presidential Early Career Award for Scientists and Engineers (PECASE).

16.2.5.1. An applicant may not directly apply for a PECASE award. Instead, once a year ARO technical program managers will nominate PECASE candidates from among all ARO YIP proposals and white papers (if any) received. The technical program manager will make the PECASE nomination based on strong endorsement of the YIP proposal by the external scientific reviewers and on the great potential shown by the investigator to contribute to science and to the mission of the Army.

16.2.5.2. Following nomination of a PECASE candidate, a supplemental PECASE proposal will be required in which the candidate will indicate how PECASE funding would augment the YIP project. PECASE awards are not to exceed $100,000 per year for five years. Supporting information including letters of recommendation, detailed scientific biographical information, and a summary of past research accomplishments will be required in the PECASE proposal.

16.2.5.3. Complete PECASE proposal packages will be evaluated by external scientific reviewers, then by an Army multidisciplinary PECASE panel. The proposals which demonstrate the greatest potential to contribute to science and to the mission of the Army, will be chosen. Historically, no more than two Army PECASE proposals have been selected for award each year.

16.2.5.4 Continued Support. Support under the YIP is limited to three years and PECASE support is limited to five years. Upon completion of the YIP or PECASE project, young investigators may apply and be considered for continued support in the areas identified in PART I, Research Areas 7-15 of this BAA. Decisions about continued funding outside the context of the YIP or PECASE will be made following a peer or scientific review and a review of ARO's research priorities and the creativity and productivity demonstrated during the previous research program.

16.3. RESEARCH INSTRUMENTATION (RI) PROGRAM. Research instrumentation is designed to improve the capabilities of U.S. universities to conduct research and educate scientists and engineers in areas important to national defense. Of the funds available to acquire research described in PART I of this BAA, funds may be provided to purchase instrumentation in support of this research or in the development of new research capabilities.

16.3.1. Eligibility and Areas of Interest. To be eligible for an instrumentation award, an offeror must have at the time of submission, a current grant or contract with the ARO, and the instrumentation requested must be in support of research presently being carried out. It is highly recommended that potential offerors contact the appropriate ARO TPOC manager for advice and assistance before preparation of an instrumentation proposal.

16.3.2. Content of Request for Instrumentation. The request for instrumentation shall include:

16.3.2.1. A concise abstract (approximately 300 words) that describes the instrumentation requested and the research to be supported by that instrumentation.

16.3.2.2. A budget that addresses equipment to be purchased, cost per item, and total cost. Indicate the proposed source of the equipment and the name and telephone number of a contact at that source. The budget should indicate the amount of funds to be contributed by other sources toward the purchase of the instrumentation.

16.3.2.3. A description of how the proposed instrumentation will: (i) establish new research capabilities, (ii) contribute to research currently proposed to DOD, or (iii) enhance the quality of research currently being funded by ARO.

16.3.2.4. A description of how the proposed instrumentation will interface with or upgrade other research facilities and instrumentation now available.

16.3.2.5. A description of the amounts and sources of ongoing or proposed support for the research to be supported by the instrumentation.

16.4. DOD PROGRAMS.

16.4.1. Each year the Army Research Office, along with the Office of Naval Research (ONR) and the Air Force Office of Scientific Research (AFOSR), participates in two programs sponsored by the Office of the Deputy Under Secretary of Defense for Science and Technology. These two programs, titled the Defense University Research Instrumentation Program (DURIP) and the Defense Experimental Program to Stimulate Competitive Research (DEPSCoR), are conducted under separate BAAs that are posted yearly on the ARO web site. For the purpose of these two programs, the areas of interest for submitting proposals are limited to Research Areas 7-15 as identified in PART I.B of this BAA. Offerors are reminded that these two BAAs have definitive closing dates for receipt of proposals (see each specific BAA for details). In addition, offerors must review the specific BAAs for eligibility considerations.

Technical Point of Contact: Mr. Kurt Preston e-mail Kurt.Preston@us.army.mil (919) 549-4234.

16.4.2. HBCU/MI Infrastructure Support Program. The Army Research Office periodically issues solicitations for proposals from Historically Black Colleges and Universities and Minority Institutions (HBCU/MI) under the DoD Infrastructure Support Program. The program's primary goals include (a) enhancing programs and capabilities in scientific and engineering disciplines critical to the national security functions of the Department of Defense and (b) increasing the number of graduates, including underrepresented minorities, in the fields of science, mathematics, and/or engineering. Awards under the Infrastructure program frequently involve the acquisition of equipment and instrumentation to enhance education and/or research programs in science, mathematics, and/or engineering. The program is executed under the policy and guidance of the Director of Defense Research and Engineering and administered through the Army Research Office (ARO). HBCU/MI Infrastructure solicitations are available on the ARO Web site under 'Funding Opportunities.' These solicitations will have a definite closing date for proposal submission, and offerors are advised to review the solicitations for eligibility considerations.

Technical Point of Contact: ARL-Adelphi: Dr. Vallen L. Emery Jr., e-mail: vallen.emery@us.army.mil , (301) 394-3585.
ARL-ARO: Ms. Jenny Haire, e-mail: Jenny.w.haire@us.army.mil , (919) 549-4205.

PART II - OTHER PROGRAMS
CONFERENCE AND SYMPOSIA GRANTS

1. Introduction. The Army supports conferences and symposia in special areas of science that bring experts together to discuss recent research or educational findings or to expose other researchers or advanced graduate students to new research and educational techniques. The Army encourages the convening in the United States of major international conferences, symposia, and assemblies of international alliances.

2. Eligibility. Notwithstanding the above, the Department of Defense (DOD) has imposed certain restrictions on the Army's co-sponsorship of scientific and technical conferences and symposia. Specifically, DOD Instruction 5410.20 prohibits co-sponsorship of conferences and symposia with commercial concerns. Scientific, technical, or professional organizations which qualify for tax exemption under the provision of 26 U.S.C. Sec. 501(c)(3) may receive conference and symposia grants. For questions regarding your organization's eligibility for a conference or symposia grant, please contact the ARO Legal Office at (919) 549-4292 or e-mail: Mark.Mark.rutter@us.army.mil or the ARL-Adelphi Legal Office at (301) 394-1696 or e-mail: patrick.emery@us.army.mil .

3. Conference Support. Conference support proposals should be submitted a minimum of six (6) months prior to the date of the conference.

4. Technical Proposal Preparation. The technical portion of a proposal for support of a conference or symposium should include:

a. A one page or less summary indicating the objectives of the project.

b. The topics to be covered.

c. The location and probable date(s) and why the conference is considered appropriate at the time specified.

d. An explanation of how the conference will relate to the research interests of the Army and how it will contribute to the enhancement and improvement of scientific, engineering, and/or educational activities as outlined in PART I B of the BAA.

e. The name of chairperson(s)/principal investigator(s) and his/her biographical information.

f. A list of proposed participants and the methods of announcement or invitation.

g. A summary of how the results of the meeting will be disseminated.

5. Cost Proposal Preparation. The cost portion of the proposal should show:

a. Total project conference costs by major cost elements.

b. Anticipated sources of conference income and amount from each.

c. Anticipated use of funds requested.

6. Participant Support. Funds provided cannot be used for payment to any federal government employee for support, subsistence, or services in connection with the proposed conference or symposium.

HISTORICALLY BLACK COLLEGES AND UNIVERSITIES (HBCUs) AND MINORITY INSTITUTIONS (MIs)

1. Introduction.

a. It is an objective of the Army to award a fair proportion of its acquisitions to HBCU/MIs. While this BAA does not reserve discrete or severable areas of research for the HBCU/MI community, the submission of research proposals in full competition with all offerors is strongly encouraged.

b. Research collaborations between principal investigators in HBCU/MIs and scientists in other institutions of higher education (not limited to HBCU/MIs) are encouraged. Technology sharing and transfer are also encouraged. To this end, proposals are welcome that envision cooperation or collaboration with others in the academic or industrial sectors.

c. The Army has an interest in awarding cooperative agreements, grants and contracts to HBCU/MIs that will enhance the Army's ability to support the HBCU/MI in conducting advanced research and development in

science, math and engineering with potential application in support of the Army war fighter. Areas of interest include but are not limited to the following:

- Continued support of the 3 HBCUs and 3 MIs currently under education and research partnership agreements with ARL.
- Professional development for faculty to participate in ARL research and development activities and to develop methods for integrating these activities into their curricula.
- Participation in Summer Faculty/Sabbatical Leave research programs and Intergovernmental Personnel Act (IPA) appointments at ARL laboratories.
- Support for graduate student research on HBCU/MI campuses or at ARL laboratories (i.e., MS or Ph.D. degree programs relevant to the ARL mission).
- Opportunities for supporting research conducted by newly hired tenure track faculty at HBCU/MIs.
- Support of M.S. and Ph.D. candidates while completing thesis' and dissertations on ARL approved topics.
- Opportunities for HBCU/MIs to conduct research symposia, workshops, and other related technical assistance programs that provide "hands on " training and information to HBCU/MIs.
- Awards for Centers of Excellence at HBCU/MIs (i.e., research and education centers relevant to Army transformation).
- Summer internship opportunities for undergraduate and graduate students at ARL laboratories.
- Instrumentation and equipment upgrade of science laboratories.
- Faculty special training.

The Army is interested in receiving novel proposals that address innovative techniques for increasing the number of minority students attending college with math and science literacy i.e. summer programs, Saturday academies, online and distance education, special partnerships with local schools and college preparatory schools, etc.

Program interests cover a broad spectrum including funding to augment projects resulting in technologies that support state of the art capabilities for the war fighter. The Army is also committed to support for outreach programs that increase the available pool of Subject Matter Expert prepared students to act as research assistants and pursue graduate degrees in math science and engineering.
Proposals are requested that address these and other areas of mutual concern.

d. Before preparation of a proposal, we strongly encourage informal discussion of a brief summary of the proposed research with the identified Technical Point of Contact. After consultation with the appropriate Technical Point of Contact, HBCU/MI' s should submit proposals through personnel listed in 3 below.

2. Eligibility. Historically Black Colleges and Universities are those institutions determined by the Secretary of Education to meet the requirements of 34 CFR Section 608.2. Minority Institutions are those institutions meeting the criteria contained in 10 U.S.C. Section 2323(a)((1)(C), which reads in part: "…minority institutions {as defined in Section 1046(3) of the Higher Education Act of 1965 [20 U.S.C. 1135d-5(3)]}, which, for the purposes of this section, shall include Hispanic-serving institutions [as defined in section 316(b)(1) of such Act (20 U.S.C. 1059c(b)(1)]." A list of the colleges and universities that meet these criteria is available at http://www.ed.gov/offices/OCR/minorityinst.html. Questions concerning the list must be directed to the Integrated Postsecondary Education Data System (IPEDS) Inquiry Line (202-205-9576) in the Office of Civil Rights, U.S. Department of Education, not to the Department of Defense.

3. Points of Contact: ARL-Adelphi: Dr. Vallen L. Emery Jr., e-mail: vallen.emery@us.army.mil , (301) 394-3585.

ARO: Ms. Jenny Haire, e-mail: Jenny.w.Jenny.w.haire@us.army.mil , (919) 549-4205.
LTC David Camps, email: David.Camps@us.army.mil, (919)-549-4200.

PART III - PROPOSAL EVALUATION (COMPLETE PROPOSALS)

1. To be eligible for an award of a research agreement, 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/ARO research program.

c. The offeror'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 principal investigator, team leader, or other key personnel who are critical to achievement of the proposed objectives.

e. The offeror's record of past performance.

f. The reasonableness and realism of proposed costs, any fee, and the availability of funds.

[**NOTE:** If your proposal leads to the award of a contract, proposal evaluation and award performance may be subject to the Office of Federal Procurement Policy's (OFPP) guidance on past performance.]

2. Upon receipt of a proposal, the ARL/ARO 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 be declined without further review.

3. All proposals are treated as privileged information prior to award and the contents 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 offeror 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 offeror must indicate on the appropriate proposal form (Form 52 or 52A) any limitation to be placed on disclosure of information contained in the proposal.

4. Each proposal will be evaluated based on the scientific merit and military relevance of the specific research proposed as it relates to the overall Army program rather than against other proposals for research in the same general area.

PART IV - PROPOSAL PREPARATION

SECTION 1 - INTRODUCTION: This part provides information for preparing research proposals for submission to the ARL/ARO.

SECTION 2 - GENERAL INFORMATION: PRELIMINARY INQUIRIES: The ARL and ARO receive 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 that the preparation of a research proposal often

represents a substantial investment of time and effort by the offeror. Therefore, in an attempt to minimize this burden, we strongly encourage organizations and individuals interested in submitting research proposals to make preliminary inquiries as to the general need for the type of research effort contemplated before expending extensive effort in preparing a detailed research proposal or submitting proprietary information. The TPOCs for each area of interest are identified as part of the description of that area and shall be contacted as appropriate. Organizations may submit white papers in electronic form. White paper instructions are outlined below.

ELIGIBILITY: To be eligible for award of a research agreement, a prospective recipient (except other governments, including state and local governments) must meet certain minimum standards pertaining to financial resources, ability to comply with the performance schedule, prior record of performance, integrity, organization, experience, operational controls, technical skills, facilities, and equipment.

POST EMPLOYMENT CONFLICT OF INTEREST: There are certain post employment restrictions on former federal officers and employees, including special government employees (Section 207 of Title 18, U.S.C.). If a prospective offeror believes a conflict of interest may exist, the situation should be discussed with ARL legal personnel (ARO: Mr. Mark Rutter at Mark.rutter@us.army.mil or ARL: Mr. Pat Emery at patrick.emery@us.army.mil) prior to expending time and effort in preparing a proposal.

MILITARY RECRUITING: This is to notify potential offerors that each grant or cooperative agreement awarded under this announcement to an institution of higher education must include the following term and condition:

"As a condition for receipt of funds available to the Department of Defense (DOD) under this award, the recipient agrees that it is not an institution of higher education (as defined in 32 CFR part 216) that has a policy of denying, and that it is not an institution of higher education that effectively prevents, the Secretary of Defense from obtaining for military recruiting purposes: (A) entry to campuses or access to students on campuses or (B) access to directory information pertaining to students. If the recipient is determined, using the procedures in 32 CFR part 216, to be such an institution of higher education during the period of performance of this agreement, and therefore to be in breach of this clause, the Government will cease all payments of DOD funds under this agreement and all other DOD grants and cooperative agreements to the recipient, and it may suspend or terminate such grants and agreements unilaterally for material failure to comply with the terms and conditions of award."

If your institution has been identified under the procedures established by the Secretary of Defense to implement Section 558, then: (1) no funds available to DOD may be provided to your institution through any grant, including any existing grant, (2) as a matter of policy, this restriction also applies to any cooperative agreement, and (3) your institution is not eligible to receive a grant or cooperative agreement in response to this solicitation.

This is to notify potential offerors that each contract awarded under this announcement to an institution of higher education shall include the following clause: Defense Federal Acquisition Regulation Supplement (DFARS) clause 252.209-7005, Military Recruiting on Campus.

STATEMENT OF DISCLOSURE PREFERENCE: Please complete Form 52 or 52A stating your preference for release of information contained in your proposal. Copies of these forms are provided in PART V of this BAA.
REPORTING REQUIREMENTS: Each award agreement shall include the required technical and financial reporting requirements in its terms and conditions.

SUBCONTRACTING: 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 concerns to be considered fairly as subcontractors under all research agreements awarded to prime contractors and grantees.

EQUIPMENT: Normally, title to equipment or other tangible property purchased with contract funds vests with nonprofit institutions of higher education or with nonprofit research organizations if vesting will facilitate scientific research performed for the Government. Commercial organizations are expected to possess the necessary plant and equipment to conduct the proposed research. Deviations shall be made on a case-by-case basis.

TYPES OF AWARDS: The ARL and ARO have the authority to award a variety of instruments. The ARL/ARO reserves the right to use the type of instrument most appropriate for the effort proposed. Offerors 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. 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 DOD's direct benefit or use.

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

   c. No fee or profit is allowed.

2. 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 DOD and the recipient when carrying out the activity contemplated by the cooperative agreement. The term does not include "cooperative research and development agreements" as defined in 15 U.S.C. 3710a. No fee or profit is allowed.

Grants and cooperative agreements are governed by the following regulations:

   a. OMB Circular A-21, "Cost Principles for Educational Institutions"

   b. OMB Circular A-87, "Cost Principles for State, Local and Indian Tribal Governments"

   c. OMB Circular A-102, "Grants and Cooperative Agreements with State and Local Governments"

   d. OMB Circular A-110, "Uniform Administrative Requirements for Grants and Agreements with Institutions of Higher Education, Hospitals, and Other Non-Profit Organizations"

   e. OMB Circular A-122, "Cost Principles for Non-Profit Organizations"

   f. OMB Circular A-133, "Audits of States, Local Governments, and Non-Profit Organizations"

   g. DOD Grant and Agreement Regulations (DODGARs), DOD 3210.6-R

Copies of OMB regulations may be obtained from:

Executive Office of the President
Publications Service
New Executive Office Building
725 17th Street, N.W., Room 2200
Washington, DC 20503

Telephone: (202) 395-7332
FAX Requests: (202) 395-9068
http://www.whitehouse.gov/OMB/grants

An electronic copy of the DODGARs may be found at http://www.dtic.mil/whs/directives/corres/html/32106r.htm

3. Other Transaction for Research. 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 an other transaction shall not be duplicative of research being conducted under an existing DOD program. To the maximum extent practicable, other transactions shall provide for a 50/50 cost share between the government and the offeror. An offeror's cost share may take the form of cash, independent research and development (IR&D), foregone intellectual property rights, equipment, or access to unique facilities, as well as others. Due to the extent of cost share, and the fact that an other transaction does not qualify as a "funding agreement" as defined at 37 CFR 401.2(a), the intellectual property provisions of an other transaction can be negotiated to provide expanded protection to an offeror's intellectual property. No fee or profit is allowed on

other transactions.

4. Other Transaction for Prototype. A legal instrument, consistent with 10 U.S.C. 2371 (as supplemented by Section 845 of Public Law 104-201 and Section 804 of Public Law 104-201), 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 weapons or weapon systems proposed to be acquired or developed by the DOD. The effort covered under an other transaction for prototype shall not be duplicative of effort being conducted under an existing DOD program. No fee or profit is allowed on other transactions for prototypes.

NOTE: In accordance with DOD Directive 3210.6, the DODGARs may include rules that apply to other nonprocurement instruments, when specifically required in order to implement a statute, Executive Order, or Governmentwide rule that applies to other nonprocurement instruments, as well as to grants and cooperative agreements.

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

DEFINITIONS:

1. Historically Black Colleges and Universities. Institutions determined by the Secretary of Education to meet the requirements of 34 CFR Section 608.2.

2. Minority Institutions. Institutions defined as those meeting the criteria contained in 10 U.S.C. Section 2323(a)(1)(C), which reads: "minority institutions [as defined in Section 1046(3) of the Higher Education Act of 1965 (20 U.S.C. 1135d-5(3)], which, for the purposes of this section, shall include Hispanic-serving institutions [as defined in Section 316(b)(1) of such Act (20 U.S.C. 1059c(b)(1)]"

3. Research Agreement. As used herein, the term refers to research contracts, grants, cooperative agreements, and other transactions.

4. Small Business Concern. A concern that is independently owned and operated, organized for profit, is not dominant in the field of operation in which it is bidding on Government contracts, and with its affiliates employs not more than 500 employees.

5. Small Disadvantaged Business Concern. A small business concern which is at least 51 per cent owned by one or more socially and economically disadvantaged individuals; or, in the case of any publicly owned business, at least 51 per cent of the stock of which is owned by one or more socially and economically disadvantaged individuals and whose management and daily business operations are controlled by one or more of such individuals.

USE OF COLOR IN PROPOSALS: All proposals received shall be stored as electronic images. Electronic color images require a significantly larger amount of storage space than black-and-white images. As a result, offerors' use of color in proposals should be **minimal** and used **only when absolutely necessary** for details. Do not use color if it is not necessary.

GENERAL PREPARATION AND SUBMISSION INFORMATION:

1. White papers and proposals may be submitted at any time. In preparing a white paper or a proposal, it is important that offerors keep in mind the characteristics of a suitable white paper or proposal acceptable for evaluation. It should include all the information specified in this BAA in order to avoid delays in evaluation. A white paper or proposal for continuation of a given research project will be considered on the same basis as proposals for other new research agreements. The white paper or proposal should be submitted sufficiently in advance of the termination of the existing agreement so that if it is accepted, support may be continued without interruption.

2. All proposals should be submitted electronically with any restrictive legends. White papers should be submitted electronically to the TPOCs; however, do not submit the complete proposal to the individual TPOC. This could delay the receipt and review of the proposal.

3. All proposals submitted under this Broad Agency Announcement must be submitted as an electronic file (.pdf preferably). All required signed forms (ARO Form 51/52A and all budget forms) must be signed, scanned and submitted electronically as well. The file(s) must not be security or password protected. Acknowledgment of receipt will be returned via e-mail.

4. All required forms may be downloaded from the ARO web site at www.aro.army.mil under "For the Researcher" (Forms, ARO BAA Forms).

5. Proposal will not be processed unless all of the above requirements are met.

6. Requests for waiver of electronic submission may be submitted via e-mail to baa@aro.army.mil or regular mail:

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

7. If a waiver is granted, the proposal and all signed forms will be accepted in hard copy along with required signatures.

UNSUCCESSFUL WHITE PAPER AND PROPOSAL DISPOSITION: Unless noted in an offeror's proposal to the contrary, unsuccessful proposals will be retained for six (6) months from declination and then properly destroyed.

DOD CENTRAL CONTRACTOR REGISTRATION DATABASE: In accordance with DOD policy, prospective contractors must be registered in the Central Contractor Registration (CCR) database prior to award of a contract, basic agreement, basic ordering agreement, or blanket purchase agreement. By submission of an offer resulting from this BAA, the offeror acknowledges the requirement that a prospective contractor must be registered in the CCR database prior to award, during performance, and through final payment of any contract resulting from this BAA. Even though this requirement is applicable to contractors, the ARL strongly encourages potential grant recipients to register also.

CLASSIFIED SUBMISSIONS: Considering that this BAA is issued for the competitive selection of basic research proposals, classified proposals are not expected. However, in an unusual circumstance where an offeror believes a proposal has the potential to be classified, the ARO Security Office shall be contacted on (919) 549-4356 prior to the proposal's submission.

SECTION 3 - WHITE PAPER PREPARATION, SUBMISSION, EVALUATION, AND DISPOSITION **(THIS SECTION PERTAINS ONLY TO RESEARCH AREAS 1-6)**:

Submission of white papers is encouraged prior to the submission of a complete, more detailed proposal. White papers should present the effort in sufficient detail to allow evaluation of the concept's technical merit and its potential contributions of the effort to the Army mission. Due to Government budget uncertainties, no specific dollars have been reserved for awards under this BAA. Therefore, informal discussion with the TPOC is again encouraged.

WHITE PAPER PREPARATION:

1. White papers should state the potential advantage to Army and present the offeror's technical approach, and

identify physical products and data to be delivered to the Government and/or any equipment, information and support required from the Government, as well as the cost and proposed duration of the effort. Offerors should identify residual equipment or capabilities that, after demonstration, will remain property of the Government.

2. White papers are limited to five (5) pages plus the cover page and one page addendum as discussed below. Evaluators will be advised that they are only required to review the white paper cover page and up to six pages including the addendum.

TECHNICAL INFORMATION:

1. A brief technical discussion of the effort's objective, approach, 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 Army's mission and how this would be demonstrated.

2. The type of support, if any, that the offeror 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). Offerors 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.

3. As an addendum to the white paper, include biographical sketches (one page) of the key personnel who will perform the research, highlighting their qualifications and experience.

4. The cost portion of the white paper shall contain a brief cost estimate revealing all the component parts of the proposal, including research hours, burden, material costs, travel, etc.

RESTRICTIVE MARKINGS ON WHITE PAPERS:

1. Any proprietary data that the offeror intends to be used only by the Government for evaluation purchases must be identified. The offeror must also identify any technical data contained in the white paper that is to be treated by the Government as limited rights data. In the absence of such identification, the Government will assume to have unlimited rights to all technical data in the white paper. Records or data bearing a restrictive legend may be included in the white paper. It is the intent of the Army to treat all white papers as privileged information before the award and to disclose their contents only for the purpose of evaluation.

2. The offerors are cautioned, however, that portions of the white papers may be subject to release under terms of the Freedom of Information Act, 5 U.S.C. 552, as amended.

WHITE PAPER SUBMISSION: Offerors are encouraged to submit white papers electronically to the TPOC using Microsoft Word. Offerors transmitting proposal submissions electronically are reminded not to transmit classified information or information of a proprietary nature as they will be doing so in a non-secure environment. Offerors shall not submit facsimile white papers in response to this BAA.

EVALUATION AND DISPOSITION OF WHITE PAPERS:

1. Evaluation Process: Offerors are advised that invitations for complete proposals will be made based on the initial white paper submission and the availability of funding. As stated above, the white paper will be evaluated for the concept's technical merit and potential contributions of the effort to the Army mission. Offerors whose white papers are evaluated as having significant technical merit may be invited to submit a complete detailed proposal. Care must be exercised to ensure that classified, sensitive, critical technology(ies) are not included. If such information is required, appropriate restrictive markings and procedures should be applied.
2. Disposition Process: After completion of the evaluation, the offeror will be notified in writing of the results.

SECTION 4 - CONTENTS OF COMPLETE RESEARCH PROPOSALS (PHASE I)

All offerors preparing research proposals for submission to the ARL should initially submit the information as described below:

COVER PAGE (FORM 51):

1. See PART V of this BAA for the required Cover Page (Form 51). “Proposals will not be processed without a signed Cover Page, Form 51.

Should the project be carried out at a branch campus or other component of the submitting organization, that branch campus or component should be identified in the space provided.

2. The title of the proposed project should be brief, scientifically representative, intelligible to a scientifically literate reader, and suitable for use in the public press.

3. The proposed duration for which support is requested should be consistent with the nature and complexity of the proposed activity. For Research Areas 1-6 offerors shall discuss the preferred performance period with the TPOC. For Research Areas 7-15, the ARO normally awards research agreements for periods up to three (3) years (1 basic year of performance with two 1-year options). Nevertheless, the federal awarding agency reserves the right to make awards with shorter or longer periods of performance.

4. Specification of a desired starting date for the project is important and helpful however, requested effective dates cannot be guaranteed. Should unusual situations, such as long lead-time on awards, create problems regarding the proposed effective date, the investigator should consult the proposing organization's business office.

5. Should any of the special aspects apply to a proposal, the appropriate box(es) should be checked.

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], federal agencies shall obtain each awardee's Taxpayer Identification Number (TIN). This number may be the Employer Identification Number for a business or non-profit entity or the Social Security Number for an individual. The TIN is being obtained for purposes of collecting and reporting on any delinquent amounts that may arise out of an awardee's relationship with the Government.

7. Offerors shall provide their organization's Data Universal Numbering System (DUNS) number. The DUNS number is a nine-digit number assigned by Dun and Bradstreet Information Services.

8. If known, offerors 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.

9. Proposals must be cleared through the organizational office having responsibility for Government business relations. An official authorized to commit the organization in business and financial affairs must sign the original copy of the Cover Page. .

TABLE OF CONTENTS: PART V of this BAA contains the required Table of Contents format. Offerors' proposals should show the location of each section of the proposal, as well as major subdivisions of the project description.

STATEMENT OF DISCLOSURE PREFERENCE (FORM 52 OR 52A): Complete Form 52 (Industrial Contractors) or Form 52A (Educational and Nonprofit Organizations) as provided in PART V.

PROJECT ABSTRACT:

1. 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 objectives, methods to be employed, and the significance of the proposed effort to the advancement of knowledge.

2. The abstract should be no longer than one (1) page and be in a form suitable for release under the Freedom of Information Act, 5 U.S.C. 552, as amended. The abstract should indicate the effort intended for each 12-month period of research, where applicable.

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

1. A complete discussion stating the background and objectives of the proposed work, the approaches to be considered, and the level of effort to be employed. Include also 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.

2. A brief description of your organization. If the offeror 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, so state. 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. The offeror shall provide a statement regarding the use of Class I and Class II ozone-depleting substances. Ozone-depleting substances mean any substance designated as Class I by EPA, including but not limited chlorofluorocarbons, halons, carbon tetrachloride, and methyl chloroform and any substance designated as Class II by EPA, including but not limited to hydrochlorofluorocarbons. See 40 C.F.R. Part 82 for detailed information. If Class I or II substances are to be utilized, a list shall be provided as part of the offeror's proposal. If none, so state.

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

BIOGRAPHICAL SKETCHES:

1. This Section shall contain the biographical sketches for senior personnel only. 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 (5) publications most closely related to the proposed project and up to five (5) 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 (4) years. Include pending publications and submissions. Otherwise, state "None."

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

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

2. 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.

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

consideration. See PART V for the appropriate format.

BIBLIOGRAPHY: A bibliography of pertinent literature is required. Citations must be complete (including full name of author(s), title, and location in the literature). See PART V of this BAA for the appropriate format.

CURRENT AND PENDING SUPPORT:

1. PART V of this BAA provides a model format for reporting all current, on-going projects, and pending support for proposals, including subsequent funding in the case of continuing award agreements. All project support from whatever source must be listed. The list must include all projects requiring a portion of the principal investigator's and other senior 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 principal investigator and/or other senior personnel.

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

BUDGET PROPOSAL (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. The budget form (Form 99) found in PART V of this BAA may be reproduced as needed. Locally produced versions may be used, 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 up to five (5) pages of budget justification for each year. A summary budget page should 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.

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

Educational Institutions: OMB Circular A-21
Nonprofit Organizations: OMB Circular A-122*
Commercial Organizations: FAR Part 31, DFARS Part 231, FAR Subsection 15.403-5, and DFARS Subsection 215.403-5
All offerors (when applicable): DOD Grant and Agreement Regulations (DODGARs), DOD 3210.6-R

**For those nonprofit organizations specifically exempt from the provisions of OMB Circular A-122, FAR Part 31 and DFARS Part 231 shall apply.*

3. The itemized budget(s) must include the following:

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 principal investigator(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:

(1) The basis for the direct labor hours or percentage of effort (e.g., historical hours or estimates).

(2) 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.

(3) The portion of time to be devoted to the proposed research, divided between academic and non-academic (summer) terms, when applicable.

(4) The total annual salary charged to the research project.

(5) Any details that may affect the salary during the project, such as plans for leave and/or remuneration while on leave.

b. Fringe Benefits and Indirect Costs (Overhead, General and Administrative, 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, offerors must provide sufficient detail to enable a determination to be made that the costs included in the forecast rate are allocable according to applicable OMB Circulars or FAR/DFARS provisions. Offerors' 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:

(1) All individual cost elements included in the forecast rate(s);

(2) Bases used to prorate indirect expenses to cost pools, if any;

(3) How the rate(s) was calculated;

(4) Distribution basis of the developed rate(s);

(5) Bases on which the overhead rate is calculated, such as "salaries and wages" or "total costs," and

(6) The period of the offeror's fiscal year.

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. Offerors 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:

(1) Vendor Quote: Show name of vendor, number of quotes received and justification, if intended award is to other than lowest bidder.

(2) Historical Cost: Identify vendor, date of purchase, and whether or not cost represents lowest bid. Include reason(s) for not soliciting current quotes.

(3) Engineering Estimate: Include rationale for quote and reason for not soliciting current quotes. If applicable, the following additional information shall be disclosed in the offeror's cost proposal:

(4) Special test equipment to be fabricated by the awardee for specific research purposes and its cost.

(5) Standard equipment to be acquired and modified to meet specific requirements, including acquisition and modification costs, listed separately.

(6) 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.

Grants, cooperative agreements, or contracts 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. The Government will not convey title to commercial contractors.

NOTE: It is the policy of the DOD that all commercial and nonprofit contractors provide the equipment needed to support proposed research. In those rare cases where specific additional equipment is approved for commercial and nonprofit organizations, such approved cost elements shall be "nonfee-bearing." In addition, commercial contractors are precluded from using contract funds to acquire facilities with a unit acquisition cost of $10,000 or less (see FAR 45.302-1).

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 **$2,500 per year per principal investigator**. 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 principal investigator**. Special justification will be required for travel requests in excess of the amounts stated above and for travel by individuals other than the principal investigator(s). Individuals other than the principal investigator(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.

e. 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 ARL-sponsored conferences, meetings, symposia, training activities, and workshops (see PART II - Special Programs). 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.

f. 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.

g. 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.

h. Consultant Costs: Offerors 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.

i. 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.

j. Subawards (subcontracts or subgrants): A precise description of services or materials that are to be awarded by a subaward must be provided. For subawards totaling $10,000 or more, provide the following specific information:

(1) A clear description of the work to be performed.

(2) If known, the identification of the proposed subawardee and an explanation of why and how the subawardee was selected or will be selected.

(3) The identification of the type of award to be used (cost reimbursement, fixed price, etc.).

(4) Whether or not the award will be competitive and, if noncompetitive, rationale to justify the absence of competition.

(5) A detailed cost summary.

If the total amount of the proposal exceeds $500,000 and the offeror is a large business or an institute of higher education (other than HBCU/MI) and the resultant award is a contract, the offeror shall be prepared to submit a subcontracting plan for small business and small disadvantaged business concerns. A mutually agreeable plan will be included in and made a part of the contract.

k. Other Direct Costs: 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 shall be fully explained and justified.

l. Fixed Fee: The fixed fee, if any, which a commercial organization proposes to assess the research project.

CONTRACT FACILITIES CAPITAL COST OF MONEY: If cost of money is proposed, a completed Contract Facilities Capital Cost of Money (FCCM) (DD Form 1861) is required.

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.

SECTION 5 - INFORMATION TO BE REQUESTED FROM SUCCESSFUL OFFERORS

(PHASE II): Offerors whose proposals are accepted for funding will be contacted before award to provide additional information required for award. The required information is normally limited to clarifying budget explanations, representations, and certifications.

SECTION 6 - CERTIFICATIONS REQUIRED FOR ASSISTANCE AWARDS (GRANTS OR COOPERATIVE AGREEMENTS):

1. CERTIFICATION AT APPENDIX A TO 32 CFR PART 28 REGARDING LOBBYING:

By signing and submitting a proposal that may result in the award of a grant or cooperative agreement exceeding

$100,000, the prospective awardee is certifying, to the best of his or her knowledge and belief, that:

a. 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.

b. 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 Standard Form-LLL, Disclosure Form to Report Lobbying, in accordance with its instructions.

c. The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers (including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements) and that all subrecipients 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 section 1352, title 31, U.S.Code. 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. CERTIFICATION REGARDING DEBARMENT, SUSPENSION, AND OTHER RESPONSIBILITY MATTERS--PRIMARY COVERED TRANSACTIONS:

By signing and submitting this proposal, the prospective primary participant is providing the certification set out below.

The inability of a person to provide the certification required below will not necessarily result in denial of participation in this covered transaction. The prospective participant shall submit an explanation of why it cannot provide the certification set out below. The certification or explanation will be considered in connection with the department or agency's determination whether to enter into this transaction. However, failure of the prospective primary participant to furnish a certification or an explanation shall disqualify such person from participation in this transaction.

The certification in this clause is a material representation of fact upon which reliance was placed when the department or agency determined to enter into this transaction. If it is later determined that the prospective primary participant knowingly rendered an erroneous certification, in addition to other remedies available to the Federal Government, the department or agency may terminate this transaction for cause or default.

The prospective primary participant shall provide immediate written notice to the department or agency to which this proposal is submitted if at any time the prospective primary participant learns that its certification was erroneous when submitted or has become erroneous by reason of changed circumstances.

The terms "covered transaction," "debarred," "suspended," "ineligible," "lower tier covered transaction," "participant," "person," "primary covered transaction," "principal," "proposal," and "voluntarily excluded," as used in this clause, have the meanings set out in the Definitions and Coverage sections of the rules implementing Executive Order 12549. You may contact the department or agency to which this proposal is being submitted for assistance in obtaining a copy of those regulations.

The prospective primary participant agrees by submitting this proposal that, should the proposed covered transaction be entered into, it shall not knowingly enter into any lower tier covered transaction with a person who is proposed for debarment under 48 CFR part 9, subpart 9.4, debarred, suspended, declared ineligible, or voluntarily excluded from participation in this covered transaction, unless authorized by the department or agency entering into this

transaction.

The prospective primary participant further agrees by submitting this proposal that it will include the clause titled "Certification Regarding Debarment, Suspension, Ineligibility and Voluntary Exclusion--Lower Tier Covered Transaction," provided by the department or agency entering into this covered transaction, without modification, in all lower tier covered transactions and in all solicitations for lower tier covered transactions.

A participant in a covered transaction may rely upon a certification of a prospective participant in a lower tier covered transaction that it is not proposed for debarment under 48 CFR part 9, subpart 9.4, debarred, suspended, ineligible, or voluntarily excluded from the covered transaction, unless it knows that the certification is erroneous. A participant may decide the method and frequency by which it determines the eligibility of its principals. Each participant may, but is not required to, check the List of Parties Excluded from Federal Procurement and Nonprocurement Programs.

Nothing contained in the foregoing shall be construed to require establishment of a system or records in order to render in good faith the certification required by this clause. The knowledge and information of a participant is not required to exceed that which is normally possessed by a prudent person in the ordinary course of business dealings.

Except for transactions authorized under paragraph 6 of these instructions, if a participant in a covered transaction knowingly enters into a lower tier covered transaction with a person who is proposed for debarment under 48 CFR part 9, subpart 9.4, suspended, debarred, ineligible, or voluntarily excluded from participation in this transaction, in addition to other remedies available to the Federal Government, the department or agency may terminate this transaction for cause or default.

CERTIFICATION REGARDING DEBARMENT, SUSPENSION, AND OTHER RESPONSIBILITY MATTERS--PRIMARY COVERED TRANSACTIONS

The prospective primary participant certifies to the best of its knowledge and belief, that it and its principals:

a. Are not presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded by any Federal department or agency;

b. Have not within a three-year period preceding this proposal been convicted of or had a civil judgment rendered against them for commission of fraud or a criminal offense in connection with obtaining, attempting to obtain, or performing a public (Federal, State, or local) transaction or contract under a public transaction; violation of Federal or State antitrust statutes or commission of embezzlement, theft, forgery, bribery, falsification or destruction of records, making false statements, or receiving stolen property;

c. Are not presently indicted for or otherwise criminally or civilly charged by a government entity (Federal, State or local) with commission of any of the offenses enumerated in paragraph (b) of this certification; and

d. Have not within a three-year period preceding this application/proposal had one or more public transactions (Federal, State, or local) terminated for cause or default.

Where the prospective primary participant is unable to certify to any of the statements in this certification, such prospective participant shall attach an explanation to this proposal.

3. CERTIFICATION REGARDING DRUG-FREE WORKPLACE REQUIREMENTS:

By signing and/or submitting this application or grant agreement, the grantee is providing the certification set out below.

The certification set out below is a material representation of fact upon which reliance is placed when the agency

awards the grant. If it is later determined that the grantee knowingly rendered a false certification, or otherwise violates the requirements of the Drug-Free Workplace Act, the agency, in addition to any other remedies available to the Federal Government, may take action authorized under the Drug-Free Workplace Act.

For grantees other than individuals, Alternate I applies.

For grantees who are individuals, Alternate II applies.

Workplaces under grants, for grantees other than individuals, need not be identified on the certification. If known, they may be identified in the grant application. If the grantee does not identify the workplaces at the time of application, or upon award, if there is no application, the grantee must keep the identity of the workplace(s) on file in its office and make the information available for Federal inspection. Failure to identify all known workplaces constitutes a violation of the grantee's drug-free workplace requirements.

Workplace identifications must include the actual address of buildings (or parts of buildings) or other sites where work under the grant takes place. Categorical descriptions may be used (e.g., all vehicles of a mass transit authority or State highway department while in operation, State employees in each local unemployment office, performers in concert halls or radio studios).

If the workplace identified to the agency changes during the performance of the grant, the grantee shall inform the agency of the change(s), if it previously identified the workplaces in question (see paragraph five).

Definitions of terms in the Nonprocurement Suspension and Debarment common rule and Drug-Free Workplace common rule apply to this certification. Grantees' attention is called, in particular, to the following definitions from these rules:

Controlled substance means a controlled substance in schedules I through V of the Controlled Substances Act (21 U.S.C. 812), and as further defined by regulation (21 CFR 1308.11 through 1308.15);

Conviction means a finding of guilt (including a plea of nolo contendere) or imposition of sentence, or both, by any judicial body charged with the responsibility to determine violations of the Federal or State criminal drug statutes;

Criminal drug statute means a Federal or non-Federal criminal statute involving the manufacture, distribution, dispensing, use, or possession of any controlled substance;

Employee means the employee of a grantee directly engaged in the performance of work under a grant, including:

(i) All "direct charge" employees; (ii) all "indirect charge" employees unless their impact or involvement is insignificant to the performance of the grant; and, (iii) temporary personnel and consultants who are directly engaged in the performance of work under the grant and who are on the grantee's payroll. This definition does not include workers not on the payroll of the grantee (e.g., volunteers, even if used to meet a matching requirement; consultants or independent contractors not on the grantee's payroll; or employees of subrecipients or subcontractors in covered workplaces).

CERTIFICATION REGARDING DRUG-FREE WORKPLACE REQUIREMENTS
(ALTERNATE I - GRANTEES OTHER THAN INDIVIDUALS)

The grantee certifies that it will or will continue to provide a drug-free workplace by:

a. Publishing a statement notifying employees that the unlawful manufacture, distribution, dispensing, possession, or use of a controlled substance is prohibited in the grantee's workplace and specifying the actions that will be taken against employees for violation of such prohibition;

b Establishing an ongoing drug-free awareness program to inform employees about--

(1) The dangers of drug abuse in the workplace;

(2) The grantee's policy of maintaining a drug-free workplace;

(3) Any available drug counseling, rehabilitation, and employee assistance programs; and

(4) The penalties that may be imposed upon employees for drug abuse violations occurring in the workplace.

c. Making it a requirement that each employee to be engaged in the performance of the grant be given a copy o the statement required by paragraph (a);

d. Notifying the employee in the statement required by paragraph (a) that, as a condition of employment under the grant, the employee will--

(1) Abide by the terms of the statement; and

(2) Notify the employer in writing of his or her conviction for a violation of a criminal drug statute occurring in the workplace no later than five calendar days after such conviction;

e. Notifying the agency in writing, within ten calendar days after receiving notice under paragraph (d)(2) from an employee or otherwise receiving actual notice of such conviction. Employers of convicted employees must provide notice, including position title, to every grants officer or other designee on whose grant activity the convicted employee was working, unless the Federal agency has designated a central point for the receipt of such notices. Notice shall include the identification number(s) of each affected grant;

f. Taking one of the following actions, within 30 calendar days of receiving notice under paragraph (d)(2), with respect to any employee who is so convicted--

(1) Taking appropriate personnel action against such employee, up to and including termination, consistent with the requirements of the Rehabilitation Act of 1973, as amended; or

(2) Requiring such employee to participate satisfactorily in a drug abuse assistance or rehabilitation program approved for such purposes by a Federal, State, or local health, law enforcement, or other appropriate agency;

g. Making a good faith effort to continue to maintain a drug-free workplace through implementation of paragraphs (a), (b), (c), (d), (e), and (f).

The grantee may insert in the space provided below the site(s) for the performance of work done in connection with the specific grant:

Place of Performance (street address, city, county, state, zip code)

_____

_____

_____

Check ( ) if there are workplaces on file that are not identified here.

(ALTERNATE II - GRANTEES WHO ARE INDIVIDUALS)

(a) The grantee certifies that, as a condition of the grant, he or she will not engage in the unlawful manufacture, distribution, dispensing, possession, or use of a controlled substance in conducting any activity with the grant;

(b) If convicted of a criminal drug offense resulting from a violation occurring during the conduct of any grant activity, he or she will report the conviction, in writing within 10 calendar days of the conviction, to every grants officer or other designee, unless the Federal agency designates a central point for the receipt of such notices. When

notice is made to such a central point, it shall include the identification number(s) of each affected grant.

SECTION V: PROPOSAL FORMS

PROPOSAL
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