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

DAAD19-00-R-0010

JULY 2000 - FY 2003

ISSUED BY:
U. S. ARMY RESEARCH LABORATORY
U.S. ARMY RESEARCH OFFICE
P. O. BOX 12211
RESEARCH TRIANGLE PARK, NC 27709-2211

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INTRODUCTION

This Broad Agency Announcement (BAA) sets forth research areas of interest to the Army Research Laboratory (ARL) which includes the following sites:

Army Research Office (ARO)
Computational and Information Sciences Directorate (CISD)
Sensors and Electron Devices Directorate (SEDD)
Survivability/Lethality Analysis Directorate (SLAD)
Weapons and Materials Research Directorate (WMRD)
Human Research and Engineering Directorate (HRED)
Vehicle Technology Directorate (VTD)

This BAA 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 that are 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.

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

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.

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 from Europe, Africa, Middle East, and Southwest Asia to the ARL European Research Office.

For ARO's Research Areas 1-8, 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. For Research Areas 10-15, offerors shall discuss the preferred performance period with the TPOC.

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 2003, unless announced otherwise, and supersedes the ARL BAA dated 30 October 1998. The current ARO BAA No. DAAD19-99-R-BAA1 dated October 1998 remains effective only until 30 September 2000. 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.

ROBERT W. WHALIN
Director
Army Research Laboratory

PART I - AREAS OF RESEARCH INTEREST

The following part presents the research areas of interest for which the Army Research Laboratory (ARL) is seeking proposals. The research areas are grouped into functional or business areas that closely correspond to the current research directorates and divisions, which carry out the overall mission of the Army.

A. ARMY RESEARCH LABORATORY: ARMY RESEARCH OFFICE (ARO)

RESEARCH AREA 1 - CHEMISTRY
RESEARCH AREA 2 - ELECTRONICS
RESEARCH AREA 3 - ENVIRONMENTAL SCIENCES
RESEARCH AREA 4 - LIFE SCIENCES
RESEARCH AREA 5 - MATERIALS SCIENCE
RESEARCH AREA 6 - MATHEMATICAL AND COMPUTER SCIENCES
RESEARCH AREA 7 - MECHANICAL SCIENCES
RESEARCH AREA 8 - PHYSICS
SPECIAL PROGRAM AREAS 9 - SHORT TERM INNOVATIVE RESEARCH (STIR), YOUNG INVESTIGATOR PROGRAM (YIP), RESEARCH INSTRUMENTATION (RI), AUGMENTATION AWARDS FOR SCIENCE AND ENGINEERING RESEARCH TRAINING (AASERT), DEFENSE UNIVERSITY RESEARCH INSTRUMENTATION PROGRAM (DURIP), and DEFENSE EXPERIMENTAL PROGRAM TO STIMULATE COMPETITIVE RESEARCH (DEPSCoR)

B. ARMY RESEARCH LABORATORY: COMPUTATIONAL AND INFORMATION SCIENCES DIRECTORATE; SENSORS AND ELECTRON DEVICES DIRECTORATE; SURVIVABILITY/LETHALITY ANALYSIS DIRECTORATE; WEAPONS AND MATERIALS RESEARCH DIRECTORATE; HUMAN RESEARCH AND ENGINEERING DIRECTORATE; AND VEHICLE TECHNOLOGY DIRECTORATE

RESEARCH AREA 10 - COMPUTATIONAL AND INFORMATION SCIENCES
RESEARCH AREA 11 - SENSORS AND ELECTRON DEVICES
RESEARCH AREA 12 - SURVIVABILITY/LETHALITY ANALYSIS
RESEARCH AREA 13 - WEAPONS AND MATERIALS RESEARCH
RESEARCH AREA 14 - HUMAN RESEARCH AND ENGINEERING
RESEARCH AREA 15 - VEHICLE TECHNOLOGY

A. ARMY RESEARCH LABORATORY: ARMY RESEARCH OFFICE (ARO)

RESEARCH AREA 1
CHEMISTRY

1.0. Chemistry is central to the operation of the Army. 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.

1.1. 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: Rshaw@usardsguk.army.mil, 919-549-4293

1.2. 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, electrocatalysis, 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: paur@arl.aro.army.mil, (919) 549-4208

1.3. 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.

Technical Point of Contact: Dr. Stephen Lee, e-mail: slee@arl.aro.army.mil, (919) 549-4365

1.4. Polymer Chemistry. The Polymer Chemistry Program seeks novel, fundamental polymer research that may provide the soldier with critical protection and required materiel. This includes chemical and biological agent protection, ballistic protection, transparent materials for eye protection and sensors, including laser protection, materials that can be manipulated to control signature, lightweight super-strong materials, and molecular electronics. Research areas of interest that may be relevant include: synthesis of polymers, including block and graft copolymers, particularly with novel architectures and compositions, organic/inorganic hybrid polymeric materials, coherently operated surface anchored molecular machines, light-weight polymeric materials with enhanced strength, environmentally benign polymeric materials, and life extension. 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: kiserow@arl.aro.army.mil, (919) 549-4213

1.5. 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: slee@arl.aro.army.mil, (919) 549-4365

1.6. 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, Rshaw@usardsguk.army.mil, 919-549-4293

RESEARCH AREA 2
ELECTRONICS

2.1. Solid State Devices. This research area includes the acquisition of basic knowledge on electronic, magnetic, and optical materials and structures for microelectronics. The Army seeks to understand those parameters of electronic materials, which potentially affect or determine characteristics of future high-performance devices. To establish the science base for future Army battlefield capabilities, innovative research is sought in the general areas of advanced electronic materials, processing and fabrication science, self assembly technologies for solid state devices, advanced device concepts, nanometer-scale devices and systems electronics-based micro machined devices, ultra low power technology and integrated systems. Areas such as generation, transport and control of charge carriers in semiconductors, and electronics contributing to novel optical, electro-optical and optoelectronic systems are of interest. Specific research fields of current interest are electronic and structural properties of elemental, binary, ternary, and quaternary semiconductors; semiconductor surface and interface studies; active quasi-optical device effects at millimeter wave frequencies; as well as novel electro-optical and optoelectronic devices and interconnects.

Studies of the new or improved operating principles for semiconductor devices as well as investigations concerning the fundamental limitations of the operating range of devices will provide directions for potential improvements. Included in this research effort is the evaluation of existing device barrier problems in the fields of generation, detection and processing of electronic signals. Research in semiconductor devices is emphasized to increase the power-frequency product or the bandwidth of new classes of electronic devices and to study transit time effects on semiconductor devices.

Army electronics systems for the twenty-first century will require a four-order-of-magnitude increase in real-time signal processing capability. Requisite device speed and densities demand that the initial feature size be lowered from the current few-micron (micrometer) level, through the very high-speed integrated circuits (VHSIC) domain (1.5-0.5 micron), to the ultra-submicron region (0.1 micron and below). Planned systematic technological realization of submicron and ultra small devices cannot be achieved without research to understand the physical laws describing band structure, charge transport, interaction effects, etc., in the submicron realm. Research needs at this stage may be grouped in five major problem areas: (i) carrier transport properties, non-equilibrium phenomena, and dissipative interactions, (ii) electrical characterization (including picosecond characterization) of ultra small electronic structures, (iii) electronic properties of sub dimensional structures and heterojunctions, (iv) novel device structures, with emphasis on nanoscale and mesoscopic devices, and (v) the coupling of ultraviolet, visible and infrared radiation to novel direct band gap semiconductor structures. Novel devices based on mixed-mode principles portend numerous multifunctional information handling applications. Whereas many current devices depend primarily upon a single phenomenon for their operation, these new devices exploit a complexity of interactions between a variety of fields, including quasi-static electric and magnetic, electromagnetic, optical and quasi-optical, thermal, and elastic. Advanced device concepts for use on the digital battlefield are needed to include: efficient, low power components; sensing of ultraviolet, visible, and infrared radiation by semiconductor structures; terahertz device technology in the 100-1000 GHz region; optoelectronic devices for optical interconnects; micromechanical and micro photonic integrated sensors; new high temperature, high power electronics utilizing wide band gap semiconductors, new unipolar and bipolar devices; devices based on high temperature superconducting materials; and molecular electronics. To ensure the timely insertion of ultra small electronics technology, program thrusts will include research on input-output coupling of nanoscale devices.

Semiconductor device research will be conducted with the aim toward ultra high-speed and low-power integrated circuits.
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.

Technical Points of Contact: Dr. Dwight Woolard, e-mail: woolard@arl.aro.army.mil, (919) 549-4297, and Dr. Michael Gerhold, e-mail: gerholdmd@arl.aro.army.mil, (919) 549-4357

2.2. Quantum and High Frequency Electronics. The Army is interested in the following electronic component areas: (i) ultra fast switching transistors and optoelectronic devices for high processing bandwidths in signal and data processing, (ii) monolithic ultra submicron device components and networks capable of application-specific signal processing, and (iii) terahertz emitters, detectors, modulators, device arrays and frequency multipliers. State-of-the-art techniques for fabricating quantum-scale structures are emphasized. New device concepts based on intersubband energy level engineering is expected to emerge as potential candidates for terahertz applications. Research in novel quantum phenomena and effects of external perturbations such as strain and band coupling effects, as well novel transport effects in nanoscale electronic structures and incorporation of these effects into devices with higher functionalities which will enable the Army's next generation electronic and optoelectronic devices. Research will also include the use of these results to demonstrate proof of principle devices employing this novel phenomena and study of them to understand their operations as well as how to apply this knowledge and understand the limitations and determine their ultimate performance ranges. Research in issues relating to design, modeling, and fabrication of these device structures are of interest. Materials issues in these novel devices are also of importance for high performance, high fields and high temperature and reliability. Research in support of these objectives includes submicron device modeling and scaling novel device structure concepts (e.g. vertical integration ballistic devices and quantum-well concepts) and submicron device fabrication for enhanced functionalities.

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.

a. Technical Points of Contact Dr John Zavada, email: Jzavada@aro.arl.army.mil, 919-549-4238 and Dr. Dwight Woolard, e-mail: woolardd@arl.aro.army.mil, (919) 549-4297.

2.3. Opto-electronic Devices. Research on the generation, detection and control of optical signals in both semiconductor and dielectric materials is of interest. In particular, novel electro-optical processes leading to greater manipulation and increased data handling capabilities are to be considered. To establish the science base for future Army battlefield capabilities, innovative research is sought in the general areas of advanced optical materials, optical and infrared sensors, solid state, semiconductor lasers and infrared detectors, as well as optoelectronic devices and circuits. Representative areas of investigation include: (i) photonics in III-V and III-N compound semiconductors, (ii) methods for altering optical and electronic properties of materials, (iii) investigations of semiconductor surfaces and interfaces, (iv) light emission and detection in nanostructures, and (v) rare-earth doping of semiconductors and dielectrics.

The Army requires high resolution, high sensitivity, "multicolor" infrared imaging arrays for target acquisition, recognition, and identification. Future systems need to be developed for the fusion of data from infrared (IR) sensor suites involving several wavelengths. Research opportunities include components based on quantum well and semiconductor materials operating in the 3-5, 8-12, and 18-24 microns regions as well as ultraviolet (UV) solar blind detectors and arrays. Army image processing requirements necessitate operations on a million pixels at rates up to a thousand frames/second at resolutions above twelve bits. Development of the necessary architectures and the optical processing components provide research challenges. 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. New device concepts are needed for all the above applications.

High speed signal processing and computing, as well as data storage, will require advanced laser diodes, and for optical processing components and optical data storage. Research is necessary in semiconductor materials growth and device processing to improve the efficiency and reliability of the output of the devices at these wavelengths. For optical processing of images, research leading to two-dimensional (2-D) arrays of surface-emitting lasers is necessary.

As the needs for information processing become more complex, the advantages of optical interconnection techniques become very clear. Optical interconnect components are needed in guided-wave data links for computer interconnection and in free-space links for optical switching and processing. Research addressing efficient, novel optical components, such as optical electro-mechanical systems (MEMs) is needed.

Optically controlled millimeter-wave and microwave devices and circuits have significant potential application in communications and radar systems, particularly mobile systems. Of particular interest are methodologies for integrated systems generating the final radio frequency (RF) signal using an optical heterodyne principle. Low loss splitters with integral semiconductor amplifiers and the control of polarization are important. Fast optical detectors for frequencies up to 60 GHz and above, which can still handle high optical powers are required. Alternative approaches to direct detection, such as optical injection locking should be considered. Modeling and simulation techniques for the optical interactions in devices and the optical propagation through complex optical structures are needed. Technologies which foster monolithic or near monolithic electrical and optical integration are components of special interest. Efficient integration of the optoelectronic components with RF is an important consideration.

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.

b. Technical Points of Contact: Dr John Zavada, email: Jzavada@aro.arl.army.mil, 919-549-4238.
and Dr. Michael Gerhold, e-mail: gerholdmd@arl.aro.army.mil, (919) 549-4357.

2.4. 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 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 "on-the-move" and must perform in environments of impressive diversity, from dense foliage to dense urban obstructions, and unintentional and intentional jamming. Research is required in broad thrust areas including end-to-end admission, flow and congestion control and reliability; adaptive routing and forwarding protocols, power control, channel access and link-layers protocols; adaptive coding and modulation techniques for power and spectral efficiency; signal processing and in modeling and simulators. Modeling of ultra wideband channels, channel parameter estimation, signal design, and coding for multiple access channels with interference is 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. 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. 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.

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. Some form of spread spectrum packet radio will be utilized. Network control must be distributed to avoid single points of failure and the system should be self-organizing with peer-to-peer capability. Adaptivity should be considered at all levels to optimize performance. Relevant areas of research include, but are not limited to, formal methods for protocol and network modeling, intelligent protocols, formal models of protocol performance and conformance, protocol conversion for tactical gateways, and adaptive protocols. Survivability in an electronic/ information warfare environment is a requirement.

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.

Technical Points of Contact: Dr. William Sander, e-mail: sander@arl.aro.army.mil, (919) 549-4241 or
Dr. Robert Ulman, e-mail: ulmanrj@arl.aro.army.mil, (919) 549-4330.

2.5. Information Processing and Fusion and Circuits.

2.5.1. *Image Analysis and Processing*. The understanding of image background, including target-competitive clutter, and of how image background compounds the difficulty of target detection and recognition is of paramount importance. The 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 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, telemaintenance, 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 relies 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 multisource, multitarget, detection, classification, recognition, and identification.

2.5.2. *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.

2.5.3. *Information and Signal Processing*. Information and signal processing research is oriented primarily toward communication, image analysis for surveillance and target acquisition and information fusion. Multi-dimensional and concurrent signal processing as well as adaptive processing and array processing for null and beam steering adaptive antennas, direction of arrival estimation, and diversity combining are included. Also of interest are research topics in image, radar, and other sensor processing related to detection, identification, and tracking of targets in real time. An interest exists in high performance multi-dimensional and concurrent signal processing architectures. Architectures suited to classes of algorithms in automated targeting; information (sensor) fusion; antenna array processing for communications, radar, direction finding, emitter location, signal intercept, electronic countermeasures (ECM), electronic counter-countermeasures (ECCM), and electronic warfare (EW); data compression to reduce bandwidth; coding, decoding, and modulation for communications; and guidance and control are needed. Also of interest are novel and hybrid implementations such as neural networks, discrete event dynamical systems, or 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 for incremental upgrades.

2.5.4. *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 gigahertz operation.

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.

Technical Points of Contact: Dr. William Sander, e-mail: sander@arl.aro.army.mil, (919) 549-4241 or Dr. Robert Ulman, e-mail: ulmanrj@arl.aro.army.mil, (919) 549-4330.

2.6. Minimum Energy/Low Power Electronics. The future Army communications, information processing, imaging, and other systems must be portable, functional, versatile, and highly reliable. In addition, the systems will require ultra-high speed capability for handling complex voice, data, and video multimedia signal formats. Many of the new systems will find application in wireless communications, infrared imaging, and portable diagnostic and computational equipment. As these systems become more sophisticated, the necessary electronic circuitry becomes more complex, with increased prime power requirements. Currently, and in the near future, prime power for mobile and light weight system utilization is limited. It is necessary, therefore, to develop a new generation of electronic and other systems that can operate under minimum energy constraints with very low direct current (DC) power dissipation. This research topic goes beyond the simple desirability of efficient devices and circuits. It is aimed at new concepts resulting from

considering the multilevel problem; materials, devices, circuits, coding, networking, and overarching system of systems considerations, in order to reduce overall power dissipation in RF systems. Research can be approached from the component level or the overall design level.

Fundamental research directed towards developing an understanding of the minimum energy required to provide functions such as communications will provide a basis for advanced system development. This involves determining the minimum energy that can be detected and the corresponding minimum energy required to be generated. Such analyses should include background noise, transmission losses, multipath, atmospheric attenuation, etc. Both theoretical and experimental projects are of interest. The systems will include both low DC power consumption digital and RF circuits. The digital portion of the unit would operate at low bias voltage to significantly reduce power dissipation. The RF transmit/receive portion of the communications system dissipates a significant fraction of the total power. Due to limitations imposed by the transmission requirements a finite level of RF energy must be transmitted. Therefore, it is necessary to develop a new generation of high-efficiency, low loss systems that can operate under minimum energy limitations.

Research on advanced modulation and coding techniques and associated circuit architectures that result in high integrity signals under reduced energy consumption conditions will provide the Army with the concepts necessary to realize next generation systems. Analyses that examine the tradeoffs between time domain and frequency domain techniques are of interest. Novel modulation techniques that will permit oscillators and power amplifiers to be operated under maximized high power-added efficiency conditions while maintaining linear performance need to be developed. It is anticipated that digital techniques will be widely utilized to make more effective use of available bandwidth, while maintaining high performance operation.

Novel semiconductor devices that can operate with high performance at low power dissipation will provide the building blocks to realize the new systems. Both digital and RF devices will be required. However, the Army has particular interest in RF devices for transmitters and receivers. System operation will extend from the low microwave bands to the millimeter wave region, depending upon the particular system application. Mixed mode circuits that utilize both digital and RF devices in novel architectures that permit functions to be implemented with minimized device counts and reduced energy consumption are attractive. Simple voltage scaling, while appropriate for complementary metal oxide semiconductor (CMOS) devices, may not be optimum for low power RF devices. Research that clarifies this issue is of interest.

Passive components such as filters, antennas, mixers, couplers, etc. are necessary building blocks for an electronic system. Research directed towards implementing these circuit functions in novel formats that are suitable for use in advanced integrated circuits will permit maximized integration to be achieved. Directed beam, phased array, and adaptive antennas are of particular interest since they permit high gain to be obtained. Advanced filters with narrow bandwidth and high off-band rejection and that can be implemented in small size suitable for use in integrated circuits are desirable.

Advanced models and simulation tools that can accurately predict device, circuit, and system performance need to be developed. The Army has interest in physically based models that allow DC and RF performance to be determined as a function of material, device design, bias, RF circuit, and operating parameters. It will be necessary to include large-signal, thermal, and breakdown effects. Simulators that include statistical design capability and yield determination will find use in reducing manufacturing costs. Advanced models for directed beam antennas, filters, mixers, etc. are also of interest.

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.

Technical Points of Contact: Dr. Dev Palmer, email: dpalmer@aro.arl.army.mil 919-549-4246.
and Dr. Dwight Woolard, e-mail: woolardd@arl.aro.army.mil, (919) 549-4297.

2.7. Electromagnetics. Three drivers of Army interest in the fields of EM and millimeter wave/microwave circuit integration are the unique capabilities available for Army electronic systems operating at mm-wave frequencies and higher on the digitized battlefield of the 21st century, the need for innovative component and circuit advances for personal and mobile communications systems, and the need for exceptional capabilities for tactical antennas at lower RF

frequencies. Novel systems capabilities can result from the unique propagation characteristics of the millimeter-wave frequencies, their imaging resolution, the potential system size reduction, and their large bandwidth. At lower frequencies, personal and mobile communications systems have requirements for small, lightweight, low cost, high performance, highly reliable circuits and components for military peculiar applications. Tactical antennas are needed which are capable of supporting multifunctional military communications systems and special purpose military applications. Research is sought in the following general technical areas: (i) innovative RF circuit integration, (ii) EM modeling, (iii) propagation over complex terrain, (iv) mobile antenna research, and (v) mine detection.

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 the millimeter-wave regime, in order to overcome loss, coupling, and spurious radiation problems. Hybrid techniques which combine high performance from component optimization with low fabrication cost due to compatibility with high volume production processes are needed at millimeter-wave frequencies and at mobile communications net wave frequencies. Higher levels of integration into chips, modules, and packages present special problems at higher RF frequencies. Dense integration techniques, including 3-D integration, must be developed. Thermal effects must be analyzed and minimized. Innovative approaches such as micromachining can provide significant advantages for circuit integration and the production and integration of passive components. Efficient power and signal combining techniques for RF frequencies, such as quasi-optical combining schemes, are needed. Innovative approaches to millimeter wave antennas are needed to develop antennas and antenna arrays with low losses and high efficiency. At millimeter wave frequencies antennas and antenna arrays tend to become part of the integrated circuit. Active antennas can increase functionality, compactness, and efficiency, and can introduce nonlinearity in the antenna for new applications such as phase conjugation. Special applications, such as conformal arrays for mounting on vehicle surfaces, can place physical limitations on size and shape. Some applications require very broadband or multiband operation. Adaptive antennas require the ability to switch in space and spectrum.

Electromagnetic analysis, simulation, and modeling are performed for several reasons. Quantitative answers can be obtained for a specific physical problem or circuit configuration, yielding qualitative understanding of a class of problems. The analysis is needed to guide experimental research and to place experimental results in perspective. Systems development decisions are guided by EM analysis of circuits, systems, packages, antennas, and propagation effects. Detailed analysis or modeling is used to design specific systems applications and it supports the optimization processes for Computer Aided Design (CAD) techniques. Of special interest is 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. New analysis concepts, techniques, and methodologies are needed for increasingly complex systems. Innovative signal processing techniques are needed for ultra-wideband radar and ground penetrating radar.

Propagation effects have a major impact on communications and radar systems. Propagation loss and multipath effects such as path delay and fading can have a serious frequency-dependent effect on communication channels. These propagation effects become highly complex in urban and built up terrain or in terrain with heavy foliage. Propagation and scattering effects are also very important for radar systems, particularly for the detection of targets in clutter.

Innovative approaches to increasing the performance and decreasing the size and signature of tactical antennas operating in the HF, VHF, UHF, and microwave frequency bands are needed. Designs for multifrequency, multiband operation are of interest. Broad impedance bandwidths and pattern bandwidths are required for spread spectrum systems. Fast frequency switching over a wide band of frequencies is required for frequency hopping systems. Efficient coupling of EM energy into the ground is required for ground penetration radar antennas. Novel ideas for ultra-wideband radar are needed for enhanced performance.

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

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.

Technical Point of Contact: Dr. James Harvey, e-mail: harvey@arl.aro.army.mil, (919) 549-4244.

RESEARCH AREA 3
ENVIRONMENTAL SCIENCES

3.0. The environmental sciences support 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.

3.1. 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, military engineering and mobility considerations under combat conditions, 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 environments, 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 elaborated in the following paragraphs. In all cases, the emphasis is on basic research.

3.1.1. *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. Research related to terrain characterization is directed toward fostering the development of advanced geoscience 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 and the accurate detection and short-term dynamic surface conditions and terrain feature change are high priority research issues.

3.1.2. *Terrestrial Processes and Landscape Dynamics*. The effects of adverse terrain and environmental conditions can directly affect the Army's strategy, mobility, logistics, and field operations. A continuous dynamic interaction takes place between solid earth materials and the most abundant fluids, water and air. Fluvial processes are dominant in shaping the continental surface through both erosion and deposition, but in more arid regions, eolian processes can give rise to active 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. At 0°C, water changes from the liquid to solid phase, which results in the formation of snow, ice and frozen ground, conditions that dramatically alter the battlefield environment and affect the performance of systems and materiel. Tropical and desert environments present particular challenges to Army personnel, materiel, and vehicles. 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 operations and training 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. Thus, improved understanding, physical representation, and quantification of terrestrial processes affecting Army operations are the focus of 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.

3.1.3. *Terrestrial System Modeling and Model Integration*. The ultimate objective of much of the effort to characterize the natural environment and study surficial processes is to develop or enhance integrated system models and simulators. 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, - plus the emerging Land Management System, to name but a few. These current systems allow 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. 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.

Technical Point of Contact: Dr. Russell Harmon, e-mail: harmon@arl.aro.army.mil, (919) 549-4326.

3.2. 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 a 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

3.2.1. *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. The rapid detection, identification, and quantification of chemical and biological agents in addition to natural and induced aerosols remotely and in place, require understanding of the atmospheric effects on the sensors. 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.

3.2.2. *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 atmospheric the 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 representativeness 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.

3.2.3. *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.

Technical Point of Contact: Dr. Walter Bach, Jr., e-mail: bach@arl.aro.army.mil (919) 549-4247.

RESEARCH AREA 4
LIFE SCIENCES

4.0 Extramural research in the Life Sciences is supported by the ARO. 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 three 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 encouraged to contact the appropriate TPOC for preliminary discussions on their ideas. The TPOC may invite the offeror to submit a preproposal.

4.1. 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: campbell@arl.aro.army.mil, (919) 549-4230.

4.2 Molecular Genetics and Genomics. This program emphasizes basic research in molecular genetics and genomics. This includes identification of gene function, and nuclear and mitochondrial DNA replication, mutagenesis, oxidative stress, and DNA repair. Additionally, basic research in gene regulatory pathways, gene regulation, and molecular adaptation to adverse environmental conditions will also be supported. This program also supports research on biomaterials and bioproduction methods. Finally, this program also supports research to reduce DNA damage in military personnel, for improving performance of military personnel, and advances in biotechnology. This includes molecular responses to pathogens, pathogen identification, and pathogen inactivation, and basic research on mitochondrial regulation and biogenesis. In particular, this program is interested in supporting

the biotechnology of micro arrays, including both genomic- and proteomic-based platforms, for real time detection of pathogens or physiological states that would reduce or interfere with human performance.

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

4.3 . 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: tove@arl.aro.army.mil, (919) 549-4344.

4.4 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, neuropsychological, 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-medical research designed to elucidate the fundamental physiology underlying cognition and possible non-invasive methods of monitoring cognitive states and processes 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 can be included.

Technical Point of Contact: Dr. Elmar T. Schmeisser e-mail schmeisseret@aro.arl.army.mil
(919) 549-4318.

RESEARCH AREA 5
MATERIALS SCIENCE

5.0. The objective of research supported by the Materials Science Division 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 crosses 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 TPOC for preliminary discussions on their ideas. The TPOC may invite the offeror to submit a preproposal.

5.1. Materials Reliability. The program in Materials Reliability investigates the metastable behavior of materials prepared by nonequilibrium surface processing approaches, including high pressure, shock, plasma, beam, and self-assembling techniques. The principal objective is to discover new non-equilibrium structural materials and novel smart materials, which will enhance the reliability of Army systems in service. This research includes non-destructive characterization of smart and ultra hard/ super strong materials and in-situ process monitoring. 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. The synthesis of novel degradation-resistant, ultrahigh strength nanolaminates and other refractory materials is also of interest. Experimental and theoretical approaches are sought that provide for characterization of surfaces and interfaces, modification of surface and near-surface regions, and processing and materials characterization as this relates to the structure, wear, and environmental resistance of smart materials and ultrahard/superstrong structural materials. Other phenomena including spectroscopic and chemical analysis of low level hydrogen and hydrocarbons, where these are important for understanding the properties of such new materials during processing and in-service life assessment, are also of interest.

c. Technical Point of Contact: Dr William Lampert, email: LampertWV @aro.arl.army.mil, 919-549-4325.

5.2 . Mechanical Behavior of Materials. The program on Mechanical Behavior of Materials addresses the fundamental relationships between the structure of materials and their mechanical properties as influenced by composition, processing, environment, stress state, and loading rate. The objectives of the subfield are to provide structural materials with improved mechanical properties and quantitative models for predicting both the response and the remaining useful life of a material. Major thrusts include the development of new strengthening, plasticity and toughening mechanisms for preventing or retarding fracture; especially at large strains (1000%) and high strain rates (to 10^6/sec). New knowledge is sought concerning fundamental deformation processes in materials including: load transfer, fatigue, creep, transformation toughening, super plasticity, and shear localization. New processing procedures are required for optimizing the mechanical properties of a material and reducing the inherent variations in the mechanical properties of materials. Additional thrusts include fundamental investigations on biomimetic and hierarchical materials to afford improved mechanical behavior and reliability. A fundamental understanding of the role of grain boundaries and interphases in composites and their hierarchical relationship to the overall mechanical behavior of the material system is desired.

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

5.3. 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: mullins@arl.aro.army.mil, (919) 549-4286.

5.4 . 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: prater@arl.aro.army.mil, (919) 549-4259.

RESEARCH AREA 6
MATHEMATICAL AND COMPUTER SCIENCES

6.0. 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 and computer 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 and computer science 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, Army areas of interest will be described to the potential researcher and user mainly by means of research topics within mathematics and computer science. 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 and computer 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 seven areas that following. Each of these seven areas is represented by a program. The research supported by the Division does not cover all or even the majority of topics in these seven 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 and computer 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.

6.1. Applied Analysis and Physical Mathematics. The Applied Analysis Program supports Army needs in mathematical modeling and analysis for advanced solid materials, soil and granular materials, fluid flow (including reactive flow), photonic bandgap materials, nonlinear dynamics and inverse scattering.

6.1.1. *Advanced Solid Materials*. The Applied Analysis Program supports mathematical research oriented toward optimizing properties or performance characteristics of highly nonlinear materials, including advanced composites for 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 are the functional ingredients of actuators, sensors and transducers.

6.1.2. *Soil and Granular Materials*. Descriptions of granular materials include static and dynamic discrete models, including discrete element models, and continuum models which depend on the size and shape of the grains. There are multiscale problems in abundance in this area. Modeling heterogeneity is important, since locally large fluctuations in force can strongly affect the dynamics of granular materials in distant regions. Large-deformation models of clay soils and other soils for a full range of environmental conditions need to be developed.

6.1.3. *Fluid Flow*. The characterization of fluid flow, especially reactive fluid flow, is an area in which many (but not all) of the basic equations are well known but which requires further investment because of the presence of vast ranges of length scales and the complexity of the phenomena observed. For characterization and optimization of airflow around rotors and of combustion, detonation and explosion, further research on vortices, vortex motion, turbulence and turbulent diffusion is critical. Research on two-phase flow, such as the break-up of viscous liquid droplets in high-speed airflow, is directly related to defense against biological or chemical weapons transported by theater missiles.

6.1.4. *Photonic Band gap Materials*. To determine the flow of EM radiation in a photonic bandgap material, one needs to solve the Maxwell equations in complicated geometry. Solution of the discretized Maxwell equations by finite elements or other procedures is computationally intensive due to the large number of parameters needed to represent the solution and due to the complicated geometry of photonic bandgap materials. The use of mathematical analysis, including boundary integral equations with specialized Green's functions, to design algorithms of great efficiency is a topic of research in the Applied Analysis Program. This area is important for optical control of phased array radar, signature control, identification of friend or foe and protection of personnel and equipment from laser radiation.

6.1.5. *Nonlinear Dynamics*. Digital communication using nonlinear (chaotic) transmitters and receivers is an exciting area of great importance. The rich characteristics of nonlinear behavior can be used to generate digital signals by simple, lightweight, inexpensive electronic and optical devices with minimal circuitry. The result may be a new digital communication technology with vastly improved bit rate, reduced power requirements and flexibility that will complement and in many instances replace conventional technology. Research in control of chaos, design of alphabets of symbols and synchronization techniques is needed to realize the potential of this area.

6.1.6. *Inverse Scattering*. Inverse scattering is of interest to the Army for detection and identification of landmines and unexploded ordnance. This is an area involving the interaction between largely unexplored areas of solid mechanics, namely the propagation of various types of waves in soils, and the inverse problem of detecting solid objects having various waveform signatures. Currently available techniques often have high false alarm rates, which impede mine clearance.

6.1.7. *Additional Areas*. Topics of potential future interest include mathematical analysis for diffraction-free femtosecond-chirped laser propagation in the atmosphere (for chem/bio detection, laser marking and secure communication), models and performance metrics for information operations (influence on an opponent's decision making and protection of one's own decision making), ultra-lightweight multiscale rod-and-strut materials (for structural components in ground and air vehicles), soil dynamics for vehicle-terrain interaction (for prediction of mobility of ground forces), compressed multiscale representation of terrain and irregular surfaces (for enhanced operational capabilities and combat modeling and simulation), and acoustic sensing systems for physiological and

situational monitoring.

Technical Point of Contact: Dr. John Lavery, e-mail: lavery@arl.aro.army.mil, (919) 549-4253.

6.2. Computational Mathematics. The Computational Mathematics Program supports Army needs in producing faster, more stable and accurate solutions to relevant problems in the physical, biological and engineering sciences, and in operations.

6.2.1. *Numerical Methods*. The areas of interest in numerical methods include methods for efficient numerical solution of nonlinear partial differential equations (both time-dependent and steady state), such as adaptive finite difference and finite element methods, high order methods, gridless methods and methods for computing interfaces, such as front tracking and level sets. Other areas of numerical analysis, such as numerical linear algebra, solution of nonlinear systems and methods for the solution of ordinary differential equations and differential-algebraic equations are of interest to the extent that they address problems of Army interest. Some Army applications may require solutions of numerical problems in real time. The emphasis of the program is on innovative methods for representing data and solving problems, analysis, and applicability to Army problems such as rotorcraft flows and penetration mechanics and high performance computing issues, including data management. Multi-scale, multi-model and closure techniques are needed in several applications of importance to the Army. Failure models and dislocation formation in solid mechanics, turbulence modeling, groundwater flow modeling and transport of airborne toxic agents are representative examples. Numerical methods for solving such problems are of considerable interest.

6.2.2. *Optimization*. Innovative approaches to integer programming, mixed integer programming and nonlinear optimization, especially for large-scale problems, are needed for C^3 applications, vulnerability analysis, logistics, resource management and design of materials (molecular chemistry). Specific topics currently supported include interior-point trust-region approaches to nonlinearly constrained optimization, limited-memory approaches for large-scale optimization, and convergence of optimization methods for singular problems. Parallel computational methods for molecular dynamics with very large numbers of particles, needed for design of new materials, are important. An important area, which has an optimization component and which needs research, is the querying and presenting of large data sets. Optimization, searching, partitioning and mathematical programming are areas that can support research on data management, representation and compression.

Technical Point of Contact: Dr. Stephen Davis, e-mail: sdavis@arl.aro.army.mil, (919) 549-4284.

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

6.3.1. *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.

6.3.2. *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.

Technical Point of Contact: Dr. Mou-Hsiung Harry Chang, email: ChangMH@arl.army.mil

6.4. Systems and Control. 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, and communications and in guidance and control of complex semi-automated and automated systems. The program invests in fundamental control theory, intelligent systems, and design and control of smart structures.

6.4.1. *Control Theory*. Topics of interest include control in the presence of measurement and model uncertainties, robust and adaptive control for multivariable and nonlinear systems and computational issues related to the design and implementation of real-rime control systems. Some theoretical issues of interest in control theory include adaptive control, robust control, optimal control, stochastic control and nonlinear control. Some practical issues of interest in control theory include hybrid control, telerobotics, micro machines, control issues in wireless communication systems, network control systems, robotics, visual tracking and human dynamics modeling.

6.4.2. *Intelligent Systems*. Given advances in technology, environmental factors and goals, an intelligent system configures 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 autonomous or semi-autonomous reconfigurable physical agents, computational vision, computational geometry, wireless communications and networks, cognitive issues in man-machine systems, hybrid systems, distributed communication, 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.

6.4.3. *Design and Control of Smart Structures*. The Army is interested in developing an analysis 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.

Technical Point of Contact: Dr Robert Launer, email: launer2arl.aro.army.mil (919) 549-4309.

6.5. Software and Knowledge-Based Systems. The program in Software and Knowledge-Based Systems (SKBS) addresses the theoretical bases for the analysis, design, development, and evolution of advanced information-based systems that enable significant improvements in state-of-the-art engineering for software, software-based applications (including modeling and simulation), machine learning, knowledge/acquisition/ representation/ synthesis, and knowledge bases/databases. Currently, the research supported by the program is in software prototyping, development and evolution, formal methods for software engineering, and knowledgebase/database sciences.

6.5.1. *Software Prototyping, Development and Evolution*. Software prototyping, development and evolution require significant investigation into iterative/adaptive graphically driven interfaces; rapid prototyping; software generation, evolution and reuse; software system simulation; distributed software change/evolution; software engineering in domain-specific architectures, tools and tool set integration; software system documentation; and validation and verification. In addition, significant advances in formal methods, the interests in which are described in the next subsection, are required.

6.5.2. *Formal Methods for Software Engineering*. The interest in this subarea includes global dependencies in software development, the maintenance of these dependencies as software evolves, the interactions among different parts of the process and compatible models for solutions to different parts of the problem. The SKBS Program is

interested in research on small-, large- and huge-grain formal methods and software languages, including specification, programming and interface languages. Finally, there is interest in research on real-time software; this research involves the investigation of formal frameworks, deductive methods and tools for the implementation of provably correct (reactive, real-time and hybrid) systems.

6.5.3. *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.

Technical Point of Contact: Dr. David Hislop, e-mail: hislop@arl.aro.army.mil, (919) 549-4255.

6.6. 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.

6.6.1. *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.

6.6.2. *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.

d. Technical Point of Contact Dr Michael Coyle, email: CoyleJM@aro.arl.army.mil 919-549-4256.

6.7. Automation, Simulation, Information Technology and Related Topics. The objective of this work-package is to maximize the combined power of mathematics and computer science for current challenging problems pertaining to automation, robotics, information technology and modeling and simulation. Topics of research includes: (i) mathematical foundations for modeling and simulation of physical phenomena related to robotics and automation, (ii) rigorous methods for information and data processing related to intelligent systems and decision making, (iii) innovative methods in high performance computing, large data set manipulation and information management related to large-scale simulation problems, and (iv) research issues in computer sciences related to and in conjunction with the subjects (i) through (iii) stated above.

e. Technical Point of Contact: Dr John Lavery email: Lavery@aro.arl.army.mil 919-549-4253.

6.8. Current Priorities. While the above descriptions reflect the current program, there are areas of higher priority among these. This, of course, does not mean that the Mathematical and Computer Sciences Division will exclude other proposals from consideration, but does reflect the Division's intention to develop programs that take into account evolving research trends as well as changing Army needs. Currently, the high priority areas include

nonlinear analysis with emphasis on design of advanced materials, novel algorithmic approaches for large-scale scientific computing, fast algorithms for real-time applications, stochastic analysis with emphasis on simulation methodology and numerical methods, symbolic methods, computational geometry with emphasis on interactive simulation and virtual prototyping, intelligent systems, large databases/knowledge bases and software systems.

RESEARCH AREA 7
MECHANICAL SCIENCES

7.0. Research supported in the mechanical sciences portion of the Mechanical and Environmental Sciences Division is concerned with a broad spectrum of fundamental investigations in the disciplines of fluid dynamics, solid mechanics, structures and dynamics, and combustion and propulsion. 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 subdisciplines, 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 focussed on investigations in vehicle structural dynamics and simulation and air vehicle dynamics including rotor aeromechanics. Research in the combustion and propulsion sciences area is concentrated on processes characteristic of reciprocating (diesel) and gas turbine engines and gun propulsion and energetic material hazards. 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.

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, rotorcraft always operates 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*. The flowfield around many modern Army weapons systems can be characterized by a high level of unsteady flow, which cannot be adequately predicted by steady or quasi-steady approaches. 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 lead 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 understanding the separation process and validation of the numerical simulations. New non-intrusive optical methods may be appropriate experimental techniques. 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 aeroelastic 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 flowfield 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. Thus, research is needed in the areas of thermodynamics, heat transfer, and fluid dynamics of these miniature devices, as well as the multidisciplinary integration of these thermal science disciplines with chemistry, structural dynamics, and materials sciences, which enable the analysis of these devices.

Technical Point of Contact: Dr. Thomas Doligalski, e-mail: tom@arl.aro.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 optimized material properties on the one hand and the desired structural behavior in terms of changes in shapes under specific set of constraints on the other. Complete understanding of the behavior of structures made of advanced materials and quantitative description of their behavior allows predictive capability so necessary for design methodology. 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 following specific topical areas are especially encouraged.

7.2.1. *High Strain Rate Phenomena*. In its many missions, Army hardware is subjected to overwhelming explosive force characterized by shock, high velocity deformation, damage, and failure. Study of structural behavior under severe conditions will be facilitated by innovative full-field computational methodologies. The purpose is to understand and model the deformation and fracture of materials under severe loading conditions. This includes 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 giga pascal (GPa)]. Constitutive models should be three-dimensional (3D) 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. The primary application of these models will be for high velocity impact and explosive detonation computations. Models are required for a wide variety of materials including metals, ceramics, composites, and energetic materials. The models should be physically based and suitable for large-scale computational modeling. 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. *Impact and Penetration*. Penetration mechanics is a research topic that integrates fundamental work in finite deformation, high pressure/high rate response, damage and failure mechanics, and computational solid mechanics. The mechanics and modeling of interfaces, in particular, need better understanding through innovative experimental and theoretical research. High velocity sliding, such as might occur at penetrator/target interface, must be understood on a physical basis. Computational methods for treating discontinuities in a 3D context are required. These methods must concentrate not only on the computational 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 penetrator/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. 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, interrupted experiments. Novel concepts are essential to defeat the projectile upon impact. Improved understanding of projectile and target interaction will require innovative diagnostic experiments and predictive modeling capabilities. Since 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 of processes and phenomena in materials and structures which can be triggered by impact to absorb energy, deflect penetrators, and/or laterally disperse momentum is encouraged.

7.2.3. *Heterogeneous Systems*. Fundamental research in damage initiation and progression, failure mechanisms, and life prediction is essential for the development of new heterogeneous structural 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. 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.

Quantitative prediction and measurement of critical length and time scales and dominant heterogeneities and mechanisms for specific material systems are needed 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 variabilities 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. 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. 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. Constitutive relations for these 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.

f. Technical Point of Contact: Dr Bruce LaMattina, email: LaMattinaB@aro.arl.army.mil 919-549-4379.

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. 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, micro-electromechanical systems (MEMS) devices, or other concepts. The development of new active materials, such as relaxor ferroelectrics and alkaline-based piezoelectric materials have 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.

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.

Technical Point of Contact: Dr. Gary Anderson, e-mail: anderson@arl.aro.army.mil, (919) 549-4317.

7.4. Combustion and Propulsion Sciences. Combustion and propulsion 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 focussed 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 low heat rejection (adiabatic) type 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 focussed 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. 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 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.

Technical Point of Contact: Dr. David Mann, e-mail: dmann@arl.aro.army.mil, (919) 549-4249.

RESEARCH AREA 8
PHYSICS

8.0. The objective of the Physics Program 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. For example, the Physics

Division has provided most of the ARO investments in laser research and the chief investigators within the laser program were often associated with Departments of Engineering.

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 pre-proposal.

8.1. Condensed Matter Physics. The properties of novel inorganic, organic, and 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 three major areas of interest within the condensed matter physics work package.

8.1.1. *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 and understanding the evolution of atomic to thin film to bulk behavior. 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.

8.1.2. *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, 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 design rules based on prescribed performance objectives, are of particular interest. Applications include infrared emitters and detectors, low observables, and micro photonics for smart sensors.

8.1.3. *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.

Technical Point of Contact: Dr. Henry Everitt, e-mail: everitt@aro.arl.army.mil, (919) 549-4369.

8.2 . 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 thermo mechanical strengths of alloys for armor and armor penetrators; 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.

8.2.1. *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.

8.2.2. *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 magneto static 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.

8.2.3. *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 that can respond to mm waves by forming magneto static and magneto optic 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.

Technical Point of Contact: Dr. Mikael Ciftan, e-mail: ciftan@aro.arl.army.mil, (919) 549-4236.

8.3. 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.

8.3.1. *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.

8.3.2. *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.

8.3.3. *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.

Technical Point of Contact: Dr. Henry Everitt, e-mail: everitt@aro.arl.army.mil, (919) 549-4369.

8.4. 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 atom optics and laser cooling and trapping for ultra sensitive detectors; nonlinear atomic and molecular processes for sensor protection and optical processing; and the study of transport and optical properties of increasingly complex molecules for potential use in hybrid or composite materials.

8.4.1. *Atom Optics*. Matter waves offer new or increased capabilities in a number of areas. For example, cooling, trapping and coherent control of atoms and molecules may provide ultra sensitive sensors such as gyroscopes for inertial navigation, or ultrahigh resolution lithography. In addition to the wavelength advantage of matter waves, they also have additional degrees of freedom such as mass that might provide new sensing capabilities. The use of matter waves and Bose condensates requires basic research to better understand issues such a decoherence and optimal trapping techniques, and it requires the development of techniques to transmit, combine, interfere and otherwise manipulate matter waves. Laser cooling and trapping of atoms also may provide proof of principle demonstrations of key components of quantum computing.

8.4.2. *Molecular Physics*. The molecular or chemical physics program is distinguished from programs in chemistry of materials science by its focused interest not on synthesis but on underlying phenomenology such as electronic transport, magnetic permeability's, and/or linear and nonlinear optical properties of well-defined molecular systems and their functionalized variants. The objective is to ascertain the sensitivity of underlying phenomena to controllable molecular parameters while also ascertaining fundamental limits or ultimate extrema of such parameters in a given class of molecules.

8.4.3. *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 may also provide 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.

Technical Point of Contact: Dr. Henry Everitt, e-mail: everitt@aro.arl.army.mil, (919) 549-4369.

8.5 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.

8.5.1. *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 depends 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 hyper spectral 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.

8.5.2. *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.

8.5.3. *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.

8.5.4. *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.

Technical Point of Contact: Dr. Richard Hammond, e-mail: hammondrt@aro.arl.army.mil, (919) 549-4313.

8.6 Surface and Interface Physics. Surfaces and Interfaces are important for many phenomena such as film growth, Fermi-level pinning, and quantum confinement effects. The ARO physics program in this area supplements other physics programs such as Nanoscience and Atomic/Molecular Physics. Novel demonstration projects are considered that are multidisciplinary in the sense of allowing a new capability in surfaces/interfaces and ultra thin film physics. Often projects in this area result from special workshops and focused sessions at major scientific conferences.

Technical Point of Contact: Dr. Jack Rowe, e-mail: rowe@aro.arl.army.mil, (919) 549-4332.

SPECIAL PROGRAM AREAS 9

9.1. 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.

9.1.1. *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 1-8 **only** of this BAA to ascertain the extent of interest in the specific research project.

9.1.2. *Research Sought*. Proposals in the amount of $30,000 or less are sought for research in the areas identified in PART I, Research Areas 1-8 of this BAA.

9.1.3. *Proposal Preparation*.

9.1.3.1. Organizations or institutions should submit proposals that are no more than twenty (20) pages in length, inclusive of the budget, transmittal letter, and attachments. Submission of ten (10) copies of the proposal, when not submitting electronically, is required. 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.

9.1.3.2. 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 six (6) months of award of the agreement. **Extensions of the six-month performance period will not be granted.**

9.1.3.3. 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.

9.1.3.4. 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.

9.1.3.5. The principal investigator(s) should disclose and explain the relevancy of the proposal to the research interests identified in PART I, Research Areas 1-8 of this BAA.

9.1.3.6. 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.

9.1.3.7. Mail or submit electronic proposals to the address found in Part IV, Section 2, General Preparation and Submission Information, para. 3 with the attention line as ATTN: AMSRL-RO-RI-STIR.

9.2. 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.

9.2.1. *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.

9.2.2. *Research Sought*. Proposals are invited for research in areas described in PART I, Research Areas 1-8 **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.).

9.2.3. *Proposal Preparation*.

9.2.3.1. 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 formal 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.

9.2.3.2. 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.

9.2.4. *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 additional, 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.

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

9.2.5.1. 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.

9.2.5.2. 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 recommendations, detailed scientific biographical information, and a summary of past research accomplishments will be required in the PECASE proposal.

9.2.5.3. 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.

9.2.6. *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 1-8 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 creatively and productivity demonstrated during the previous research program.
9.3. 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.

9.3.1. *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 being presently 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.

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

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

9.3.2.2. 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.

9.3.2.3. 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.

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

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

9.4. DOD PROGRAMS. 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 which 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 1-8 as identified in PART I.A 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. David Seitz, e-mail: seitz@arl.aro.army.mil, (919) 549-4207.

B. ARMY RESEARCH LABORATORY DIRECTORATES

RESEARCH AREA 10
COMPUTATIONAL AND INFORMATION SCIENCES

10.1. 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: skaramch@arl.army.mil, (301) 394-3198

10.2. 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 warfighter in the analysis, assimilation, and dissemination of real and simulated digitized battlespace 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: gowens@arl.army.mil, 301-394-1722

10.3. Wireless Information Assurance and Survivable Communications. The ARL is interested in receiving proposals that address the underlying science and technology 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: cirincione@arl.army.mil, (301) 394-4809

10.4. 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: Ronald Tobin, e-mail: rtobin@arl.army.mil, phone: (301) 394-2184

10.5. 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 multiuser 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: bsadler@arl.army.mil, 301-394-1239.

10.6. 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: awetmore@arl.army.mil, (301) 394-2499

10.7. 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 any 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 which support the Army Information Architecture, Army modernization efforts, and the Army's Future Combat System (FCS).

Technical Point of Contact: Ms. Pat Jones, email: pjones@arl.army.mil, 410-278-5840

10.8. 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: pjones@arl.army.mil, 410-278-5840

10.9. Technology for Course of Action (COA) Analysis. The ARL is interested in basic and applied research resulting in technologies that support state-of-the-art capabilities for the warfighter in the analysis, assimilation and dissemination of real and simulated digitized battlespace information. The Computational and Information Sciences Directorate is leading the ARL's Digitization and Communications Science thrust. One aspect of the effort is the development of methods for providing data for warfare (and operations other than war) to the commander's planning staff in a manner that can be readily used. The ARL is soliciting proposals for technology to provide automated tools for the future force that support planning, commander-staff-subordinate collaboration, dissemination of mission intent, mission monitoring, and adaptation.

In particular, current COA analysis methods may lack the sophistication and speed required to guarantee that understandable information is provided in a timely manner to intended recipients. The ARL seeks approaches to analysis of COAs that address the domain of the Army command and control systems vis-à-vis tactical operations centers and that can be extended across the spectrum of operations to be encountered by the future Army. Areas of interest include: techniques for automation augmented planning and decision-making; analytical tools to increase decision cycle speed; approaches to integration of the results of multiple war games and simulations for consideration of many COAs in near real time; COA analysis approaches accounting for incomplete data; identification of data structures required for battlefield analysis of COAs produced in the near-term C2 infrastructure; approaches to evaluation of COA systems (e.g., with regard to utility and quality); interface with standardization efforts involving C2 message elements; systems to check COAs against standards (e.g., the principles of war, historical "sanity") or criteria (e.g., the commander's intent, supportability); statistical techniques (e.g., nonparametric hypothesis testing) for COA comparison; operations research methods for COA evaluation (e.g., multi-attribute utility analysis).

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

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

a. Microscale atmospheric boundary layer meteorology, at resolutions below 1 km that consider urban and vegetative canopy effects.
b. Diagnostic tools for determination of realistic spatial variability of atmospheric parameters in limited but complex domains.
c. Electromagnetic and acoustic propagation, especially electro-optical EM propagation, and infrasonic acoustic propagation.
d. Atmospheric aerosol properties and behavior, including mineral, biological and liquid components.
e. Efficient distributed weather forecasting technology for hosting on future Army tactical computer platforms.
f. Methodology and applications for the use of satellite remote sensing of environmental conditions.
g. Environmental decision support technology (tactical decision aids) for transforming weather information into mission planning and battle decision intelligence.
h. Physically accurate weather visualization tools.

Technical Point of Contact: Dr. Jon Mercurio, email: jjmartin@arl.army.mil,
(301) 394-2500

10.11. 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. Andrew Mark, e-mail: amark@arl.army.mil, (410) 278-9761

10.12. Knowledge Management and Business Intelligence Systems. Integrated enterprise systems that include web-based portals of entry, enterprise data repositories, integrated data environments, advanced data and text search

engines, integrated enterprise ERP applications, and advanced data discovery software for the analysis and display of context-rich information is critical for knowledge management and business intelligence. Interest includes knowledge fusion of heterogeneous data and multimedia types, data mining, text mining, knowledge agents, knowledge brokers, knowledge visualization systems, federated knowledge warehouses, and knowledge standards.

Technical Point of Contact: Dr. Dana Ulery, e-mail: ulerydl@arl.army.mil, (410) 278-8609

10.13. Information Technology. ARL is interested in proposals that focus on new, innovative uses of Internet web technologies and Lotus Domino/Notes as a primary user interface into a wide variety of enterprise-wide business applications that use Army Standard Systems. In particular, the research should focus on methods and tools that improve developers' abilities to provide new applications across varied user platforms and operating systems while dealing with legacy systems and legacy systems data. ARL is interested in proposals that focus on technologies that can be applied to life-cycle management of heterogeneous electronic records to enable compliance with directives and regulations such as the Modern Army Records Keeping System (MARKS) and National Archives and Records Administration (NARA) requirements.

Technical Point of Contact: Mr. Kenneth Calabrese, email: kcalabrese@arl.army.mil, (301) 394-5442

RESEARCH AREA 11
SENSORS AND ELECTRON DEVICES

11.1. 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: gsimonis@arl.army.mil, (301) 394-5754.

11.2. 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.

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., correlation analysis) and methods for detection using elaborate photosensitive devices (e.g., charge-coupled devices). 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: gsimonis@arl.army.mil, (301) 394-5754.

11.3. 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: stidrow@arl.army.mil, (301) 394-3180 or Dr. Madan Dubey, e-mail: mdubey@arl.army.mil, (301) 394-1186.

11.4. 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: eadler@arl.army.mil, (301) 394-0933.

11.5. Radio Frequency (RF) Signal Processing. Development 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 or 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: eadler@arl.army.mil, (301) 394-0933.

11.6. Sensors. Research proposals are desired that will lead to the ability to sense, locate, identify, and engage targets a 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: brucew@arl.army.mil, (301) 394-2610 and Electro-Optical/Infrared - Dr. Greg Sztankay, e-mail: sztankay@arl.army.mil, (301) 394-3130.

11.7. 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 development, 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: Dr. Jagadeesh Pamulapati, e-mail: jpamulapati@arl.army.mil, (301) 394-1475.

11.8. Position Location Technology. The ARL has research areas related to the Global Positioning System (GPS) for a variety of Army or dual-use applications, including remote asset tracking, tracking of artillery projectiles, smart fuzing concepts that employ GPS to determine optimum function time, combat identification, and GPS guidance integrated fuzing. Related applications include vehicle navigation and remote tracking of land vehicles, aircraft, watercraft, weather balloons, etc. Technology areas of interest include GPS integrated circuits, innovative electronic countermeasures (ECM) or electronic counter-countermeasures (ECCM) techniques, fast acquisition receivers, high dynamic receiver designs, receiver algorithms, antennas, differential techniques, encryption algorithms, very-high-accuracy signal processing techniques, etc. Both GPS receiver and GPS translator technologies are of interest. Research is needed in these areas to fill technology gaps left by current commercial GPS work, with an emphasis on potential military uses of GPS. In addition to GPS location technology, the ARL has interest in other techniques, technologies, devices, etc., that can be used to provide accurate position information, including gyroscopes, rate sensors, and other devices. Technologies of potential interest include terrestrial- or space-based communications systems, which provide location information, GLONASS (Russian Navigation Satellite System), etc. Both existing military or commercial systems might be considered if they can fulfill Army or dual-use requirements.

Technical Point of Contact: Mr. Andrew Ladas, e-mail: aladas@arl.army.mil, (301) 394-2622

11.9. 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: jsichina@arl.army.mil, (301) 394-2530.

11.10. 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.

11.10.1. *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.

11.10.2. *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.

11.10.3. *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.

11.10.4. *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.

11.10.5. *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: pgillesp@arl.army.mil, (301) 394-1374.

11.11. Unattended Ground Sensor (UGS) Technology. Smart mines technology concepts, sensors, algorithms, and hardware modules that support:

a. Wide-area detection, localization, and identification of people, ground vehicles, and aircraft.

b. Accurate position, orientation, localization and field deployment of UGS.

c. Communication and fusion of information among various UGS and outside systems.
d. Remote control of UGS. Of particular interest are low-cost, low-powered, and small-sized hardware modules that implement the functions listed above.

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

11.12. 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: nsrour@arl.army.mil, (301) 394-2623.

11.13. 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. Offerors are urged to only consider submitting proposals under this announcement if they have technologies proven to show promise for this application.

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

11.14. 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: stidrow@arl.army.mil, (301) 394-3180 or Mr. Eric Adler, e-mail: eadler@arl.army.mil, (301) 394-0933

11.15. 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: eburke@arl.army.mil, (301) 394-4375.

11.16. 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: bzandi@arl.army.mil, (301) 394-2091.

11.17. Traveling-Wave Tubes. The Army requires study and development 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: rosario@arl.army.mil, (301) 394-3562 or Mr. Paul Fisher, e-mail: pfisher@arl.army.mil, (732) 222-8687.

11.18. High-Power Vacuum Electronics RF Sources. The Army requires study and development 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: rosario@arl.army.mil, (301) 394-3562 or Mr. Paul Fisher, e-mail: pfisher@arl.army.mil, (732) 222-8687.

11.19. 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: svensson@arl.army.mil, (301) 935-6969 or (301) 394-5429.

11.20. Low Cost Alkaline Power Sources. The SEDD is seeking proposals for research and development of improved zinc/alkaline/manganese dioxide power sources (primary or rechargeable) for Army electronics applications. Alkaline battery technology is attractive because of the intrinsic cost, safety and environmental benefits. Topics of interest include new cell and battery materials, cell and battery design, chargers (rechargeable systems), electronics and processing methods. Significant improvements in energy density, power density, storability, temperature range of operation and cycle life (rechargeable systems) are desired. Hardened cell and battery prototypes capable of shipment and six months storage are required as proof of principle. Charger prototypes are also required for rechargeable systems.

Technical Point of Contact: Dr. Don Foster, e-mail: dfoster@arl.army.mil, (301) 394-0312.

11.21. 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: alee@arl.army.mil, (301) 394-2800.

11.22. 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 development 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: cfazi@arl.army.mil, (301) 394-3011.

11.23. Frequency Control. The Army requires study and development 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 piezoeletric 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: cfazi@arl.army.mil, (301) 394-3011; Dr. Steve Tidrow, e-mail: stidrow@arl.army.mil, (301) 394-1801; or Mr. Mike Patterson, e-mail: exc@arl.army.mil, (301) 394-6000.

11.24. 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: dsnider@arl.army.mil, (301) 394-5166
*For additional security information: Mr. Lewis Tippett, e-mail: ltippett@arl.army.mil, (301) 394-4395.

11.25. 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: dsnider@arl.army.mil, (301) 394-5166
*For additional security information: Mr. Lewis Tippett, e-mail: ltippett@arl.army.mil, (301) 394-4395

11.26. 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: dsnider@arl.army.mil, (301) 394-5166
*For additional security information: Mr. Lewis Tippett, e-mail: ltippett@arl.army.mil, (301) 394-4395

11.27. 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: dsnider@arl.army.mil, (301) 394-5166.
*For additional security information: Mr. Lewis Tippett, e-mail: ltippett@arl.army.mil, (301) 394-4395.

11.28. 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: dsnider@arl.army.mil, (301) 394-5166.
*For additional security information: Mr. Lewis Tippett, e-mail: ltippett@arl.army.mil, (301) 394-4395.

11.29. 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: dsnider@arl.army.mil, (301) 394-5166.
*For additional security information: Mr. Lewis Tippett, e-mail: ltippett@arl.army.mil, (301) 394-4395.

11.30. 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.

Technical Point of Contact: Dr. Donald Snider, e-mail: dsnider@arl.army.mil, (301)394-5166.
*For additional security information: Mr. Lewis Tippett, e-mail: ltippett@arl.army.mil, (301) 394-4395.

11.31. 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: dsnider@arl.army.mil, (301) 394-5166.
*For additional security information: Mr. Lewis Tippett, e-mail: ltippett@arl.army.mil, (301) 394-4395.

11.32. 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: dsnider@arl.army.mil, (301) 394-5166.
*For additional security information: Mr. Lewis Tippett, e-mail: ltippett@arl.army.mil, (301) 394-4395.

11.33. Wide Band-Gap Power Devices. The SEDD is seeking proposals for research and development 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: sscozzie@arl.army.mil, (301) 394-5211.

11.34. 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 risetime, 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 risetime 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 is 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, pulsewidth 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 risetimes 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, are 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: akehs@arl.army.mil, (301) 394-2291.

11.35. Microsensor Technology. Research proposals are desired that are related to small, rugged, low cost, low power sensors that can be employed on a battlefield. Such sensors may be employed on the ground, ground and air vehicles, munitions, or individual soldiers and may be delivered by hand, via airdrop, ground vehicles or by munitions. They may be used individually or as part of a wide-area sensor array for surveillance, target acquisition, and/or engagement. These micro sensors should be able to be networked together and used to detect tanks, other tracked vehicles, wheeled vehicles, low flying fixed and rotary wing aircraft and/or individual soldiers at tactically useful distances. Other applications include inertial measurement and electronic stabilization as part of navigation or self-location systems and conditioned-based maintenance of complex military platforms. Proposals will be accepted in these areas:

a. Research on novel micro sensor concepts leading to quantification of detection distance(s), bearing, and/or identification of various classes of targets.

b. Research in Micro Electro Mechanical Systems (MEMS) for battlefield micro sensor applications.

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

d. Development of prototype design(s) of individual micro sensors suitable for detecting tanks, other tracked vehicles, wheeled vehicles, low flying fixed and rotary wing aircraft and/or individual soldiers at tactically useful distances in a battlefield environment. Development of prototype design(s) for unattended networks of sensors and/or conditioned-based maintenance applications. Sensor network communications and inter-sensor communication techniques should be considered.

Technical Point of Contact: Mr. John Hopkins, e-mail: jhopkins@arl.army.mil, (301) 394-3196.

11.36. 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 radar applications. 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: kajones@arl.army.mil, (301) 394-2005.

11.37. RF Devices. Innovative electronic materials and devices for RF applications. Work should involve new III–V materials, novel III-V materials growth technology, or novel device fabrication and integration.

Technical Point of Contact: Dr. Allen Lepore, e-mail: anlepore@aol.com, (301) 394-0243 or (732) 445-2158.

11.38. 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 facilitates 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 van der Gracht, e-mail: van@arl.army.mil, (301) 394-0929.

11.39. RF Electronics. Research and development 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: exc@arl.army.mil, (301) 394-0923.

11.40. Acousto-Optic Tunable Filters. The ARL is engaged in research and development of novel collinear and noncollinear acousto-optic tunable filters (AOTFs) operating from ultraviolet (UV) to long infrared (IR) wavelengths. The range of applications includes spectroscopic remote sensing of biological and chemical agents, pollution monitoring, detection of plumes, condition-based management, multispectral, hyperspectral, 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 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 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, etc.

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

11.41. 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, cathodoluminescence, and photoluminescence.

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

c. Investigation of light modulation materials and devices.

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

11.42. Nonlinear Optics. The ARL requires investigations into nonlinear optical materials, components, devices and relevant nonlinear mechanism and propagation modeling to help define and solve the problem of sensor/eye protection, with particular interest in the visible/near infrared (400-900nm) wavelength range. This research is needed to ensure that the current and future optical systems of the Army are protected against agile laser threats on the battlefield. The protection concept proposed should not have an adverse impact on the performance of the optical system but should provide protection for a variety of agile laser scenarios. The SEDD is interested in receiving novel proposals that address the technical barriers associated with developing sensor/eye protection devices that could be utilized at the foot soldier level or the advanced optical system level. 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.

b. Novel component or device concepts to address individual soldier protection and/ or advanced optical system (such as periscopes, CCD cameras, I2 devices) protection.

c. Modeling efforts to relate nonlinear material properties to their optical limiting capabilities. Modeling effort should include details on how the nonlinear materials affect the propagation of incoming laser beams.

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

11.43. Micro-Devices and Micro-electromechanical Systems (MEMS). Topics of interest include research and exploratory development 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: mdubey@arl.army.mil, (301) 394-1186.

11.44. 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 develop 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: twong@arl.army.mil, (301) 394-0060.

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

11.45.1. *Active and Reserve Primary Batteries for Munitions Applications* – Development 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.

11.45.2. *Electrochemical Capacitors* – Development 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.

11.45.3. *Primary Lithium Batteries* – Development 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.

11.45.4. *Rechargeable Li (Li Ion) Batteries* – Development of chemistries for cells and stacks of cells using liquid or polymeric electrolytes and capable of providing specific energies greater than 120 Whr/kg and specific power greater than 50 W/kg over the full military temperature range. Emphasis on enablement of soft-packaging.

11.45.5. *Proton Exchange Membrane (PEM) Fuel Cell Systems and System Components* – Improved protonic

membranes and electrocatalysts for use with methanol-fueled systems, hydrogen generators and fuel reformers for use with hydrogen-fueled systems.

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

11.46. Passive Electromagnetic Sensor Technology. Research proposals are desired that are related to small, rugged, w-power magnetic and/or 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 may be characterized by exceptionally low power, size, weight, and/or cost; they may or may not have exceptional individual performance.

These sensors may be used individually or as part of a wide-area sensor array for surveillance, target acquisition, and/or engagement. They should operate unattended, 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 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 include gunshots, mortar and artillery launches, and explosions.

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 magnetic and 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. Development of prototype design(s) of individual magnetic and/or electric field sensors suitable for detecting tactically significant targets in battlefield environment.

Emplacement strategies, automatic sensor network generation, and inter-sensor communication techniques are not included in this topic. These kinds of research issues are specifically addressed under the "Micro sensor Technology" topic above. This topic also does not include proposals that focus on controlling or otherwise reducing sensor power consumption. Proposals which address sensor location and orientation issues should be submitted against the "Position Location Technology" topic.

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

11.47. 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: svensson@arl.army.mil, (301) 935-6969 or (301) 394-5429.

11.48. 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: eburke@arl.army.mil, (301) 394-4375.

11.49. 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: eburke@arl.army.mil, (301) 394-4375.

11.50. 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 ratiometry, 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: eburke@arl.army.mil, (301) 394-4375.

11.51. Multi-Function Radio Frequency Technologies. The Army has an interest in developing 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: eburke@arl.army.mil, (301) 394-4375.

11.52. 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: kehs@arl.army.mil, (301) 394-2291.

11.53. 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 development 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: richt@arl.army.mil, (301) 394-5756.

11.54. 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: jgillesp@arl.army.mil, (301) 394-1880.

11.55. 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: jgillesp@arl.army.mil, (301) 394-1880.

RESEARCH AREA 12
SURVIVABILITY/LETHALITY ANALYSIS

12.1. Coupling Phenomenology of ADP Equipment as an HPM Predictive Tool. 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 an electromagnetic environment (EME) present in the battlefield conditions. 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 the battlefield. 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.

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 W. Landin, e-mail: dlandin@arl.army.mil, (505) 678-7891.

12.2. 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: gonzalez@arl.army.mil, (505) 678-5309.

RESEARCH AREA 13
WEAPONS AND MATERIALS RESEARCH

13.1. Materials and Structures for Missile Defense. Proposals are requested involving innovative approaches to materials and structures development, processing, and testing with the goal of improving performance and lowering the cost of systems intended for missile defense. The broad areas of interest include (a) high-strength/high-temperature materials for propulsion heat shields, nozzles and nose tips, and missile skins; (b) optical seeker

materials, materials processing, and surface modification for optics used in endo-atmospheric and exo-atmospheric environments; (c) high-strength, lightweight materials and structures for use in electro-magnetic accelerators and advanced high-velocity missiles and projectiles; (d) hardened materials and structures for use in protecting against directed-energy, kinetic-energy, and nuclear-energy threats; (e) smart materials and structures that could aid in processing, monitoring load distribution, and shape changes; and (f) affordable/reproducible environmentally insensitive composite structures that exhibit high stiffness.

Technical Point of Contact: Dr. James Walbert, e-mail: jnw@arl.army.mil, (410) 306-0712.

13.2. 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; 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. Bruce K. Fink, e-mail: bfink@arl.army.mil, (410) 306-0755.

13.3. Advanced Optics. Proposals are requested for high quality research in advanced optics manufacturing approaches to attainment of computer controlled flexible manufacturing methods for spherical and aspheric lenses appropriate as components in military optical and electro-optical systems operating in the visible and infrared region of the electromagnetic spectrum. The objective is to further the capabilities and application of deterministic methods for precision optics fabrication and to implement these technologies in the CONUS industry. Areas of interest include, but are not limited to, improving the net shape surface quality attained by microgrinding (DMG) and advancing the development of the magnetorheological finishing (MRF) process to produce final surface form and function, and manufacturing advances required for fabrication of conformal optics.

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

13.4. 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: fstento@arl.army.mil, (410) 306-0807.

13.5. 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 Schmidt@arl.army.mil (410) 306-0663.

13.6. 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: schmidt@arl.army.mil, (410) 306-0646.

RESEARCH AREA 14
HUMAN RESEARCH AND ENGINEERING

14.0 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 provides the basis for databases and models to guide the optimal design of battlefield systems involving soldier-machine interaction. HRED topics shall be included in this BAA as funding is programmed.

Technical Point of Contact: Wendy Leonard, email:leonard@arl.army.mil (410) 278-5813.

RESEARCH AREA 15
VEHICLE TECHNOLOGY

15.0. 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 Edward Healy, email: e.a.healy@larc.nasa.gov, 757-864-3091.

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 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. 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: rutter@arl.aro.army.mil or the ARL-Adelphi Legal Office at (301) 394-1696 or e-mail: pemery@arl.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 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 SME 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: vemery@arl.army.mil, (301) 394-3585.

ARL-ARO: Ms. Jenny Haire, e-mail: haire@arl.aro.army.mil, (919) 549-4205.

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 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.

[**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.]

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

2. Upon receipt of a proposal, the ARL staff will perform an initial review of its scientific merit and potential contribution to the Army mission and also determine if funds are expected to be available for the effort. Proposals not considered to have 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. It is the policy of the ARL to treat all proposals as privileged information prior to award and to disclose the contents 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 is intended to provide information needed for preparing research proposals for submission to the ARL.

SECTION 2 - GENERAL INFORMATION:

PRELIMINARY INQUIRIES: The ARL receives several hundred research proposals annually. Because of financial constraints, we are able to provide support for only a limited number of the proposals received. We realize 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. ARL TPOCs for each area of interest are identified as part of the description of that area and shall be contacted as appropriate. In addition, 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 rutter@arl.aro.army.mil or ARL: Mr. Pat Emery at pemery@arl.army.mil) prior to expending time and effort in preparing a proposal.

MILITARY RECRUITING:

1. This is to notify potential offerors that each grant or cooperative agreement that is 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.

2. 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 in its terms and conditions the required technical and financial reporting requirements.

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 shall be vested in nonprofit institutions of higher education or with nonprofit organizations whose primary purpose is the conduct of scientific research and if vesting will facilitate scientific research performed by the institution 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 has the authority to award a variety of instruments. The ARL 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 which, 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://web7.whs.osd.mil/pdf/32106r/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. Submission of three (3) copies of a white paper and ten (10) copies of a complete proposal are required if not submitting electronically. Each copy must contain any restrictive legends (see guidance provided above). White papers should be submitted directly 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. Offerors are STRONGLY ENCOURAGED to submit proposals electronically to the following address: BAA@arl.aro.army.mil. Offerors must use PDF format. "Page" means, that once printed, the document is on one-side of a standard 8 1/2 x 11 inch piece of paper with no more than six lines per inch and margins of no less than one (1) inch. Pre-printed instructions on forms, superscripts and subscripts, footnotes, and repetitive proprietary notices are not subject to this type-size limitation. When submitting a complete proposal electronically, offerors shall submit one copy of an originally signed Form 51 and Form 52 or 52A. Only as a last resort should white papers and complete proposals be submitted in hardcopy to the following address: **[For deliveries by the Federal Government's United States Postal Service (USPS)]**

Director
U.S. Army Research Office
ATTN: AMSRL-RO-RI (DAAD19-00-R-0010)
(TPOC: *"insert name"*)
P. O. Box 12211
Research Triangle Park, NC 27709-2211

In the European hemisphere:

USARDSG-UK
PSC 802 Box 15
FPO AE 09499-1500

[If you plan to hand-deliver your proposal or use special mail services such as FedEx, DHL, Airborne, the following street address and zip code must be included.]

Director
U.S. Army Research Office
ATTN: AMSRL-RO-RI (DAAD19-00-R-0010)
(TPOC: *"insert name"*)
4300 South Miami Boulevard
Durham, NC 27703-9142

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, Mr. Robert Gordon, shall be contacted on (919) 549-4356 or e-mail: gordon@arl.aro.army.mil prior to the proposal's submission.

SECTION 3 - WHITE PAPER PREPARATION, SUBMISSION, EVALUATION, AND DISPOSITION **(THIS SECTION PERTAINS ONLY TO RESEARCH AREAS 10-15)**:

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. Offerors submitting hard copies should submit the original plus two (2) copies of the white paper. The original and copies of the white paper shall be bound as one document with a single staple in the top left hand corner. Ring or loose-leaf binders are discouraged. 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 estimated 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. Hard-copy white papers shall be mailed directly to the TPOC listed with each research area. 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. Evaluators will be advised that they are only required to review the white paper cover page and up to six pages, including the addendum.

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 1-8, the ARO normally awards research agreements for periods up to three (3) years (1 basic year of performance with two 1-year options). For Research Areas 10-15, offerors shall discuss the preferred performance period with the TPOC. 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 to the ARL staff, 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. Other copies provided may be reproductions.

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 to identify 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.

PART V
PROPOSAL FORMS

PROPOSAL
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