DOE/ER-0731

CYCLE 17

SMALL BUSINESS INNOVATION RESEARCH

PROGRAM SOLICITATION

Closing Date: March 2, 1999

U.S. Department of Energy
Office of Science
19901 Germantown Road
Germantown, MD 20874-1290

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Department of Energy Solicitations for upcoming years are expected to be released at approximately the same dates (early October for STTR and early December for SBIR). Please make a reminder note on your calendar. To receive electronic notifications from the Department, you must notify the SBIR/STTR office of your e:mail address.

MAJOR DIFFERENCES BETWEEN DOE SBIR PROGRAM SOLICITATIONS IN FISCAL YEARS 1998 AND 1999

- The Phase I award amount has been increased to a maximum of $100,000.
- The Department of Energy has discontinued the early submission of Phase II grant applications. There will be one deadline for Phase II submissions.

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Small Business Innovation Research

General Information and Guidelines

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Small Business Innovation Research

Technical Topic Descriptions

TECHNICAL TOPIC DESCRIPTIONS

The technical topic descriptions for this solicitation are given below. The topics are related to the DOE programs and follow the program area overview. Note that grant applications are effectively in competition with other grant applications submitted to those technical topics that belong to a single DOE program area (see Section 4.2).

The text in the first section of each topic gives general and background information for the topic. Each topic is divided into a maximum of four subtopics. A grant application must respond specifically to the description given in one subtopic and not just to the general description at the beginning of the topic; it must comply, however, with any restrictions and exclusions contained within that general description.

PROGRAM AREA OVERVIEW - ENERGY EFFICIENCY AND RENEWABLE ENERGY

http://www.eren.doe.gov

The mission of the Office of Energy Efficiency and Renewable Energy (EE) is to lead the nation to a stronger economy, a cleaner environment, and a more secure future through development and deployment of sustainable energy technologies. EE develops technologies that protect the environment and support the nation's economic competitiveness through a program of research, development, and market deployment using private sector partnerships. EE is organized around the four main energy users--utilities, industry, transportation, and buildings--an orientation that has helped the technology development programs focus on addressing the needs of the marketplace.

It is estimated that the energy technologies and practices supported by the Energy Efficiency and Renewable Energy program have saved Americans ten to fifteen billion dollars in energy costs over the past decade. These savings continue to mount as new energy technologies developed by the program for buildings, transportation, utilities, and industry are put to use and as research continues. These energy savings are accompanied by parallel reductions in the emission of pollutants that affect human health and in the production of greenhouse gases. The EE program in renewable energy has advanced the state of technologies in such areas as solar, wind, and biomass to the point where renewables have been projected to supply as much as 28 percent of the nation's energy by 2030.

1. BIOMASS POWER

Biomass power (i.e., biomass-to-electricity power generation) is a proven electricity generating option in the United States. With about 10 GW of installed capacity, it is the single largest source of non-hydro renewable electricity. Of the 10 GW, about 7 GW are generated using forest product industry and some agricultural industry residues, about 2.5 GW use fuels based on municipal solid waste (MSW), and 0.5 GW use other resources such as landfill gas. The 7 GW of traditional biomass capacity represents about 1 percent of the total electricity generating capacity and about 8 percent of all non-utility generating capacity in the U.S. All of today's biomass power capacity is based on mature, direct combustion boiler/steam turbine technology. The average size of existing biomass power plants is 20 MW (the largest approaches 75 MW), and the industry average biomass-to-electricity efficiency is 20 percent.

At current levels of biomass power production, the supply of biomass residues can meet the demand. Biomass could provide a much larger portion of sustainable electric power if the economic viability of such systems are improved. At the present time, resource costs are too high for biomass power systems to be economically competitive with other electricity generation systems. Innovative ideas are needed

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for products that will improve the economic viability of biomass power systems. **Grant applications are sought only in the following subtopics:**

a. Modular Systems–There is a rapidly growing global market for modular biomass power systems in remote rural areas using small (5 kW to 200 kW) and larger units. In this context, the term modular refers to integrated systems that can be factory-fabricated and mass produced to lower capital equipment costs. Grant applications are sought to develop modular systems (based on combustion, gasification, or pyrolysis) to economically convert farm animal wastes (such as poultry litter and hog manure) to electricity (and to heat as a by-product, if this would improve the economics). Proposed systems, in addition to being small and modular, must also be fuel flexible, be efficient to operate, and have minimum negative impact on the environment. Modular systems of interest could include the utilization of such technologies as advanced fuel cell systems, Stirling engines, and micro-turbines. The Phase I feasibility study must include a preliminary market and resource assessment, preliminary tests to determine material and energy balances, a preliminary integrated system design, preliminary cost estimates (including electrical interface costs) to compare costs with traditional disposal/conversion methods, and estimates of environmental emissions and benefits. Applications that propose traditional anaerobic digestion methods to convert animal wastes to methane are not of interest and will be declined.

b. Biomass Resource Production–Principles of and techniques for gene isolation, genetic transformation and marker-aided selection have been developed over the past 15 years as a means of improving all forms of agronomic and industrially based organisms. Although applications of molecular techniques to the biomass-based renewable energy industry have been limited to research evaluations and small-scale tests, these tests have successfully demonstrated proof-of- principle, setting the stage for further development and commercial deployment. Grant applications are sought to apply molecular genetics techniques (including genetic transformation, marker-aided selection, and *in vitro* propagation) to create high-yielding, cost-effective, locally adapted biomass energy crops (including, but not limited to, switchgrass and hybrid poplar) in order to improve overall productivity, insect and disease resistance, and feedstock composition. For productivity, approaches of interest include, but are not limited to, marker-aided selection for genes associated with photosynthetic efficiencies, carbon allocation, and gender determination. For improved insect and disease resistance, approaches of interest include, but are not limited to, genetic transformation techniques. For feedstock composition, approaches of interest include, but are not limited to, the use of marker-aided selection for increase cellulose content, reduced lignin content, and genetic transformation for co-product production. Associated with each of the above examples is the need to develop reliable *in vitro* propagation techniques which would allow commercial nurseries to capture and distribute improved genotypes. The ultimate objective is to develop energy crops that produce 10-15 dry tons per acre annually.

c. Feedstock Supply–Genetic selection and improvement programs directed toward the identification of superior biomass crops (e.g., clonal woody crop planting stock) are currently underway. These programs involve the evaluation and ranking of hundreds of genotypes, grown over multiple years and tested at numerous sites. In each program, one to a half dozen superior genotypes are identified and prepared for commercial evaluation. Typically, another two to three years are required to scale up enough planting stock of the selected genotypes to allow for commercial evaluation. Each year's delay in getting the newly developed plant material out into commercial use delays the commercial realization of genetic improvement. To eliminate such delays, new propagation techniques are needed.

Grant applications are sought to develop technologies for cost-effective rapid propagation systems useful in the deployment of newly released biomass crops. One area of interest is the mechanization or automation of traditional propagation methods; the application of micropropagation is another. Ideally, newly released plant materials should be ready for commercial use on thousands of acres within nine months. In addition to the need for rapid increases in the development of planting stock, the planting stock quality must be maintained to assure planting success. To facilitate this, proposed techniques must produce planting stock that conforms to existing nursery standards.

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d. Biomass Material Handling Systems–Materials handling technology -- dryers, process and inert gas generation/processing systems, and waste streams analysis, evaluation, and mitigation, etc. -- are integral to the successful operation of biomass-to-electricity systems. Handling systems are needed for both field operations (such as harvesting, collection, preparation, short and long term storage, and delivery to conversion facilities) and plant operations (such as storage, blending, sizing, contaminant removal, and transfer to boilers or reactors). Grant applications are sought to improve the economics of materials handling systems in biomass-to-electricity systems in the following areas: (1) the harvesting and transportation of woody crops and grasses, as well as the storage of grasses; (2) the collection, handling, storage, and transportation of residues; and (3) the handling, storage, processing and feeding of biomass materials (crops or residues) into power boilers (both cofiring and dedicated systems) or gasifiers. Regarding storage, efficient low cost approaches are sought that minimize biomass degradation. Note that different handling strategies may be appropriate for different combinations of power conversion technologies and biomass resources; for example, conversion systems include both cofiring systems (biomass plus coal) and dedicated direct-fired combustion, gasification, or pyrolysis systems. Grant applications must fully describe the type of power conversion technology (or technologies) assumed (including anticipated conversion efficiency) and the biomass resource type.

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   http://www.eren.doe.gov/biopower

2. U.S. DOE Oak Ridge National Laboratory
   Bioenergy Feedstock Development Program
   Bioenergy Information Network
   http://www.esd.ornl.gov/bfdp

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* See Section 7.1

2. HIGH-TEMPERATURE ELECTRONICS FOR GEOTHERMAL DRILLING

Sensing, communication, and process control are becoming commonplace functions of geothermal drilling operations. However, unlike oil and gas well drilling, geothermal wells have a unique and harsh environment in which the instrumentation for these processes must survive. Electronic devices and sensors (to control and optimize the geothermal drilling operation) are needed that operate at the high temperatures (greater than 300°C) in geothermal wells. These devices and sensors would eventually become components in high-temperature-capable systems such as measurement-while-drilling (MWD) systems, logging-while-drilling (LWD) systems, data telemetry systems, and process control systems. **Grant applications are sought only in the following subtopics:**

a. Electronic Devices—Grant applications are sought to develop electrolytic capacitors, SiC or GaAs bandgap voltage references, and digital clocks (perhaps using micro-machine technologies) that can operate in the temperature range from 20°C to greater than 300°C, have minimum mean-times-to-failure (MTTF) greater than 1000 hours, and satisfy the following requirements over the full temperature range. (1) The high temperature electrolytic capacitors must be large-valued, low-voltage capacitors greater than 10 microfarad, and 20 volts minimum); for deployment in well logging tools, an ideal device would be no larger than 1 inch in diameter and 6 inches in length. (2) The bandgap voltage references must be discrete electronic PC board mountable precision voltage references, with accuracy greater than +/- 3%, and a nominal voltage of 1 to 10 volts. (3) The digital clock, needed for precision timing of microprocessor-based circuits used in high temperature electronics, must have a nominal frequency of 1-12 MHz and an accuracy of +/-500 ppm.

b. Sensors—Grant applications are sought to develop high accuracy pressure transducers and high accuracy inclination sensors. The high accuracy pressure transducer must be operational over the temperature range from 20°C to greater than 300°C, measure fluid pressure above 10K psi to an accuracy of +/- 0.5 psi, and have a minimum MTTF of 5000 hours. High accuracy inclination sensors, needed to determine and control the direction of a geothermal well, must be operational at temperatures greater than 300°C,with an accuracy of +/- 0.3 degrees inclination.

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* See Section 7.1

3. ADVANCED MEASUREMENT AND CONTROL TECHNOLOGIES FOR INDUSTRIAL MANUFACTURING APPLICATIONS

The U.S. DOE Industries of the Future (IOF) Program targets energy-intensive and waste-intensive industry sectors to achieve the following objectives: (1) lowering raw material and depleted energy use per unit output, (2) improving labor and capital productivity, and (3) reducing generation of waste and pollutants. The IOF Program, spearheaded by the Office of Industrial Technologies of the DOE Office of Energy Efficiency and Renewable Energy, now consists of nine such industries: agriculture, aluminum, chemical, forest products, glass, metal casting, mining, petroleum, and steel. These IOF industries have developed individual visions for the next 20 years and industry-specific technology development roadmaps to fulfill these visions. To implement these roadmaps, partnerships with DOE have been established to develop and deliver advanced science and technology options. A critical element in these technology roadmaps is the development of advanced measurement and control technologies that are abler and smarter than currently used systems. By implementing these advanced technologies, maximal process efficiency and minimal waste generation can be achieved.

This solicitation focuses on addressing the high priority measurement and control technology needs identified in six of these IOF industry roadmaps, one each for aluminum[1], chemical[2], metal casting[3], glass[4], steel[5], and forest products[6]. (Roadmaps for agriculture, mining, and petroleum are being developed, and their measurement and control needs will be addressed in the future.) Each grant application must identify the primary and secondary, if any, IOF industries targeted for the technology being proposed and must provide linkages with the subject industry roadmaps. Technologies that have broad applicability across more than one IOF industry are preferred. Constituents or parameters addressed

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by the proposed technology must be clearly stated, and performance goals (accuracy, precision, target measurement ranges and limits, etc.) identified. In addition, information concerning the baseline technology and its performance must be provided so the stated benefits of the proposed technology development can be assessed. **Grant applications are sought only in the following subtopics:**

a. **Advanced Chemical Analyzers for In-Process Applications**–Real-time compositional information for solid, liquid, and gas phase streams is needed in industrial applications for process control. For solid streams, such applications include sorting and separating of scraps, recyclable materials, alloys, and varying grades of materials in the glass, pulp and paper, primary metal, and fabricated metal product industries. For liquid and gas phase streams, compositional information is needed for monitoring emissions and effluents in the glass and forestry industries and for characterizing chemical constituents and impurities in process streams across all the IOF industries. Although a wide range of chemical analyzers has gradually evolved from laboratory applications, improvements in reliability, robustness, speed of analysis, and low maintenance are still needed to meet the challenges of operating in industrial environments. Grant applications are sought for the development and use of chemical analyzers for real-time compositional analyses of industrial processes, which incorporate these improved performance characteristics. Analyzers of interest include gas/ion chromatography, FTIR/Raman spectroscopy, X-ray/NMR/mass spectrometry, and those using electrochemical and fiber-optic sensors. Grant applications must provide details about the specific IOF industry application(s) and application environments where the proposed technology would be used for on-line process control. The robustness of the analyzer must accommodate specific operating environments of concern, such as elevated temperature, dust, humidity, vibration, electromagnetic interference or electrical noises, and pressure, among others. To address the low maintenance and high reliability requirements, each grant application must provide specific information about how the instrument will be calibrated during the in-process applications. Technologies with a built-in failure sensing capability are preferred.

b. **Nondestructive Measurements for On-Line Diagnostics and Control**–Nondestructive evaluation (NDE) techniques are needed to measure material properties and characteristics during manufacturing operations. Grant applications are sought for development and use of NDE techniques in the following areas of particular importance to the IOF industries: (1) surface and bulk temperature measurement of metals, paper, glass, and polymers; (2) thickness measurement of aluminum, steel, paper, glass, and refractory materials; (3) measurement of flow and viscosity of glass, black liquor, molten metal, and chemical process streams; (4) detection of flaws, stresses, and strains in metals, ceramics, and composites; and (5) prediction of microstructure, intermetallic phase formation, and bubble distribution as a function of cooling conditions of aluminum, steel, and other metal casting processes. NDE techniques of interest include ultrasonic, radiography, eddy current, and electromagnetic techniques. Grant applications must address the potential use of proposed technologies in operating environments consisting of high temperatures and significant vibrations. Improvement over current NDE techniques for both the measurements themselves and for such parameters as maintenance, calibration, and reproducibility must be demonstrated. Each grant application must describe a target IOF industrial process for use of the proposed technology, along with the associated operating environments and process maintenance cycle. The proposed technology must be easy to maintain and be failure free for the duration of the target process maintenance cycle. Technologies with on-line or built-in diagnosis and calibration capabilities are preferred.

c. **Measurement Tools for Interface Characterization**–Measurement of interfacial properties is important to detailed studies of chemical kinetics, adsorption and desorption phenomena, catalysis, surface properties and microstructure of alloys, and drug release. The ability to measure interfaces is also essential to advanced manufacturing processes to control the effect of casting, grinding, milling, melting, and solidification on material properties. Understanding these phenomena often requires characterization of heterogeneous materials at the molecular level, thereby requiring measurements with both high spatial resolution and high sensitivity. Grant applications are sought for the development of measurement tools to

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characterize surfaces and interfaces at molecular scales and for the application of these tools to the chemical, aluminum, steel, metalcasting, and glass manufacturing industries. On-stream measurement capabilities for use in these manufacturing operations are highly desirable. Each grant application must address one or more of the following areas: elemental identification, molecular composition, bonding and coordination, crystallographic information, reaction rates and pathways, reaction site chemistries (active vs. inactive, promoting vs. poisoning, etc.), and three-dimensional chemical compositional imaging. Improvements in such measurement parameters as speed of measurements, temporal and spatial resolution, and sensitivity must also be demonstrated. Finally, grant applications must provide details about the target performance improvements over baseline technology.

d. Integrated System for Process Measurement and Control–Systems connecting process models and control with on-line measurements are needed by all IOF industries for process optimization and automation. Real-time linkage of measurement results with the process model is critical for intelligent control of production and fabrication processes. Benefits of model-based control include increased productivity, improved product quality, and reduced costs resulting from effective and efficient control of resource consumption. To realize these benefits, individual elements of the system (such as dynamic modeling of process control, measurement instruments, and control systems) must all be advanced and integrated seamlessly. Grant applications are sought for an integrated system, not individual components, to intelligently control and/or automate IOF industrial processes. The integrated system must be based on an open-system configuration capable of adapting off-the-shelf, plug-and-play components. An open-system configuration would allow integration of off-the-shelf hardware and software components for process control and automation, and would stimulate the advancement of individual components, allowing for even higher levels of sophisticated control. A specific performance characteristic of the integrated system is the adaptability of such a "standardized" platform to other industrial processes; therefore, such adaptability must be clearly addressed in the grant application. Each grant application must also provide detailed information about how the proposed system will be incorporated into an identified industrial process for control and/or automation. Quantitative benefits over baseline technology must be specifically described in terms of increased productivity, reduced waste generation, and improved energy efficiency.

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4. HYBRID ELECTRIC VEHICLE TECHNOLOGY

In support of the Partnership for a New Generation of Vehicles (PNGV), the development of new technologies is needed in connection with electric motors, electric systems, and engine combustion systems for future highway vehicles. These technologies could reduce the drive train cost and weight and improve the energy management, emissions, and control of electric and hybrid electric vehicles. This topic deals with reductions in the cost and weight of electric motors, advanced energy conversion technologies, and advanced concepts for diesel engines with architecture to increase the overall power efficiency, and improve performance and driving range, and reduce start up emissions. **Grant applications are sought only in the following subtopics:**

a. Improved Electric Motors for Hybrid Electric Vehicle Transportation–Advances in electric motors are needed to meet joint program goals for electric and hybrid electric vehicle power trains. As a reference, the cost and power density goals for a 50 kW electric motor are $4/kW and 2 kW/kg, respectively. Grant applications are sought for technology advancements in synchronous reluctance, switched reluctance, and permanent magnet synchronous motors. Areas of interest include innovative cooling techniques for motors operating in high torque ranges, innovative ways to reduce the number of motor parts counts (because a low part count will provide a lower cost motor), and improvements in starting performance and insulation. Grant applications should attempt to quantify the projected reduction in motor cost and increase in power density, and show how the technologies could be applied to large volume manufacturing. Research efforts are expected to involve multi-disciplinary teams of scientists and engineers.

b. Advanced Concepts for Diesel Engines–In compression-ignition, direct-injection (CIDI) engines, the fuel injection system must precisely meter fuel to each cylinder based on load, speed, and other operating parameters such as ambient air pressure and temperature. Because current fuel injection systems cannot control fuel delivery with sufficient accuracy during cold starts or during load and speed transients, CIDI engines produce relatively high emissions of particulate matter and oxides of nitrogen during these operating conditions. Therefore, grant applications are sought to develop advanced direct fuel injection systems that will enable CIDI engines to meet the more stringent emissions standards of the future while maintaining high efficiency. Advances are sought in the areas of sensing and feedback control (e.g., using real-time, on-board particulate mass sensors) and improved atomization and injection rate control. Proposed designs must demonstrate improved performance at costs comparable to existing production systems.

c. Advanced Materials for Thermoelectric Devices–Thermoelectric phenomena, involving energy transfers between electric power and thermal gradients, have been employed for cooling and heating over a wide temperature range (from cryogenic to well above room temperature). The technology has not only been used for air conditioning, refrigeration, and various aspects of thermal management but also in generating significant electrical power from waste heat. However, the application of this technology to the harvesting of electrical power from a vehicle's internal combustion engine has been limited by the high cost per watt. Grant applications are sought to develop advanced materials to make thermoelectric devices cost effective for the following vehicular applications: (1) electric power generation from waste heat recovered from vehicle propulsion engines, and (2) air conditioning for electric powered vehicles. One area of interest is the development of new or improved quantum well materials that would have conversion efficiencies greater than 25 percent in a vehicle application. Grant applications are also sought to develop fabrication techniques for these thermoelectric devices in order to assure mechanical integrity and to maintain device geometry over a broad range of device sizes. Grant applications should address how higher efficiency materials and/or methods of device fabrication would enhance device reliability and improve electrical power generation efficiency in order to accelerate the path to commercialization.

Bibliography

Subtopic a: Improved Electric Motors for Hybrid Electric Vehicle Transportation

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5. SYSTEMS AND PRODUCTS FOR PASSIVE SOLAR LOW ENERGY BUILDINGS

Passive solar low-energy buildings make strategic use of natural heating, cooling, lighting, and ventilation in combination with other energy efficiency measures to significantly reduce the need for conventional energy sources. When passive solar building strategies are used with other renewable energy measures, the buildings can be energy self-sufficient. Advances in design know-how, building materials, and construction techniques, driven by energy, environmental, and other market concerns, hold promise for further dramatic improvements in the thermal and environmental performance of buildings. Examples of recent system and product improvements are high performance glazings for windows, structural insulated panels, materials made of recyclable wastes, and most importantly, design strategies that manage the interaction of the various building systems interact with one another.

To fully capture the benefits associated with these advancements, appropriate design solutions and construction techniques must be implemented within the "whole building" context. An understanding of the trade-offs involved requires an understanding of aesthetics, comfort, and use of models and design tools that adequately characterize these systems, including their interactions and impacts on building performance. It is also important that adequate data be available to provide confidence in the design tools and building energy performance projections. **Grant applications are sought only in the following subtopics:**

a. Integrated Wall System Concepts for Commercial Buildings using Renewable Energy—Significant improvements have occurred in commercial building envelopes and in components developed to increase the use of renewable energy in buildings. Emerging practices include high performance glazings, which allow appropriate levels of solar gain or heat rejection, daylighting, photovoltaic thin film technology, and insulation levels appropriate to the building's design. This know-how could be applied to the development of integrated wall systems that not only complement passive solar, low-energy building

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designs but also incorporate other technologies (e.g., photovoltaics) to meet defined needs. In the past, designs have concentrated on decreasing the overall heat transfer through the wall (U-value) while sacrificing the potential for solar gain. Grant applications are sought for commercial building wall systems that will facilitate increased use of renewable energy in combination with better thermal performance. Of particular interest are cost-effective innovations using advanced materials and system concepts.

Grant applications must address the overall thermal performance of the wall system, with special attention on how to overcome heat transfer conduits such as thermal bridges. (Previous efforts have used thermal breaks to interrupt the thermal bridge, but have failed to address structural integrity.) For wall system concepts that include the use of glazing products, allowances must be made to assure that significant solar gains will be available for those times and applications when they are needed. Grant applications based on known products/systems (e.g., insulation to resist heat conductivity or air barriers to resist air infiltration) are not of interest and will be declined.

b. Lightweight Building-Integrated Thermal Storage Materials–Effective utilization of thermal storage in a passive solar low-energy building can significantly improve the building's energy performance and comfort. In current practice, masonry materials are the most widely used storage medium. They are typically used in walls or floors on south-facing exposures. Although masonry has many positive attributes, it may not always be appropriate because of structural limitations, especially in building renovations. If lightweight materials with sufficient heat capacity were available, greater architectural design choices would be possible. Examples of such lightweight materials that have previously been investigated are phase-change-material wall board and masonry composites.

Grant applications are sought for lightweight thermal storage materials that can be readily fabricated into building elements (e.g., walls, floors, roof structural or sheathing panels) for new construction and renovation. The materials must have the potential for volume production, meet requisite safety/fire codes, and have superior performance/cost characteristics compared to existing materials. Design information should be provided regarding the target climate/application, how the material is to be used/distributed within the building (e.g., directly coupled to the solar aperture or distributed), and key characteristics such as surface temperature excursions (daily/seasonal ranges, design transition temperatures). Performance measurements should address the impact on overall building energy requirements (e.g., heating and cooling). Of particular interest are materials/products that have environmentally beneficial properties (e.g., those that can be recycled and/or require low energy for manufacture).

c. Small HVAC Systems for Low-Energy Buildings—As "whole building" design strategies reduce building energy loads; the size of furnaces and air-conditioning equipment must be decreased. Existing equipment is larger than necessary for most low-energy buildings. As a result, equipment cycles too frequently, sensible and latent loads are not balanced, and the equipment does not operate at peak efficiency. These effects can lead to buildings that are drafty, too cold (because the air-conditioning overcools due to latent heat imbalances), and have moisture problems. Grant applications are sought for smaller HVAC systems that are appropriate for heating and cooling requirements which are only 1/4 to 1/3 as large as for conventional building designs. Systems that integrate hot water heating and/or ventilation features are also of interest. The goal is to create simple HVAC systems that are readily accepted by the industry.

d. Passive Cooling and Dehumidification—A number of passive cooling and dehumidification concepts have been developed, including natural ventilation strategies, earth-coupled designs, and radiative cooling using roof ponds. Of these, the greatest practical success to date has been natural ventilation. Grant applications are sought that could significantly increase natural cooling or dehumidification through the use of innovative materials or products. This could include materials or products that accelerate heat transfer or reduce humidity build-up. Examples include systems that use radiative cooling techniques to take advantage of day-night sky temperature differentials, building envelope designs that promote natural ventilation, and earth contact designs (e.g., earth tubes). The focus is on whole building concepts that integrate cooling load

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avoidance and heat/humidity removal strategies to reduce or eliminate conventional air conditioning and fan requirements without increasing heating season energy needs. Grant applications must demonstrate a significant advance over earlier concepts, clearly identifying how previous problems/limitations are overcome by the new concept.

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PROGRAM AREA OVERVIEW - FOSSIL ENERGY

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Our nation's economic prosperity is built on a secure energy supply. Fossil energy plays a key role with contributions mainly from coal, natural gas, and oil energy resources. However, national complacency, derived from low cost imported oil, has allowed

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petroleum imports to increase to alarming levels in the last two decades. We need not go far back in history to find out how uncertainty in petroleum supply can affect our nation's economic growth. Nonetheless, our near term power generation and transportation needs still require the utilization of these hydrocarbon-based fuels. As the economy expands, demand for hydrocarbons will increase accordingly. Unfortunately, with current control technologies, this demand will be accompanied by increased emissions of global warming gases and pollutants. Therefore, the Office of Fossil Energy seeks to develop advanced technology for the efficient and cleaner utilization of these energy resources.

Technological innovation is required to take advantage of the United States' large supply of coal and natural gas reserves. Coal's major drawback is that it contains sulfur, nitrogen, and ash, precursors of pollutants that could have a deleterious effect on the environment. This is particularly alarming because more than half of the electric power generated in the U.S. originates from coal utilization. Natural gas is also produced with a wide variety of pollutant-forming compounds which preclude some advanced applications such as fuel cells and gas turbines. For both coal and natural gas, further improvements are needed to develop advanced, low cost, high-efficiency processes for the production of clean energy and specialty fuels and chemicals.

Improvements are also needed in our ability to recover both oil and natural gas. About two-thirds of our national petroleum reserve is "unrecoverable;" i.e., it cannot be extracted economically by conventional means. This unused resource could play a major role in supplementing the national petroleum supply if efficient approaches were developed for improved extraction. Natural gas production and utilization could also be increased through improved characterization of gas reservoirs.

In this solicitation, the Office of Fossil Energy seeks to use small businesses to address problems related to the utilization of coal and natural gas to produce power, fuels, or chemicals, and to the recovery of oil and natural gas.

6. COAL/GAS POWER SYSTEMS

The efficient and environmentally safe utilization of our most abundant fossil energy resources, coal and natural gas, is needed to sustain economic progress. The Department of Energy (DOE) is supporting the development of advanced technology power plants that offer higher efficiency, lower emissions, and reduced capital and operating cost. The "Vision 21" concept is a new approach to the production of energy from fossil fuels in the 21st century. It will integrate advanced concepts for high-efficiency power generation and pollution control into a class of fuel-flexible facilities capable of co-producing electric power, process heat, and high value fuels and chemicals, with near zero emissions. The approach includes a variety of configurations to meet differing market needs, including both distributed and central generation of power. DOE is interested in innovative research related to gas turbines, coal gasification, and high temperature fuel cells that will benefit these advanced technologies and the Vision 21 concept. **Grant applications are sought only in the following subtopics:**

a. Advanced Gas Turbine Systems—Achieving ultra-high efficiencies for gas turbine systems, along with a concurrent reduction in emissions, will require operation at higher temperatures and pressures. Advanced combustion design and technology is therefore needed to achieve higher performance in these advanced turbine systems. Grant applications are sought to develop new combustion concepts and technology (e.g., catalytic combustion technology) for enhanced high efficiency, low emission (of NO_x and hydrocarbons) performance in utility-scale or distributed generation gas turbine applications.

In addition, the ability to repair and refurbish engine components, especially turbine blades and vanes cast with high performance alloys, would contribute to the life extension of advanced turbine systems, as well as to reduced operating costs. Therefore, grant applications are also sought to develop novel techniques for the repair of defects or damage, caused by the high temperature operation or the casting process itself, to both single crystal castings and directionally solidified castings of components for advanced turbine systems.

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b. Advanced Integrated Gasification Combined Cycle—In the Integrated Gasification Combined Cycle (IGCC) system, coal and other carbonaceous feedstocks are partially combusted at elevated temperatures and pressures to produce synthesis gas, a mixture of carbon monoxide and hydrogen. The synthesis gas must be cleaned of sulfur, particulates, and other contaminants to meet subsequent processing requirements, i.e., combustion in a high efficiency gas turbine/generator or catalytic conversion to fuels or chemicals. In its Vision 21 concept, DOE seeks to achieve near-zero discharge of SO_x, NO_x, hazardous air pollutants (HAPs) such as mercury, particulates, and other pollutants, as well as zero discharge of water from future facilities, while simultaneously achieving thermal efficiencies greater than 60 percent. In addition, through continued development of improved technologies, DOE hopes to reduce the capital cost of IGCC facilities to $800 to $850 per kilowatt, co-produce environmentally superior transportation fuels and/or premium chemicals that are cost competitive with those produced from petroleum, and minimize carbon dioxide emissions. Grant applications are sought to develop novel, low-cost, and reliable technologies for the removal of particulate and chemical contaminants from the raw, high pressure synthesis gas produced from the gasification of coal and/or mixtures of coal and other alternative feedstocks (i.e., biomass, municipal solid waste, petroleum coke, etc). Proposed technologies may include multiple stage separations, be either dry or wet processes or a combination of the two, and be conducted at low, medium, or high temperatures. Grant applications must show the potential for improved IGCC system performance (i.e., higher thermal efficiencies), lower capital costs, and lower operating and maintenance costs compared to conventional gas cleaning technologies. In addition, the proposed technologies must be capable of near zero discharge of liquid, solid, and gaseous emissions. The clean synthesis gas must also be suitable for combustion in modern high efficiency gas turbines, conversion to transportation fuels and/or chemicals, or use in fuel cells.

c. Solid Oxide and Molten Carbonate Fuel Cells—Since fuel cells do not rely on combustion (in fuel cells, an electrochemical reaction generates power), these systems are potentially the cleanest power options being readied for the power industry. Solid oxide and molten carbonate fuel cell (SOFC and MCFC) technologies can achieve higher efficiencies compared to first generation fuel cells now being commercialized. However, their high temperature operation (650 to 1000°C) is accompanied by high materials and manufacturing costs, poor performance, or both. To address these problems, grant applications are sought to develop: (1) alternative materials or manufacturing methods for the fuel cell package (i.e., stacks or tube bundles) in order to radically reduce costs (to less than $250/kW for systems of greater than 100 kW, exclusive of balance of plant components, and assuming mass production and power densities at the present state-of-the-art); and (2) improved seals, for electrodes and the stack perimeter, that will function effectively at high temperatures.

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** See Section 7.1

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7. RECOVERY AND UTILIZATION OF FOSSIL FUELS

The Department of Energy seeks innovative methods and concepts that will contribute to more efficient and economic processes for the recovery of oil and natural gas. For oil, subtopic a focuses on improved chemical techniques to maximize domestic oil recovery. For natural gas, subtopic b focuses on reducing the risk of siting new wells by using reconnaissance tools to locate natural fracture systems in low permeability resources containing vast deposits of natural gas.

Ultimately, the utilization of fossil fuels can be enhanced by the commercial production of fuels or chemicals from synthesis gas, which is derived from coal or natural gas.Subtopic c focuses on membrane technology for the low cost production of oxygen, a critical component of the process for producing synthesis gas. **Grant applications are sought only in the following subtopics:**

a. Oil Recovery Technology—Improved chemical methods are needed to recover the remaining oil that can not be economically recovered using conventional technologies. Grant applications are sought to develop: (1) innovative chemical systems or techniques for near wellbore cleanup/stimulation, and (2) methods for applying surfactants to complement other recovery methods (but not including steam-foam and CO2 foam methods). Grant applications are also sought to develop cost effective, non-petroleum based chemicals (surfactant or polymers) for use in oil recovery processes, including the processes described in (1) and (2) above. Only innovative ideas will be considered; grant applications, which propose to modify or improve slightly upon currently practiced technologies, will be declined.

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b. Gas Reservoir Diagnostics—Grant applications are sought for innovative methods for detecting natural fracture systems in both tight gas formations and gas storage reservoirs. The grant applications should emphasize characterizing the orientation, spacing, areal extent, and areas of optimum permeability for these reservoirs. Methods of interest include three-dimensional seismic techniques (i.e., longitudinal and/or shear waves), fracture system mapping using data from various sources of aerial reconnaissance, well-to-well reconnaissance methods for siting production wells and storage wells, and innovative software for integration and analysis of seismic data.

c. Oxygen Production—Wide-spread commercial production of fuels or chemicals from synthesis gas has been hindered by the high cost of producing oxygen, which is required for either the gasification of coal or the reforming of natural gas. Current processes for producing synthesis gas often use pure oxygen. The oxygen is produced in a cryogenic air separation plant, which requires high capital investment and high energy penalties. The production of oxygen from air at low cost is the key challenge that must be met to enable an expansion of the use of coal and natural gas to provide fuels and chemicals in the future. Advances in membrane separation science offer the possibility for low cost oxygen production. Therefore, grant applications are sought to develop and demonstrate membrane technology to produce oxygen from air at lower cost. One area of particular interest is the use of novel materials, such as mixed-conducting ceramic membranes, that exhibit long-term performance and stability at the high temperatures and pressures required to achieve an industrially significant oxygen flux.

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** See Section 7.1

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PROGRAM AREA OVERVIEW - FUSION ENERGY SCIENCES

http://wwwofe.er.doe.gov

The Department of Energy is funding fusion science and technology research as a valuable investment in the clean energy future of this country and the world, as well as to sustain a field of scientific research--plasma physics--that is important in its own right and has produced insights and techniques applicable in other fields of science and industry. The mission of the Fusion Energy Sciences (FES) program is to acquire the knowledge base needed for an economically and environmentally attractive fusion energy source. FES research efforts seek to: (1) understand the physics of plasmas, the fourth state of matter--plasmas constitute most of the visible universe, both stellar and interstellar, and progress in plasma physics has been the prime engine driving progress in fusion research; (2) identify and explore innovative and cost-effective development paths to fusion energy--the current fusion program encourages research on a wide range of approaches, including the Tokamak, the leading power plant candidate, other

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magnetic configurations, and inertial fusion energy using particle beams or lasers; and (3) explore the science and technology of energy producing plasmas, the next frontier in fusion research, as a partner in an international effort--reducing costs, avoiding duplication of efforts, and bringing the best available scientific and engineering talent together to seek solutions to complex problems can best be done through the cooperative efforts of the world fusion community.

This is a time of important progress and discovery in fusion research. The FES program is making great progress in understanding turbulent losses of particles and energy across magnetic field lines used to confine fusion fuels, identifying and exploring innovative approaches to fusion power that may lead to more economical power plants, and encouraging private sector interests to apply concepts developed in the fusion research program. It is felt that small businesses, by performing research within the following technical topics, can make significant contributions to these efforts. This solicitation is restricted to science and technology relevant to magnetically confined plasmas. Grant applications pertaining to cold fusion will be declined, as will those related to other fusion energy concepts not based specifically on magnetic confinement of plasmas for purposes of producing energy/electricity for non-defense purposes.

8. FUSION PLASMA SCIENCE RESEARCH

The Fusion Energy Sciences program currently supports several fusion experiments with many common objectives. These include improving the performance of high temperature plasma for eventual energy production and expanding the scientific understanding of plasma behavior. The goals of this topic are to develop and demonstrate innovative techniques, instrumentation, and concepts for measuring magnetic plasma parameters, for plasma processing; and for magnetic plasma simulation, control, and data analysis. It is also intended that concepts developed as part of the fusion research program will have application to industries in the private sector. **Grant applications are sought only in the following subtopics:**

a. **Diagnostics for Magnetic Fusion Plasma Research**—Grant applications are sought to develop measurement techniques for parameters such as plasma density, electron and ion temperature, plasma current and current density, plasma position and shape, impurity density, magnetic field strength, ambipolar potentials, and radiation from the plasma. Diagnostics suitable for experimental devices using relatively low magnetic fields or burning plasmas are of particular interest. In addition, methods are desired for examining the edge and divertor regions in Tokamak plasmas. Both new techniques and methods to improve the accuracy and resolution of existing diagnostics (e.g., improving the signal-to-noise ratio or extending the range of measured parameters) will be considered. Measurements must be both spatially and temporally resolved for both the absolute values of parameters and for small relative differences. For some of these parameters, real-time measurements will be an advantage in order to provide for plasma control. For additional information, see the summary of the February 1998, workshop addressing measurements needs in magnetic fusion devices, listed as one of the references.

Grant applications are also sought to apply diagnostics technology, developed for fusion energy, to the use of plasmas in manufacturing. These grant applications should show how the application of these diagnostics would contribute to the understanding of plasmas used in manufacturing, as well as provide an improved basis for modeling these plasmas.

b. Plasma Simulation, Control, and Data Analysis—The simulation of fusion plasmas is important to the development of plasma discharge feedback and control techniques. The simulations can be used to make reliable predictions of the performance of proposed feedback and control schemes and to identify those which should be tested experimentally. However, accurate simulations of fusion plasmas are very difficult because of the enormous range of temporal and spatial scales involved in plasma behavior. Considerable progress has been made in recent years in understanding and simulating plasma turbulence along with associated transport, macroscopic equilibrium and stability, and the behavior of the edge plasma. However, there

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remains a need to integrate the various plasma models. Grant applications are sought to develop computer algorithms applicable to plasma simulations which account for an expanded number of plasma features and an integration of plasma models. Some examples of possible approaches include algorithms that incorporate mathematical techniques such as neural networks, sparse linear solvers; and adaptive meshes; algorithms for coupling disparate time and space scales; efficient methods for facilitating comparison of simulation results with experimental data; and visualization tools for local and remote analysis and presentation of multi-dimensional time dependent data.

Grant applications are also sought to develop software tools useful for the analysis and distribution of fusion data. Areas of interest include methods for coupling codes across architectures and through the Internet; techniques for making highly configurable scientific codes; data management and analysis techniques for large data sets; and remote collaboration tools that enhance the ability of a geographically distributed group of scientists to interact in real-time.

The computer algorithms and programming tools should be developed using modern software techniques and should be based on the best available models of plasma behavior.

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9. ENABLING TECHNOLOGIES FOR FUSION PLASMA EXPERIMENTS

The enabling technology program supports experiments in Fusion Energy Science research related to the production and sustenance of the high temperature plasma. Advanced technologies are needed to better understand the behavior of high temperature plasmas and to improve performance. Hence, the goal of this topic is to develop and demonstrate

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techniques and instrumentation which will have applications in ongoing fusion-related experimental research. It is also expected that concepts developed as part of the fusion research program will have industrial applications in the private sector. **Grant applications are sought only in the following subtopics:**

a. **Superconducting Magnets and Materials**—This subtopic addresses the design and development of new or advanced superconducting magnet concepts for plasma fusion confinement systems; i.e., high field magnets (12 to 20 T) and low loss pulsed magnets. Grant applications are sought for: (1) innovative and advanced materials and manufacturing processes that have a high potential for improved conductor performance and low fabrication costs; (2) cryogenic superconductor materials with high critical current density, low sensitivity to strain degradation effects, and radiation resistance; (3) novel, low-cost cable designs and fabrication techniques which minimize conductor strain; (4) superconducting joints for high field and pulsed applications; (5) novel, advanced sensors and instrumentation for non-invasively monitoring magnet and helium parameters (e.g., pressure, temperature, voltage, mass flow, quench, etc.); (6) thick (15-30 cm) weldable structural case materials with high strength and toughness at 4 K; (7) welding techniques for such thick cryogenic structural materials; and (8) radiation-resistant electrical insulators (e.g., wrapable inorganic insulators and low viscosity organic insulators which exhibit low outgassing under irradiation).

b. **Plasma Facing Materials and Components**—Plasma facing materials and components for fusion experiments that are operating or planned, including a burning plasma, must perform their functions under harsh environmental conditions that include high heat and particle fluxes, high temperatures, and plasma-induced erosion, as well as neutron irradiation from burning plasmas. Grant applications are sought for: (1) radiation resistant and high thermal conductivity materials and concepts to remove high surface heat flux and to control erosion and deposition for limiters, divertors, wall armor, and liners; (2) heat dissipating materials and concepts; (3) non-silver joining techniques for graphites, carbon/carbon composites, tungsten and beryllium to substrate structural or heat sink materials; (4) compliant or functionally graded interlayers with high thermal conductivity; (5) transpiration cooled armor concepts; (6) techniques to enhance heat transfer and critical heat flux limits for water- or gas-cooled components; (7) in-situ inspection and repair techniques for damaged armor; (8) methods for cleaning plasma facing surfaces with emphasis on the *in-situ* removal of co-deposited tritium layers; and (9) nondestructive evaluation techniques for armor joints and critical heat flux monitoring.

All materials and components proposed must be able to withstand surface heating conditions which include long pulse (tens of seconds to steady state) heat fluxes for first wall components (0.1 to 2 MW/m^2) and for limiter and divertor components (5 to 50 MW/m^2). In addition, materials and components which are also capable of accommodating short pulse (about one thousandth of a second) heat fluxes on surfaces subjected to plasma disruptions (10 to 500 MW/m^2) are of particular interest. Grant applications must clearly identify any proposed materials and configurations and include preliminary analysis to indicate the potential for achieving the performance capabilities sought, including maximum and minimum temperatures of key materials. Grant applications pertaining to the use of silicon carbide/silicon carbide (SiC/SiC) composites in plasma facing components will not be considered responsive; these should be submitted under Topic 10.

c. **Components for Plasma Heating and Profile Control**—Two radio frequency heating methods are now extensively used for fusion applications: Ion Cyclotron Resonance Heating, in the frequency range of 50 to 300 MHZ, and Electron Cyclotron Resonance Heating, in the frequency range of 100 to 300 GHz. These systems are expected to operate at total power levels of 10 to 50 MW in continuous operation. Grant applications are sought to develop components related to the generation, transmission and launching of electromagnetic waves in the above frequency range. Components of interest include: (1) power supplies, (2) antenna systems, (3) tuning and matching components, (4) mode converters, windows, output couplers, loads, diagnostics to evaluate the performance of such components, (5) fault protection devices which limit tube faults to less than a few joules (e.g. the use of the new high temperature superconducting material to act as a current

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limiting device), and (6) energy extraction systems from spent electron beams. Grant applications should address the ability of the components to withstand the harsh environment of the fusion research devices.

d. Plasma Fueling and Vacuum Systems—Grant applications are sought to develop techniques for fueling the high temperature plasmas in magnetic fusion experiments. Areas of interest include improvements to the widely used deuterium or tritium pellet injectors, as well as alternative concepts. Grant applications are also sought to develop vacuum system components used to remove undesired particles.

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10. ADVANCED TECHNOLOGIES AND MATERIALS FOR FUTURE FUSION ENERGY SYSTEMS

An attractive fusion energy source will require the development of technologies and materials that can withstand the high levels of surface heat flux and neutron wall loads expected for the in-vessel components of future fusion energy systems. These technologies and materials will need to be substantially advanced relative to today's capabilities in order to assure the safe, reliable, economic, and environmentally benign operation of fusion energy systems. **Grant applications are sought only in the following subtopics:**

a. Structural Materials and Coatings—Grant applications are sought for research that will lead to the relaxation of operating limits by further developing the following materials: (1) vanadium alloy structural materials, (2) silicon carbide/silicon carbide (SiC/SiC) structural composites, (3) oxide dispersion strengthened (ODS) ferritic steels, (4) copper alloys, and (5) electrically insulating coatings to reduce magnetohydrodynamic (MHD) effects in vanadium alloy/liquid lithium systems. For vanadium alloys, areas of interest include the development of improved alloys, increased resistance to degradation under neutron irradiation, relaxation of protection requirements set by their sensitivity to gaseous impurities, and the development of advanced welding/joining techniques to produce tough, ductile vanadium alloy-to-vanadium alloy or vanadium alloy-to-steel joints. For SiC/SiC composites, techniques to improve the thermal conductivity, improved and low cost production methods, and advanced joining processes are needed. For ODS ferritic steels, areas of interest include developing low cost production techniques, product isotropy, and joining methods; these materials would allow for higher temperature service than permitted by the creep strength limits of conventional low activation ferritic steels. For copper alloys, improved radiation resistance, fracture toughness and fatigue properties are desired, while retaining high conductivity properties. For electrically insulating coatings, coating technologies to reduce MHD effects must take into consideration the compatibility with both the coated vanadium alloy and liquid lithium coolant for long time operation at elevated temperatures. In addition, grant applications must address the use of candidate coatings on actual system components and account for the *in situ* repair of defects that could develop in the coating. Note that in this subtopic, the emphasis is on materials for structural

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applications; issues related to plasma-surface interactions should not be addressed.

b. High Power Density Concepts—Research on innovative fusion power technologies for in-vessel components could significantly enhance the potential of fusion to become an attractive and competitive energy source. Grant applications are sought to develop new in-vessel concepts to efficiently extract heat from plasmas in fusion energy systems operated on the deuterium-tritium fuel cycle, while also satisfying all fusion power functional requirements with high degrees of reliability, maintainability, safety, and environmental attractiveness. One area of particular interest involves the use of flowing liquids in contact with the plasma. Candidate liquids include lithium, gallium (for divertors), flibe (fluorine-lithium-beryllium salt, Li_2BeF_4), and lead-lithium ($Pb_{83}Li_{17}$). For this concept, experimental and/or modeling techniques could be used to investigate one or more of the following areas: erosion behavior of liquid surfaces, interactions of sputtered and vaporized liquids with the plasma, hydrogen and helium recycling, fluid dynamics of free surface liquid flows in proposed fusion reactor configurations, and efficient removal of high levels of power. Other innovative in-vessel concepts are also of interest.

The performance capabilities being sought for these new in-vessel concepts are: (1) high power density handling, with peak neutron load >10 MW/m^2, peak surface heat flux at first wall and divertor of about 2 MW/m^2 and 50 MW/m^2, respectively (2) high power conversion efficiency, with net efficiency > 40%, (3) clear potential to achieve high availability through low failure rate, large design margin, and short downtime for maintenance, and (4) high public safety and minimization of radioactive waste. Grant applications must clearly indicate the specific concept being investigated, describe the issue(s) that must be addressed to prove feasibility, and present an outline of the proposed approach. Proposed materials and configurations for in-vessel components must be identified, and preliminary analysis (including maximum and minimum temperatures of key materials) must be conducted to indicate the potential for achieving the above performance capabilities.

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PROGRAM AREA OVERVIEW - HIGH ENERGY PHYSICS

http://www.er.doe.gov/production/henp

Through fundamental research, scientists have found that all physical matter is composed of apparently point-like particles, called leptons and quarks. These constituents of matter were created at the "big-bang" which originated our universe and they are components of every object that exists today. We also understand a great deal about the four basic forces of nature which we experience: electromagnetism, the strong-nuclear force, the weak force, and gravity. We have recently learned that the

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electromagnetic and weak forces are two components of a single force, called the electro-weak force. This is analogous to the conceptual unification in the mid-nineteenth century of the electric and magnetic forces into the theory of electromagnetism. History shows that, over a period of many years, the understanding of electromagnetism has led to many practical applications which form the technical basis of modern society.

The goal of the Department's High Energy Physics (HEP) program, is to provide mankind with new insights into the fundamental nature of energy and matter and the forces that control them. This program is a major component of the Department's fundamental research mission. Such fundamental research provides the necessary foundation that enables the nation to progress in its science and technology capabilities, to advance its industrial competitiveness, and to discover new and innovative approaches to our energy future.

Experimental research in HEP is primarily performed by university scientists using particle accelerators located at major laboratories in the U.S. and abroad. Under the HEP program, the Department operates the Fermi National Accelerator Laboratory (Fermilab) near Chicago IL, the Stanford Linear Accelerator Center (SLAC) near San Francisco CA, and the Alternating Gradient Synchrotron (AGS) complex at Brookhaven National Laboratory (BNL) on Long Island, NY. Further, the Department is finalizing arrangements for a significant role in the Large Hadron Collider project at the CERN laboratory in Switzerland. The Tevatron at Fermilab is currently the world's highest energy accelerator. SLAC and the AGS also provide unique experimental capabilities.

While much progress has been made during the past three decades in our understanding of particle physics, future progress depends on the availability of new state-of-the-art technology for accelerators, colliders, and detectors operating at the high energy and/or high intensity frontiers.

Within High Energy Physics, the High Energy Technology subprogram supports the research and development required to extend relevant areas of technology in order to support the operations of highly specialized accelerators, colliding beam facilities, and detector facilities which are essential to the goals of the overall High Energy Physics program. The Department of Energy SBIR program provides a focused opportunity and mechanism for small businesses to contribute new ideas and new technologies to the pool of knowledge and technical capabilities required for continued progress in high energy physics research, and to turn these novel ideas and technologies into new business ventures. The technical topics which follow include four accelerator-related topics and two detector-related topics.

11. ADVANCED CONCEPTS AND TECHNOLOGY FOR HIGH ENERGY ACCELERATORS

The DOE High Energy Physics program supports a broad research and development (R&D) effort in the science, engineering, and technology of charged particle accelerators, storage rings, and associated apparatus. Advanced R&D is needed in support of this program in the following areas: (1) new concepts for acceleration, (2) novel device and instrumentation development, (3) inexpensive electron sources, and (4) computer software that will contribute to overall advances in accelerator technology applicable to the High Energy Physics program. Relevance to applications in high energy physics must be explicitly described. Advanced accelerator R&D more appropriate to applications in nuclear physics is specifically excluded from this topic and should be submitted under Topic 18. Grant applications which propose using resources of a third party (such as a DOE Laboratory) must include, in the application, a letter of certification from an authorized official of that organization. **Grant applications are sought only in the following subtopics:**

a. New Concepts for Acceleration—Grant applications are sought to develop new or improved acceleration concepts to provide very high gradient (>100 MeV/m for electrons and >10 MeV/m for protons) acceleration of intense bunches of particles. Stageability, beam stability, manufacturability,

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and high wall plug-to-beam power efficiency must be addressed in detail. Grant applications must also address the marketability of any systems, technologies, and devices to be developed.

b. Novel Device and Instrumentation Development—Grant applications are also sought for the development of electromagnetic or permanent magnet based charged particle optical elements for particle beam focusing. Examples include, but are not limited to, dipoles, quadrupoles, higher order multipole correctors for use in small electron linear accelerators, and solenoids for use in electron-beam or ion-beam sources or for klystron or other radio frequency amplifier tubes operating at wavelengths from 0.1 to 10 cm. Permanent magnets in these optical elements which are made with materials having very high residual magnetization, radiation resistance, and thermal stability (low variation of field strength with temperature) are of particular interest.

Grant applications are also sought for: (1) novel charged particle beam monitors to measure the transverse or longitudinal charge distribution in small radius (0.1 micrometers to 5 millimeters diameter), short (10 micrometers to 10 millimeters length) relativistic electron or ion beams; (2) devices capable of measuring and recording the Schottky or transition radiation spectrum of these beams (proposed techniques should be nondestructive to the beams monitored and have computer-compatible readouts); and (3) compact multi-terawatt laser systems for laser-accelerator applications.

Regarding (3) above, the multi-terawatt laser systems must be capable of providing at least 1 J energy in 50 femtoseconds in ultra-short pulse, single frequency operation at a high (around 10 Hz or greater) repetition rate. Alternately, such a system must be capable of providing approximately 60 J energy in 4 picoseconds in dual frequency (for example, near 1.05 micrometer and 1.06 micrometer) operation with a repetition rate of better than 2 per hour. Applications that promote novel systems architecture (e.g., multi-pass or bow-tie amplifiers to obtain compactness) and the ability to manipulate pulse shapes using phase masks are highly desirable. The laser pulses must be able to be synchronized with an electron beam generated by a radio frequency linac to a high level of precision (less than approximately 1 picosecond cycle-to-cycle jitter).

c. Inexpensive electron sources—Grant applications are sought for the design and prototype fabrication of small, inexpensive (<$1 million) electron sources for use in advanced accelerator R&D laboratory experiments and commercial or industrial spinoff applications. The following parameters are target values for accelerator research experiments: (1) energy range of 5 to 35 MeV providing, at a minimum, on the order of 10^9 electrons in a bunch less than 5 picoseconds long; (2) normalized transverse beam emittance less than or equal to 5 pi mm-mrad; and (3) pulse repetition rate greater than 10 Hz. Commercial or industrial applications using this technology may have other specifications.

Grant applications are also sought to develop radio frequency photocathodes (robust, with quantum efficiencies >0.1%) or other novel rf gun technologies operating at output electron beam energies >3 MeV. Laser or electron driven systems for such guns are also sought.

Cathodes are needed for vacuum-electronic devices such as klystrons, gyrotrons, and high brightness electron sources for accelerators. Currently, they have many limitations: conventional thermionic cathodes are limited to about 10 amps/cm^2; reservoir cathodes can operate at higher temperatures and can deliver up to 40 amps/cm^2, but may have life limited by the build-up of deposits from the evaporated barium oxide; photocathodes require expensive lasers, and plasma cathodes have limited life. Grant applications are solicited for research and development leading to rugged, long-life cathodes or electron guns that are capable of producing current densities and currents (several hundred amperes pulsed) comparable or greater than thermionic emission devices. The following areas of investigation are of interest: (1) use of secondary emission to amplify a lower current density beam to generate a higher density one, (2) arrays of field emission needles and knife edges (these have been studied extensively but are still easy to damage and hard to use), (3) use of field emission from diamond films or other surfaces at higher pulsed fields (flat diamond films have been found to yield significant current

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densities with quite low fields), (4) use of ferroelectric cathodes, and (5) new methods for bonding evaporated barium oxide in reservoir cathodes -- because evaporated material sometimes peels off and causes breakdown, improved bonding could increase the lifetime of devices using such cathodes.

Grant applications are also sought for research and development on gated electron sources with several microsecond pulses at about 200 pulses per second, on semiconductor photocathode sources of electrons with polarization in the range of 80 percent and energy in the range of a few volts to several hundred kilovolts.

d. Computer software—Grant applications are solicited for developing new or improved computer software specifically for the design or study of charged particle beam optical systems, accelerator systems, or accelerator components. Such applications should incorporate the innovative development of user-friendly interfaces with emphasis on graphical user interfaces and windows. Grant applications are also solicited for the conversion of existing codes to incorporate such interfaces, provided that existing copyrights are protected and that applications include the authors' statements of permission where appropriate.

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12. RADIO FREQUENCY ACCELERATOR TECHNOLOGY FOR HIGH ENERGY ACCELERATORS AND COLLIDERS

The DOE High Energy Physics program supports a broad research and development (R&D) effort in the science, engineering, and technology of charged particle accelerators, storage rings, and associated apparatus. Advanced R&D is needed in support of this program in (1) high gradient accelerator structures, (2) high peak power radio frequency (rf) technologies, and (3) new concepts for low-cost, very efficient, pulse power modulators. Relevance to applications in high energy physics must be explicitly described.

Advanced accelerator R&D more appropriate to applications in nuclear physics is specifically excluded from this topic and should be submitted under Topic 18. Grant applications which propose using resources of a third party (such as a DOE laboratory) must include, in the application, a letter of certification from an authorized official of that organization. **Grant applications are sought only in the following subtopics:**

a. Radio Frequency Acceleration Structures—Grant applications are sought for research on very high gradient rf accelerating structures, normal or superconducting, for use in accelerators and storage rings. Gradients >100 MeV/m for electrons and >10 MeV/m for protons in normal cavities are of particular interest, as are means for suppressing unwanted higher-order modes and reducing costs. Means for achieving unloaded voltage gradients >20 MeV/m and reducing costs in superconducting cavities are also of interest, as are methods for reducing surface breakdown and multipactoring (such as surface coatings or special geometries) and for suppressing unwanted higher order modes. Grant applications should be applicable to devices operating at wavelengths from 0.25 to 25 cm.

b. Radio Frequency Power for Linear Accelerators—Grant applications are sought for new concepts, approaches, components, and instrumentation for producing high peak power (>50 MW at 10 GHz, appropriately reduced when scaled to higher frequencies), narrow band, low duty-cycle, low pulse repetition frequency (approximately 0.1 to 1 kHz) pulsed rf amplifiers for application to upgrading future large electron/positron linear colliders. Potential electrical efficiencies greater than 45 percent are considered essential. Innovation related to cost saving, manufacturability, and electrical efficiency is especially sought.

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For example, one way of providing rf power is the cluster klystron, a device consisting of a "cluster" of separate magnetron gun driven klystrons that share a common focusing field and accelerating gap. Such a device could give high total pulsed power with relatively small individual beam currents, and thus be capable of high efficiency. The use of magnetron guns allows the many beams to be enclosed in a compact space, and have modulation anodes that allow the current to be switched, thus eliminating the need for a pulsed high-voltage modulator. Grant applications are sought to develop cluster klystrons, as well as highly stable magnetron guns for cluster klystrons.

Upgrades to the next generation linear collider will require many radio frequency power handling components which are not presently available, e.g., rf windows, couplers, mode transformers, rf loads, and high power rings capable of operating at high pulse powers (20 - 100 MW), high frequencies (11 - 100 GHz), and pulse lengths of several microseconds. Areas of interest include rf components such as mode converters from rectangular to circular waveguides, high-power rf windows, and high-power rf pulse compression methods for use in future linear colliders.

Also sought are higher efficiency (>65%) 1.0 GHz or higher frequency sources appropriate for a superconducting-rf option for a linear collider. Such sources should provide a few MW power, 2-10 msec (millisecond) pulse length, and 5-100 Hz repetition rate.

c. New Concepts for Pulsed Power Modulator—Most rf power sources for future linear colliders require high peak-power, pulse modulators of considerably higher efficiency than presently available. Grant applications are sought for new types of modulators in the 400 kV - MV range for driving currents of 400 - 800 A, with pulse lengths of 0.2 - 2 microseconds, and rise- and fall-times of less than 0.2 microsecond. Innovation related to cost saving, manufacturability, and electrical efficiency in modulators is especially important. Modulators with improved voltage control for rf phase stability in some alternate rf power systems are also sought.

A special case of interest is synchronized alternating current (AC) sources for powering gridded or modulator-controlled vacuum electronic devices. These devices can be operated with simple direct current (DC) or synchronized sources, but breakdown can be reduced with synchronized AC sources by using a nonlinear circuit to sharpen the voltage swings in the desired direction and flatten them in the opposite direction. One example is a transformer with a biased, saturating short. Grant applications are sought for new technical approaches to, and development of, synchronized ac sources for powering gridded or modulator-controlled vacuum electronic devices operating at high power, with a special focus on electrical efficiency and manufacturing economy.

Note: Grant applications for components and systems which target the presently envisioned Next Linear Collider should be submitted under Topic 14.

d. Radio Frequency Power for Muon Colliders—Grant applications are sought for new concepts, approaches, or designs for radio frequency amplifiers for use in the acceleration and ionization cooling channels of a future muon collider. The amplifiers must have high peak power (>50 MW), and pulsed, low frequency (in the range 2 millisecond pulses at 20 MHZ to 0.1 millisecond pulses at 200 MHZ). There is also interest in higher power (>100 MW) pulsed sources at higher frequencies (in the range 30 microseconds at 400 MHZ to 10 microseconds at 800 MHZ). All muon collider amplifiers must have moderate repetition rate capability (e.g. 15 Hz). Cost per unit of peak power, including that of the needed power supplies, is of particular interest.

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13. HIGH-FIELD SUPERCONDUCTOR AND SUPERCONDUCTING MAGNET TECHNOLOGIES FOR HIGH ENERGY PARTICLE COLLIDERS

The Department of Energy High Energy Physics program supports a broad research and development (R&D) effort in the science, engineering, and technology of charged particle accelerators, storage rings, and associated apparatus. Advanced R&D is needed in support of this program in (1) high-field superconductor and (2) superconducting magnet technologies. This topic addresses only those superconductor and superconducting magnet development technologies that support dipoles, quadrupoles, and higher order multipole corrector magnets for use in accelerators, storage rings, and charged particle beam transport systems. Relevance to applications in high energy physics must be explicitly described and will be a factor in selection. Grant applications which propose using resources of a third party (such as a DOE laboratory) must include, in the application, a letter of certification from an authorized official of that organization. **Grant applications are sought only in the following subtopics:**

a. High-Field Superconductor Technology—Grant applications are sought for new or improved materials and related processing techniques for high critical-current, high critical-field conductors to produce low alternating current (AC) loss conductors for use in very high-field magnets. While improvements are sought for magnets above 8 Tesla, the engineering goal for the near future (7 to 10 years) is at least 15 Tesla. Applications must demonstrate such property improvements as higher critical-current densities, higher critical fields, as well as manageable degradation of these properties as a function of applied strain. Vacuum requirements in accelerators and storage rings favor operating temperatures below 20 K. Process improvements

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must result in equivalent performance at reduced cost. Advanced conductor fabrication techniques also include methods to utilize high aspect ratio stranded conductors or tape geometries in particle accelerator applications. Materials of interest include: niobium-titanium, ternary niobium-titanium alloys, the so called "A-15" compounds (e.g., niobium-tin and niobium-aluminum), and oxide (high temperature) superconductors. Regarding oxide superconductors, a minimum current density of 1200 A/mm^2 (not cm^2) in the superconductor itself and a minimum current density of 250 A/mm^2 over a total conductor cross section, at 12 Tesla minimum and 4.2 K, must be produced. All responsive grant applications for A-15 and oxide superconductors must address the challenge of long length, large volume industrial production for practical applications. The details of such production plans, including expected development time, also must be discussed.

In addition, grant applications are sought for innovative insulating materials which would enable employment of new superconductors, such as the A-15 or oxide types, in practical devices. Insulating materials must be compatible with high temperature reactions in the 750-900°C range, and must be capable of supporting high mechanical loads at cryogenic temperatures.

b. Superconducting Magnet Technology—Grant applications are sought to develop: (1) improved instrumentation to measure properties (such as local strain, temperature, and magnetic field) which are directly applicable to the testing of superconducting magnets; (2) improved high-temperature superconductor based current leads for application to high-field accelerator magnets--requirements include current level at 5 kA or greater, stability, low heat leak, and good quench performance; (3) alternative designs, to traditional "cosine theta" dipole and "cosine two-theta" quadrupole magnets, that may be more compatible with the more fragile A-15 and the oxide, high-field superconductors; and (4) designs for bent (e.g., bending radius of 0.5 meter) solenoids (e.g., 4 T, 30 cm inside diameter) with superimposed dipole fields (e.g., 1 T) for dispersion generation in large emittance beams.

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14. TECHNOLOGIES FOR THE NEXT-GENERATION ELECTRON-POSITRON LINEAR COLLIDER

The DOE High Energy Physics program includes research and development (R&D) of technologies for a TeV-scale electron-positron linear collider that would use normal-conducting X-Band (11.4 G Hz) microwave power. This collider will be ten times the size of present-generation linear accelerators. This topic addresses near-to-medium term developments to enhance performance and reliability and/or to reduce costs of accelerator components and infrastructures. Applications should demonstrate relevance to these issues. Any letters included in an application which indicate the use of resources of a third party (such as a DOE Laboratory) must include certification from an authorized official of that organization. **Grant applications are sought only in the following subtopics:**

a. Direct Current (DC) and Pulsed Power Components—Grant applications are sought to develop DC power supplies, differential current transducers, traveling wave tube (TWT) cathode pulser/power supplies, and modulators. **DC power supplies:** A "hot swappable" 5 kW (nominally 40 V, 125 A) power supply with 100,000 hours MTBF (mean time between failures) and efficiency > 90 percent. It is desired to remove and replace a supply without disturbing the supplied current. The design must provide small physical size and be cost effective. **Differential Current Transducer**: A current transducer with (i) low cost, (ii) minimum 2.5 inch diameter center hole for two conductors carrying up to 750 amps each, (iii) dynamic range ±100 mA accurate to 1 mA, and (iv) overload and failure indication. **Traveling Wave Tube (TWT) Cathode Pulser/Power Supply:** A highly-reliable cathode pulser and power supply to drive an X-band TWT. The pulser should deliver a 10 kV pulse to the heater/cathode element of a 1.2 μperv TWT. Rise and fall times should be < 1 μsec each and the 2 μsec flat-top should be within 0.2 percent ripple and droop. Low-cost and compact packaging are important. **Modulators:** Pulse modulators for klystron amplifiers must provide good efficiency, reliability, and maintainability, and be produced at low cost. Each modulator must support two klystrons and deliver a 500 kV pulse into the combined impedance of 1 kΩ at repetition rates up to 180 Hz. The rise and fall times of the voltage pulse must be below 300-400 ns and the output flat-top must be 1.5-1.8 μs.

With regard to modulators, the following components are required: **Power Supply for Dual Klystron Modulator:** A 100 kW power supply to charge a pulse forming network (PFN) of total capacity 0.2 μF to a maximum of 80 kV in < 500 μsec with electrical efficiency > 90%. The supply must be compact in size, highly reliable (MTBF > 50,000 hours), and cost-effective to manufacture and maintain. **High Power Switch:** A hydrogen thyratron or other type high-power switch capable of operating at 80 kV and switching up to 8,000 amps in < 50 ns. The switch should have MTBF > 50,000 hours and the total operating power should be minimized. Applications are also sought to investigate solid state devices to replace thyratrons. **Pulse Capacitors:** Capacitors for PFNs require series inductances < 50 nH with capacitance > 0.005 μF for 80 kV pulses. The PFN must be charged to 80 kV in 500 μsec and fully discharged during the 1.5 μsec output pulse. Circuits must withstand partial voltage reversal during non-standard conditions. The PFN must be compact and reliable (MTBF > 100,000 hours). **Pulse Forming Line**: Ferrite loaded, ceramic dielectric, or coaxial transmission lines in tubular or strip configurations. Lines must be compact and configured as 4 - 5 Ω impedances. The high-voltage high-current connections must be considered. **Pulse Transformers:** A transformer (ratio 1:14) to convert 35 kV/7,500 amp PFN pulses to 500 kV/530 amp pulses (with 1.5 μsec flat-top with rise time < 300-400 ns and droop and ripple < 2%) that drive two 0.75 μperv klystron cathodes in parallel. The transformer must operate in 40 kV breakdown transformer oil, be compact, efficient, and cost-effective to manufacture.

b. Microwave Power Technologies—Grant applications are sought to lower the cost, increase the reliability, and extend the life of three components which are major cost drivers of the klystron amplifiers that power the accelerator. **Electron gun:** (I) a less costly high-voltage (500 kV for 2 μs pulse) vacuum seal, (ii) high-current (10 A/cm^2), long-life (MTBF greater than or equal to 50,000 hours) cathodes and heater packages, (iii) packaging to minimize fixturing and assembly labor. **Collector:** Low-cost fabrication and innovative cooling designs for a 140 MW peak power,

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20 kW average power electron beam collector. **RF Window:** Low-cost rf window designs which will reliably pass 75 MW of peak rf power, 11 kW of average rf power for > 50,000 hours.

Grant applications are also sought to develop or advance **net shape or near net shape manufacturing for mass production** of high-conductivity (100 percent dense) oxygen-free (ASTM F.68, Metallographic Class I) copper components used in ultra high-vacuum (equilibrium vapor pressure > 1 x 10^{-9} Torr @ 300°C) high-power microwave applications. Mechanical tolerances from a few microns to 50-100 microns and surface finishes of 10 nanometers must be achieved for a few of these parts. Development must yield significant cost reduction over current numerical controlled machining methods. Related processes for other materials (stainless steel, aluminum, copper alloys) are of interest if applicable to a high-volume linear collider component.

c. Auxiliary Systems—Signature Processing and Identification: Grant applications are sought to develop techniques to measure and characterize ambient vibration signatures from near and far, point and line, acoustic sources. Frequencies up to several hundred Hertz are of primary interest. **Signature Reduction:** Grant applications are sought to develop techniques to control vibration in central and distributed auxiliary systems. Static and dynamic techniques can be considered, and frequencies up to several hundred Hertz are of primary interest. Cost and reliability are important. **HVAC:** Grant applications are sought to develop techniques to cool enclosed racks of power electronics. Nominal operation is 25°C for heat loads of 3-5 kW per enclosure. Total heat load for the combined enclosure system is 35 MW distributed in clusters over 30 kilometers. Cost and reliability are important.

d. Controls & Instrumentation—The linear collider control and monitoring electronics are distributed over 30 kilometers. Low cost with very high reliability and maintainability are critical issues. Grant applications are sought to develop or advance technologies in the following areas: **X-band Phase Shifter:** New or optimized X-Band microwave phase-agile phase shifters. Phase must be programmable to all angles with < 0.3 dB amplitude variation and a phase shift must settle in < 3 nanoseconds. Operation is at 100 milliwatts with < 3 dB insertion loss and VSWR < 1.05. **Beam Position Monitors (BPMs):** The BPM electronics digitize amplitudes of signals induced by bursts (180 PPS) of 100 bunches of 10^{10} electrons (2.8 ns bunch spacing). This sampling rate, reliability, and economy suggest integration on a chip. A grant application should consider packaging, cabling, control, power, cooling, timing, cost, and reliability. Some radiation exposure to electronics is possible. **Microwave BPMs:** Electronics for microwave BPMs that sense amplitude and phase in a 15 MHz band at 14-16 GHz. Resolution requires -22 dBm noise power referred to the input. Peak powers can exceed 10 kW. A down-conversion must occur near the source; IF and baseband processing could also be done locally. System cost, reliability, packaging, and interfaces must be considered. Radiation tolerance will affect location of components. **High-Bandwidth Acquisition and Control:** Extended communications links and inexpensive processors to implement feedback with bandwidth at 0.1 to 1 kHz. Architectures should keep real-time processing near data ports and minimize real-time latency between processing nodes. Goals include good noise immunity, maximum buffer lengths, and high reliability and maintainability. **Vacuum Control:** Modular controls that work for either a vacuum pump or gauge. Millisecond response, range from 10^{-3} amps to 10^{-11} amps on a single log scale, and interlock outputs are required. Also of interest is a programmable controller to accept several interlock signals and provide power to close a vacuum valve. Cost and reliability are important. **Ion Chamber Power:** A power supply for zero-gain gaseous ion chambers that require high-voltage (300-400 V) with exceedingly good isolation from output to ground. Cost and reliability are important. **Stepping-Motor Control and Read back:** Distributed systems for precision stepping-motor drive and control. Remote front-end electronics must be radiation tolerant. Cost and reliability are important. Duty factors are low, so pulsed power and local board-mounted converters should be considered. **Control and Monitoring Links and Networks:** Investigation of tradeoffs between copper cable and medium bandwidth serial links to limited numbers of front-end devices. The technical and economic feasibility of fiber optic and copper links should be investigated and the top-end architecture studied for cost-performance. Remote front-end electronics must be radiation

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tolerant. **Network Protocols and Serial Data Acquisition and Control:** Protocols for real-time serial data collection with high reliability, timing precision and synchronization, and immunity from systematic errors. Consideration should be given to server or concentrator architectures. Issues include hardware options, availability of commercial software, and support for high-level protocols. **Personnel Safety and Monitoring:** Personnel safety systems in accelerators are function-critical and require: (i) redundancy and fail-safe implementation of all features, (ii) serial fiber or copper links from single entry points, (iii) firmware reconfigurability, (iv) modular architecture, (v) high reliability, (vi) radiation tolerance, (vii) optical or inductance interrupt switches, (viii) high-security card-reader key technology, and (ix) combined data, audio, and video to remote monitoring and control. **Pulsed Power for Instrumentation and Control:** Custom integrated circuits with pulsed power (180 PPS) for compact front-end electronics. It is desired to reduce the total power of a channel (typically 10 W steady state) to perhaps 1 W average. On-board DC-DC and AC-DC converters should be considered. Reliability and cost are of extreme importance for these applications. Remote front-end electronics must be radiation tolerant.

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* See Section 7.1.

15. HIGH ENERGY PHYSICS DATA ACQUISITION AND PROCESSING

DOE supports research and development (R&D) in a wide range of technologies essential to experiments and particle accelerators used for high energy physics (HEP) research. The development of advanced electronics and computational technologies for the recording, processing, and analysis of experimental data, as well as for the monitoring and control of accelerator systems and devices is desired. Areas of present interest are event triggering, data acquisition, and data analysis systems and components used in high energy physics experiments and particle accelerators. **Grant applications must clearly and specifically indicate their particular relevance to present or future high energy physics programmatic activities.**

Although particle physics detector instrumentation and data processing equipment development and construction are usually centered in large, collaborative efforts at major national particle accelerator centers, there are many developmental endeavors in collaborative or stand-alone efforts where small businesses can make creative and innovative contributions to the further development of the required advanced technologies. Nonetheless, applicants are encouraged to collaborate with active high energy elementary particle physicists at universities or national laboratories to

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establish mutually beneficial goals. On-line directories of appropriate researchers are available by institution at http://www.hep.net/sites/directories.html. Grant applications which propose using resources of a third party (such as a DOE laboratory) must include, in the application, a letter of certification from an authorized official of that organization. **Grant applications are sought only in the following subtopics:**

a. High-Speed Electronic Instrumentation—This subtopic includes:

Components-Grant applications are sought for special purpose chips and devices for use in the internal circuitry employed in large particle detectors. Desirable features include low noise, low power consumption, high packing density, radiation resistance, very high response speed, and/or high adaptability to situations requiring multiple parallel channels. Desirable functions include amplifiers, counters, analog pulse storage devices, decoders, encoders, analog-to-digital converters, controllers, and communications interface devices.

Electronics-Grant applications are sought for circuits and systems for rapidly processing data from particle detectors such as proportional wire chambers, scintillation counters, silicon microstrip detectors, particle calorimeters, and Cherenkov counters. Representative processing functions and circuits include low noise pulse amplifiers and preamplifiers, high speed counters (>300 MHZ), and time-to-amplitude converters. Compatibility with one of the widely used module interconnection standards (e.g., CAMAC, FASTBUS, or VMEbus) is highly desirable, as would be low power consumption, high component density, and/or adaptability to large numbers of multiple channels.

Systems-Grant applications are sought for advanced, high speed logic arrays and microprocessor systems for fast event identification, event trigger generation, and data processing with very high through-put capability. Such systems should be compatible with or implemented in one of the widely used module interconnection standards (e.g., CAMAC, FASTBUS, or VMEbus).

Instrumentation Modules-Much of the electronics instrumentation in use in high energy physics is packaged in one of the international module inter-connection standards (e.g., CAMAC, FASTBUS, or VMEbus). Grant applications are sought for modules that will provide capabilities not previously available, for substantial performance enhancement to existing types of modules, and for components, devices, or systems that will enhance or significantly extend the capability or functionality of one of the standard systems. Examples include large and/or fast buffer memories, single module computer systems (either general purpose or special purpose), display modules, interconnection systems, communication modules and systems, and disk-drive interface modules.

b. Special Computer Systems and Peripherals—Grant applications are sought for innovative software and hardware for applications in high energy physics experiments, data processing, accelerator control systems, and theoretical computations, including, for example, distributed microprocessor systems, pattern-recognition systems, database management systems, code development systems, emulators for high-speed computation, large scale parallel processors for large-scale simulation, and cost-effective, multiple-access, large-memory systems. Grant applications are also sought for hardware for local and wide area computer-to-computer networks, network switching devices, network monitoring and control instrumentation, cost-effective alternatives to magnetic tape or disk on-line storage, new approaches to very long-time or large-scale on-line data storage (e.g., optical disk), smart terminals, scientific work stations, and enhancements to CAD-CAM (computer-assisted design and manufacture) systems and devices.

c. Computer Software—Grant applications are sought for the production of computer software to meet identified computing problems. Areas of interest include: (1) computer network management, interconnection, and control; (2) transition to ISO network protocols; (3) CAD-CAM conversion between dissimilar systems; (4) systems for the management of very large databases of the type created in connection with the operation of large detectors; (5) general purpose software for controlling and interfacing with large electronic systems; and (6) software for the control of large

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12. Standard for a Versatile Backplane Bus: VMEbus, October 1985. (IEEE 1014-87)**

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16. HIGH ENERGY PHYSICS DETECTORS

The Department of Energy (DOE) supports research and development in a wide range of technologies essential to experiments in high energy physics and to the accelerators at DOE high energy accelerator laboratories. The development of advanced technologies for particle detection and identification to be used in high energy physics experiments or particle accelerators is desired. Principal areas of interest include particle detectors based on new techniques and technological developments (e.g. superconductivity or solid-state devices) or detectors which can be used in novel ways as a consequence of associated technological developments in electronics (e.g. sensitivity or bandwidth), with particular interest in devices exhibiting insensitivity to very high radiation levels. Also of interest are novel experimental systems that use new detectors or use old ones in new ways that either extend basic high energy physics experimental research capabilities or result in less costly and less complex apparatus. **Grant applications must clearly and specifically indicate their particular relevance to high energy physics programmatic activities.**

Although particle physics detector development is often centered in major national particle accelerator centers, there are many developmental endeavors, especially in collaborative efforts, where small businesses can make creative and innovative contributions to the further development of the required advanced technologies. Nonetheless, applicants are encouraged to collaborate with active high energy elementary particle physicists at universities or national laboratories to establish mutually beneficial goals. On-line directories of appropriate researchers are available at http://www.hep.net/sites/directories.html. Grant applications which propose using resources of a third party (such as a DOE laboratory) must include, in the application, a letter of certification from an authorized official of that organization. **Grant applications are sought only in the following subtopics:**

a. Particle Detection and Identification Devices—Grant applications are sought for novel devices in the areas of charged and neutral particle detection and identification. Examples include, but are not limited to, solid-state detectors (silicon strip, silicon pixel, photodiode), photosensitive detectors (photomultipliers, micro-channel plates, visible-light photon counters, scintillating fibers, crystals, and other scintillating materials), and gas or liquid-filled chambers (used for particle tracking or in electromagnetic or hadronic calorimeters, Cherenkov or transition radiation detectors). The proposed devices must be explicitly related to future high-energy physics experiments, either accelerator or non-accelerator based, or to future uses in particle accelerators. Relevant potential improvements over existing devices and techniques must be discussed explicitly (e.g., radiation hardness, energy, position, and timing resolution, sensitivity, rate capability, stability, dynamic range, durability).

b. Novel Experimental Instrumentation Systems—Grant applications are sought for novel experimental instrumentation systems which use new detectors or use old ones in new ways that either extend basic high energy physics experimental research capabilities or result in less costly and less complex apparatus (e.g., improved or less costly calorimeters or vertex detectors). The proposed instrumentation system must be explicitly related to future high energy physics experiments, either accelerator or non-accelerator based, or to future uses in particle accelerators.

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PROGRAM OVERVIEW - NUCLEAR PHYSICS

http://www.er.doe.gov/production/henp/nucphys.html

Nuclear physics research seeks to understand the structure and interactions of atomic nuclei and the fundamental forces and particles of nature as manifested in nuclear matter. Nuclear processes are responsible for the nature and abundance of all matter, which, in turn determines the essential physical characteristics of the universe. It has been long understood that atomic nuclei can be described as a collection of nucleons (protons and neutrons) which are bound together by the mechanism of exchange of subatomic particles called mesons. The research forefront in nuclear physics now requires incorporation of the quark substructure

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of the nucleon into the understanding of nuclear structure. Quarks, which are the most elemental building blocks of matter, are bound together in groups of three by exchange of gluons to form nucleons.

The primary mission of the Nuclear Physics program is to develop and support the scientists, techniques, and facilities that are needed for basic nuclear physics research. Attendant upon this core mission are responsibilities to enlarge and diversify the nation's pool of technically trained talent and to facilitate transfer of technology and knowledge to support the nation's economic base. The Nuclear Physics program works in close cooperation with a corresponding program at the National Science Foundation (NSF) and is assisted by the joint DOE/NSF Nuclear Science Advisory Committee in setting scientific priorities.

The SBIR topics which follow describe research and development opportunities in the equipment, techniques, and facilities that are needed to conduct nuclear physics research.

17. NUCLEAR PHYSICS INSTRUMENTATION AND TECHNIQUES

The Department of Energy (DOE) seeks innovative and novel approaches to technical problems encountered in basic research in nuclear physics. Measurements in this field are performed typically at the limit of technical feasibility. Hence, new capability will often generate important advances in scientific knowledge. The DOE is particularly interested in supporting projects that may lead to advances in target and detection systems for nuclear physics experiments. Opportunities exist for developing equipment beyond the present state-of-the-art and outside the usual scope of research and development activities at the nuclear physics national accelerator facilities. All grant applications must explicitly show relevance to the nuclear physics program. **Grant applications are sought only in the following subtopics:**

a. Detectors, Detector Materials and Targets—Nuclear physics research has a need for devices for detecting and analyzing charged particles, neutrons, photons, and single atoms with improved energy, position and timing resolution, sensitivity, rate capability, stability, dynamic range, durability, and background suppression. These devices include: solid-state devices such as silicon strip and silicon drift detectors; photosensitive devices such as photodiodes, avalanche photodiodes, hybrid photomultiplier devices, single and multi anode photomultipliers tubes, and other novel photon detectors; detectors utilizing CsI photocathodes for Cherenkov and UV light detection, and the development of new types of large area photoemissive materials such as solid, liquid or gas photocathodes; micro-channel plates; gas-filled detectors such as proportional, drift, streamer, Cherenkov, micro-strip, gas electron multiplier detectors, and straw drift tube chambers; liquid argon and xenon ionization chambers; single-atom detectors using laser techniques; particle polarization detectors; and magnetic spectrometer components and systems. Grant applications are sought to develop: (1) thicker (more than one mm) segmented silicon charged particle and x-ray detectors and associated compact (high density), high resolution electronics; (2) very high resolution particle detectors or bolometers based on semiconductor materials and cryogenic techniques; (3) cost-effective production of n-type and p-type silicon drift chambers with active areas >16 cm^2; (4) detectors with high position resolution, high radiation hardness, small surface temperature gradients, and integrated calibration systems; (5) high precision, low-cost time of flight detectors; (6) efficient polarization-analyzing materials; and (7) large area image intensified systems such as those using carbon coupled devices, pixilated avalanche photodiodes, or PIN photodiodes, for use in single photon counting image reconstruction.

Grant applications are also sought for the development of special nuclear targets which specifically and explicitly address nuclear physics research needs. These special targets include: polarized (with nuclear spins aligned) high-density gas or solid targets; windowless gas targets and supersonic jet targets, for use with very low energy charged particle beams; and liquid, gaseous, and solid targets capable of high power dissipation when high intensity, low emittance charged particle beams are used. There is also interest in new

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technology for the production of ultra-thin films for targets, strippers, and detector windows.

b. Scintillators and Associated Materials—Grant applications are sought for research and development of new scintillators and associated materials. Areas of interest include new heavy crystals or glasses which can serve as scintillators; Cherenkov materials for electromagnetic calorimeter applications; Cherenkov radiator materials with indices of refraction up to 1.10 or greater with good optical transparency; stable calorimeter materials in single block lengths (up to 20 radiation lengths) which could be produced in large quantities and at low cost; and composite materials with high radiation resistance.

New scintillation materials are also needed for use in large intermediate-energy photon detector arrays. These materials should exhibit a light output comparable or greater than bismuth germinate, have a fast decay time (in the range from less than one nanosecond to a few tens of nanoseconds) with no slow component, and be useful for high rate and/or time of flight applications. It is essential that the density and mean nuclear charge of the materials be such that the radiation length is less than 2 cm, and that they can be fabricated in large pieces (up to 20 radiation lengths) at reasonable costs.

c. Electronics Instrumentation and Systems—Grant applications are sought for special purpose, custom designed integrated circuits and for circuits and systems for rapidly processing data from highly segmented, position-sensitive Ge detectors (pixel sizes of approximately 1 cm^2), and from particle detectors (e.g., gas detectors, scintillation counters, silicon drift chambers, silicon strip detectors, particle calorimeters, and Cherenkov counters) used in nuclear physics experiments. Representative circuits include low noise preamplifiers, amplifiers, analog storage devices, analog-to-digital and time-to-digital converters, transient digitizers, and time-to-amplitude convertors. Compatibility with one of the widely used module interconnection standards (e.g., CAMAC, FASTBUS, or VMEbus) is highly desirable, as would be low power consumption, advanced packaging, and/or adaptability to a large number of multiple channels. Readout electronics for solid-state pixilated detectors, including interconnection technologies and amplifier/sample and hold integrated circuits, are also of interest.

Grant applications are also sought for improved or advanced devices and systems to be used in conjunction with the above electronic circuits and systems. Areas of interest include bus systems, data links, event handlers, multiple processors, and fast buffered time and analog digitizers, as well as generalized software and hardware packages with improved graphic and visualization capabilities for the acquisition and analysis of data specifically addressing needs related to nuclear physics research and development.

d. Data Management—Large scale data storage and processing systems are needed to store, retrieve, and process data from experiments conducted at the Brookhaven National Laboratory's Relativistic Heavy Ion Collider and the Thomas Jefferson National Accelerator Facility. These data, produced at rates of 100 MB/sec or more, result in the annual production of data sets on the order of several hundred Terabytes. Similar data management systems are required to support the needs for non-accelerator nuclear physics experiments. Grant applications are sought for hardware and software techniques to improve the effectiveness and reduce costs of handling such large data volumes.

Grant applications are also sought for research and development of software systems to facilitate the handling, management, and dissemination of compiled and evaluated nuclear data.

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18. NUCLEAR PHYSICS ACCELERATOR TECHNOLOGY

The Nuclear Physics program of the Department of Energy (DOE) supports a broad range of activities aimed at research and development related to the science, engineering, and technology of heavy ion, electron, and proton accelerators and associated systems. Research and development is desired that will contribute to overall accelerator technology and applications which are tailored to nuclear physics scientific research. Areas of interest include work conducted at the Brookhaven National Laboratory's Relativistic Heavy Ion Collider with heavy ion energies up to 100 GeV/amu for each beam, superconducting accelerator devices such as the Thomas Jefferson National Accelerator Facility's electron machine, as well as the development of devices and/or methods that would be useful in the generation of intense accelerated beams of radioactive isotopes related to the construction of an Isotope Separator On-Line (ISOL) Facility. Relevance of applications to nuclear physics must be explicitly described. **Grant applications are sought only in the following subtopics:**

a. Materials and Components for Radio Frequency Devices—Grant applications are sought for research and development leading to improved or advanced superconducting and room temperature materials or components for radio frequency (rf) devices used in particle accelerators. Areas of interest include: (1) peripheral components such as ultra high vacuum seals, terminations, cryogenic radio frequency windows, and magnetostrictive cavity tuning mechanisms; (2) termination materials for use at 2 to 4 K, compatible with the ultra high vacuum and

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dustfree environment, and capable of absorbing microwaves efficiently from 2 to 90 Ghz; (3) methods to avoid inclusions in the superconducting material and contamination on the surface of the superconductor; and (4) innovative designs for hermetically sealed refrigerators and other cryogenic equipment that simplify procedures and reduce costs associated with reparability and modification.

b. Design and Operation of Radio Frequency Systems—Grant applications are sought for the design, fabrication, and operation of radio frequency structures and systems. Areas of interest include: (1) superconducting and conventional continuous wave structures for the preacceleration of radioactive beams, which can operate in the velocity regime between 0.001 and 0.01 times the velocity of light, for ions with charge-to-mass ratios between 1/30 and 1/240; (2) rf accelerating structures with large acceptances and that maintain good beam quality in both longitudinal and transverse phase spaces; (3) the economical fabrication of rf cavities with more than five cells while still providing moderate damping of all higher-order modes; (4) improved techniques for phase stabilization of low velocity ion acceleration structures; (5) improvements to accelerating gradients and quality factor (Q) in cavities for both continuous wave and pulsed operation; (6) high duty factor, high power rf systems for radio frequency quadrupoles and linacs; and (7) techniques for coupling rf power into superconducting cavities operating at 2 K.

Power requirements could be significantly reduced if the 5 kW, 1500 MHz klystrons, currently available for use at nuclear physics accelerator facilities, could be replaced by alternative technology. Grant applications are therefore sought for the design and development of high power solid state devices or other techniques which would allow for significant reductions in accelerator power usage. The gain should exceed 30 dB and devices should exhibit long life, cost effectiveness, reliability, and high electrical efficiency.

c. Particle Beam Sources and Techniques—Grant applications are sought to develop: (1) particle beam ion sources with improved intensity, emittance, and range of species (areas of interest include high-charge-state sources for heavy ions, sources for negative and light ions, and polarized sources for hydrogen ions and electrons); (2) ion sources for radioactive beams (emphasizing high efficien high-charge-state ions, high temperature operation coupling to high temperature production targets, and elem selectivity; e.g., through the use of laser ionization); methods to increase the charge state of ion beams (e.g., the use of special electron-cyclotron-resonance ionizers special stripping techniques); (4) power supplies to dri these sources; (5) high brightness electron beam sourc utilizing continuous wave superconducting rf cavities w integral photocathodes operating at high accelerati gradients; and (6) methods to improve high voltage stand- and reduce field emission from high voltage electrodes in t presence of work function lowering material (i.e., cesium) order to enhance the performance of photoemission electr sources.

Grant applications are also sought to develop target materi for radioactive beam production. These targets must capable of use with beams of protons, neutrons, or hea ions, with beam power of 10-100 kW, and must configured for rapid release of isotopes and permit clo coupling to an ion source to generate high intensi radioactive beams.

d. Accelerator Control and Diagnostics—Gra applications are sought for "intelligent" software a hardware to facilitate the improved control and optimizati of charged particle accelerators and associated componen for nuclear physics research. Developments that off generic solutions to problems in the initial choice operation parameters and the optimization of selected bea parameters with automatic tuning are especially encourage

Grant applications are sought for advanced beam diagnosti concepts and devices that provide high speed compute compatible measurement and monitoring of particle bea intensity, position, emittance, polarization, luminosit momentum profile, time of arrival, and energy. The use advanced methods such as neural networks or expert systen is appropriate. Techniques that are nondestructive to t beams being monitored are especially of interest.

Grant applications are also sought to develop bea diagnostic devices that have increased sensitivities throug the use of superconducting components, such as filters base

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on high Tc superconducting technology or Superconducting Quantum Interference Devices. Measurements of direct current charged particle average beam currents in the range 0.1 to 100 μA to very high precision ($<10^{-4}$) are also needed.

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PROGRAM AREA OVERVIEW - ENVIRONMENTAL MANAGEMENT

http://www.em.doe.gov

With the end of the Cold War, the Department of Energy (DOE) is focusing on understanding and eliminating the enormous environmental problems created by the Department's historical mission of nuclear weapons production. The Environmental Management program seeks to eliminate these threats to human health and the environment, as well as to prevent pollution from on-going activities. The goals for waste management and environmental remediation include meeting regulatory compliance agreements, reducing the cost and risk associated with waste treatment and disposal, and expediently deploying technologies to accomplish these activities. While radioactive contaminants are the prime concern, hazardous metals and organics, as defined by the Resource Conservation and Recovery Act (RCRA), are also important.

Reduction in cost of treatment and disposal of wastes and in environmental problems can be achieved by a number of approaches. These include reducing the volume of waste or waste streams directed toward disposal; using separations or processing technologies to alter the characteristics of the waste or waste streams so as to allow less expensive disposal; recycling materials used in treatment to reduce costs; retrieving economically valuable materials from the wastes to offset costs of treatment and disposal; and using improved characterization technologies to better guide the assessment of environmental problems, the monitoring of treatment processes, and the behavior of the treated materials. The two topics below seek grant applications which will employ these approaches and others in the assessment, treatment, and disposal of radioactive and other hazardous wastes.

Grant applications in response to these topics should target specific DOE needs which have been documented on the world wide web (http://ost.em.doe.gov/ifd/stcg/needs.htm). Also of interest (but not required for this solicitation) are grant applications that build on results produced by the Department's Environmental Management Science Program (EMSP), a basic research effort directed by the Office of Environmental Management in partnership with the Office of Science. The EMSP already has identified some potentially fruitful areas for follow-on development in bioremediation and phytoremediation, speciality (micro)sensors for hazardous chemical and radiochemical detection, non-thermal treatment processes based on sonochemistry or electrochemistry, and novel surface cleaning processes to remove radiological contaminants from porous and nonporous surfaces.

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19. WASTE CHARACTERIZATION

For the Department of Energy (DOE) to conduct its environmental management mission properly, the problems that it faces and the solutions that it uses must be adequately characterized. Much of the currently available characterization technology, though applicable to DOE problems, is too costly for widespread use. For many other problems, no appropriate technology is available. The complexity of many DOE waste streams can impose stringent demands on technology since a broad variety of contaminants can be present over a very wide range of concentrations in geologically complex and heterogeneous environments. Depending on the application, the technology may face different requirements. For screening, rapid and inexpensive analysis is usually the driver; while for monitoring, greater accuracy may be the overriding factor.

Grant applications should clearly identify the contaminants of interest and the host matrix for which the proposed characterization technology would find application. Technologies having commercial potential outside DOE are strongly encouraged, but all grant applications must target a specific DOE problem. In addition, sufficient detail must be provided about the proposed technology, as well as the baseline technology (for that specific problem), so that its advantages can be clearly evaluated. Of particular interest are technologies that can be applied where no alternative is currently available, or that offer a rapid deployment to meet DOE needs. In all cases, flexibility is important; e.g., a technology that addresses multiple contamination situations is preferable to one that addresses a single situation. **Grant applications are sought only in the following four subtopics:**

a. Field Screening Tools for RCRA (Resource Conservation and Recovery Act) and Radioactive Contaminants in Soils and Liquids—The conventional approach to assessing the levels of contaminants in the environment involves collection of samples in the field, transportation of samples to laboratory facilities, sample preparation, sample analysis and analytical data interpretation. The approach is reliable, but slow and resource intensive; past experience has shown that this investigation phase of a project can be a major contributor to the total cost of cleaning up a site. In contrast, field screening is a comparatively new approach that offers great potential to cost effectively address the growing needs of environmental monitoring. The field screening approach uses more rapid methods, techniques, and protocols (e.g., mobile laboratories; portable analytical equipment; accelerated sampling strategies; integrated site characterization, reconnaissance, data management and visualization; and new detectors, sensors, monitors, and non-invasive techniques) to give near real time results. Being near real-time, these results can, in turn, be used to quickly guide the efficient collection of additional samples. Grant applications are sought to further develop the field screening approach for the on-site measurement of contamination levels. Grant applications with proposed field screening technologies that incorporate R&D results funded by DOE's Environmental Management Science Program are strongly encouraged

b. Microsensors for Environmental Monitoring—Environmental monitoring covers a broad range of activities (e.g., sampling, analysis, measurement, surveillance, testing, data acquisition, processing and management, field testing) and faces a number of challenges before its full potential can be achieved. These challenges include integrating data from varied formats, handling large volumes of data, and communicating data from remote locations. New sensor technology is needed to address these challenges. (For the purposes of this solicitation, a sensor is a device that responds to a physical, chemical, biological, or radiological quantity, or a change in these quantities, by the generation of a measurable output signal.) In addition, there has been a general trend toward smaller devices since they have tended to lead to reduced overall costs, increased speed, reduced reagent use, multi-functional characteristics, higher sensitivity, and improved precision. Further, the development of new materials with unusual properties (e.g., electro-optic, piezoelectric, magneto-optic, etc.) has expanded the range of measurements for potential sensors. Therefore, grant applications are sought to develop innovative microsensor technologies that widen the range of environmental monitoring possibilities or reduce the costs of current monitoring activities.

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c. Microsensors for Cone Penetrometer Applications—The cone penetrometer is a truck-mounted device that hydraulically drives a conically tipped rod of up to two inches diameter into the ground. Sensors placed on the rod give information about subsurface conditions. Rates of penetration are high (of the order of 50 feet per hour), hence characterization data are quickly and inexpensively obtained. The cone penetrometer can monitor contaminants as the probe is advanced or it can leave monitors in place as the rod is withdrawn. The cone penetrometer essentially provides access. The characterization of contaminants is dependent on the variety and type of sensors mounted on the rod. Sensors and techniques that are currently available (or under development) include soil moisture and electrical resistivity measurements, fluorescence detection, fiber-optic, downhole Laser Induced Breakdown Spectroscopy (LIBS), samplers, dielectric probes, soil temperature/pH/redox probes. Grant applications are sought to increase the utility of cone penetrometer technology by developing new sensor technology (to expand the range of available measurements) or characterization devices that can work with the cone penetrometer.

d. Vadose Zone Monitoring Tools—Grant applications are sought for innovative technologies to assist in monitoring and characterizing contamination in the vadose zone (the region between the ground surface and the underlying water table) at DOE sites. The conventional approach has been to drill wells and monitor groundwater underlying the vadose zone. The problem with this approach is that serious contamination of the vadose zone can occur before the contaminants have migrated to the groundwater. Emphasis must be placed on direct monitoring of the vadose zone itself in order to stop the spread of contamination. At the DOE's Hanford Site, recent attention has been focused on the contamination in the vadose zone and groundwater beneath the site's single-shell high-level waste tanks. DOE has recognized a need to develop an effective site-wide strategy to assess the impacts of Hanford Site contaminants in the vadose zone There are significant uncertainties and data gaps in the current understanding of the inventory, distribution, and movement of contaminants. These data are essential for evaluating the impact of radioactive and hazardous releases to the environment. Monitoring tools that provide direct information on the nature and extent of contamination in the vadose zone are actively sought.

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http://www.cmst.org/
http://www.cmst.org/cmst/NewServer/rp.html

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http://ost.em.doe.gov/ifd/stcg/stcg.htm
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* See Section 7.1

20. WASTE TREATMENT AND STABILIZATION

Treatment technologies such as separation and processing technologies can remove radionuclides, hazardous materials, and unwanted chemicals from radioactive wastes, contaminated soils and groundwater, and waste streams resulting from the decontamination, deactivation and decommissioning of facilities. Separation and processing technologies can remove bulk inert materials from radioactive or hazardous waste streams, thereby reducing volumes or enabling more efficient subsequent separations and processing. Processing technologies such as stabilization/solidification/fixation can treat waste streams directly, or after appropriate separation, and produce environmentally stable and regulatory acceptable final waste forms.

Grant applications should identify separations, processing, stabilization, solidification, or fixation technologies which are selective for specific contaminants of interest; produce low-volume secondary waste streams; reduce total systems cost and risk, and provide high loading capacities, high separation factors, and simplicity of operation. Technologies having commercial potential outside the DOE are strongly encouraged, but all grant applications must target a specific DOE problem. In addition, sufficient detail must be provided about the proposed technology, as well as the baseline technology (for that specific problem), so that its advantages can be clearly evaluated. Of particular interest are technologies that can be applied where no alternative is currently available, offer a rapid deployment to meet DOE needs, and extract economic values from waste streams. In all cases, flexibility is important; e.g., a technology that addresses multiple contamination situations is preferable to one that addresses a single situation.

Applicants that do not have the facilities to perform research involving radioactive species should consider partnering with a research institution (e.g., a university or national laboratory) with these capabilities. Alternatively, grant applications will be considered in which an innovative separation or processing technology is demonstrated with a non-radioactive simulant; after further development, the approach must be applicable to radioactive species. **Grant applications are sought only in the following four subtopics:**

a. Separation of Contaminants from Liquid Waste Streams—Grant applications are sought for separation or enabling processes to remove contaminants from liquid waste streams. The main emphasis is placed on dilute aqueous streams, but other streams (such as concentrated aqueous streams or non-aqueous streams) will also be considered. Dilute aqueous streams include groundwater (from either *in situ* or pump and treat operations), streams arising from deactivation and decommissioning operations, and slightly acidic offgas scrubber solutions. Radionuclides and other materials under consideration include Resource

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Conservation and Recovery Act (RCRA) and heavy metals such as thorium, mercury, chromium (III and VI), lead, cadmium, and copper; RCRA organics; transuranic elements (TRU) such as neptunium, plutonium, americium and curium; long lived soluble fission products such as technetium (^{99}Tc) and iodine (^{129}I); and activation products such as carbon (^{14}C) and tritium (H). Separations and processing methods of interest could include the addition of complexants to the feed to adjust the effective selectivity of a sorbent during loading (in which case the repercussions of introducing the complexant must be considered). Of particular interest are technologies that can perform highly selective calcium/strontium separations for groundwater treatment and methods for the removal of complexed technetium (e.g., in radioactive tank waste applications).

b. Separation of Contaminants from Solid Waste Streams—Separation or enabling processes are needed to remove contaminants from solid waste streams. Solid wastes include sludges from defense reprocessing activities, solids such as metals and concrete from deactivation and decommissioning operations, excavated soils from environmental remediation activities, and fine solids and colloidal particulates in aqueous waste streams (solid/liquid separations). Highly radioactive sludges are typically metal oxides with large amounts of potentially soluble materials such as sodium or aluminum; in these, about 0.1 percent of the waste is radioactive. Grant applications are sought for the direct removal of the radioactive materials (e.g., selective leaching of transuranics and strontium) or for the removal of the bulk constituents (aluminum, sodium) to leave a smaller volume of high level waste. Technologies to treat hazardous, non-radioactive species are also sought (e.g., the selective oxidation of chromium species to chromium (VI) without concurrent oxidation of transuranics or organics). Methods of interest include bulk leaching, selective leaching with dissolution, and extraction.

In addition, soils at DOE facilities contain a wide variety of radioactive, toxic, and heavy metal contaminants. Some of the most common are uranium, technetium, trichloroethylene, and polychlorinated biphenyls. Grant applications are sought for reagents that can assist in the electrokinetic decontamination of these soils.

Lastly, grant applications are sought for high temperature and chemical methods to separate radionuclides and hazardous materials from calcined waste streams. Of particular interest are processes that separate species into concentrated product streams, that can withstand a radiolytic environment, that are economically viable, that can be scaled to processing rates of 2 to 30 gallons per minute, and that are simple to construct and operate.

c. Stabilization/Fixation/Solidification of Contaminants in Solid Wastes—Conventional approaches to contamination in solid waste involve either the processing of the solid to remove the problem species or the transportation and direct disposal of the waste. The former approach can involve significant processing costs if volumes are large and can produce secondary waste streams that incur further cleanup costs; the latter approach merely shifts the problem from one location to another, and can also involve significant cost and risk if volumes are large. In appropriate situations, stabilization or fixation technologies can offer cost and operational benefits over treatment--a complex waste stream that might require considerable treatment, with little reduction in volume or associated risk, may well be a candidate for a stabilization approach if an acceptable waste form results. Existing approaches include use of additives to produce appropriate waste forms (e.g., phosphates or sulfides, polymers, grouts, synthetic clays, and pozzolanic or cementitious materials), sintering, ceramification, organic polymer or sulfur polymer cement encapsulation, grouting, vitrification. Grant applications are sought for novel approaches that permit the cost effective stabilization or fixation of contaminants in solid wastes. Proposed technologies should supplement the toolbox of available treatment techniques and apply to any of the hazardous contaminants including radionuclides, metals, inorganics, or organics.

d. *In Situ* Treatment of RCRA Metals and Radionuclides in the Subsurface—The need for effective treatment technologies for metals and radionuclides in the subsurface is urgent. The DOE's Subsurface Contaminants Focus Area (SCFA) reported that 59 waste sites at 14 DOE facilities across the nation have been identified that exhibit radionuclide (primarily metals) contamination in excess of established limits. The rapid and efficient remediation of

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these sites and the areas surrounding them represent a technological challenge with no existing solution. The conventional approach of excavating and treating the solid matrix and/or removing groundwater contaminants by pump and treat methods can involve significant cost and produce problems such as secondary waste, additional risk due to removal of dispersed contaminants, need to determine final disposal, transportation concerns, etc. Therefore, grant applications are sought for innovative *in situ* technologies to reduce the risk and cost of remediating radionuclide and hazardous metal contamination in subsurface soils and groundwater. *In situ* treatment approaches such as stabilization or fixation can offer a route to overcome some of these problems. If the release rate of contaminants from the stabilized or treated waste is sufficiently low, the material may already satisfy environmental standards, or it may be allowed to remain in place pending decisions on ultimate disposition. If the material must be removed, then contamination control during removal may be less stringent. Approaches of interest include the manipulation of metal properties *in situ* by chemical, physical, biological, or thermal techniques. Enabling technologies (such as a pretreatment that will remove the highly mobile forms of the metal leaving the more strongly bound forms to be treated by a stabilization/fixation treatment technology) will also be considered.

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* See Section 7.1

PROGRAM AREA OVERVIEW - NUCLEAR ENERGY, SCIENCE AND TECHNOLOGY

http://www.ne.doe.gov

Continued use of nuclear power is an important part of the Department's strategy to provide for the Nation's energy security, as well as to be responsible stewards of the environment. Nuclear energy currently provides about 22 percent of U.S. electricity generation and will continue to provide a significant portion of U.S. electrical energy production for many years to come. Also, nuclear power plants in the U.S. make a significant contribution to lowering the emission of gases associated with global climate change.

The Office of Nuclear Energy, Science and Technology (NE) enables the Department of Energy to provide the technical leadership necessary to address critical domestic and international nuclear issues by administering research and development in four general program areas. In the Energy Resource area, activities include the development and demonstration of technologies that address critical issues associated with the continued safe operation of nuclear power plants, research and development to minimize spent fuel, and the management and sale of excess DOE-owned uranium. NE Science activities include the production of radioisotope thermoelectric generators and heaters for deep space missions, development of isotope technologies, and operation of research and test reactors. Environmental Quality activities include management of depleted uranium hexafluoride stored in cylinders at DOE sites and assessment of disposal options, deactivation of nuclear facilities, and development of advanced waste treatment technologies. Activities in the National Security area include providing power and propulsion systems for the Department of Defense, eliminating the production of weapons-grade plutonium in the former Soviet Union, converting weapons-grade uranium from dismantled Russian nuclear warheads to commercial-grade, and improving international nuclear safety by enhancing the design and safety of Soviet-designed plants.

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NE's SBIR activities for this solicitation focus on the development of approaches for utilization of the uranium in DOE's stockpile of depleted uranium hexafluoride.

21. TECHNOLOGY FOR TREATMENT, MANAGEMENT, AND DISPOSITION OF URANIUM HEXAFLUORIDE

The Office of Nuclear Energy, Science and Technology (NE) supports research and development that is critical to domestic and international nuclear issues. One area of major interest is the long-term management of depleted uranium hexafluoride (UF_6) currently stored in cylinders at DOE sites. A Programmatic Environmental Impact Statement has been prepared in accordance with the National Environmental Policy Act of 1969 to minimize the environmental impact and address the long-term storage of the depleted UF_6 material.

Depleted UF_6 material is a byproduct resulting from uranium (U235) enrichment that produces low enriched uranium for nuclear power electricity generation plants which currently provide about 22 percent of the U.S. electricity generation. Approximately 687,000 metric tons of depleted UF_6 have accumulated at the three gaseous diffusion plants located in Oak Ridge, Tennessee, Paducah, Kentucky, and Portsmouth, Ohio. The Department of Energy operated the plants from 1945 until July 1, 1993; consequently, DOE is responsible for all depleted UF_6 which accumulated before July 1, 1993.

DOE's depleted UF_6 contains less than 0.3 percent U235 fissile material and is stored as a solid in a partial vacuum in 10 to 14-ton steel cylinders, each about 12 ft long and 4 ft in diameter. 56,608 cylinders are currently distributed as follows: 34,884 at Paducah, 16,041 at Portsmouth, and 4,683 at Oak Ridge (K-25 Site). The cylinders are stacked two high, resting on concrete or wooden storage chocks, in outdoor gravel, asphalt, or concrete storage yards. The cylinders are regularly inspected, and corrective maintenance activities, such as restacking cylinders, replacement of wooden storage chocks (which prevent corrosion by ground water), and replacing or refurbishing cylinders, are performed as needed.

The goal of the Depleted UF_6 Management Program is to select and implement a long-term management strategy for DOE's depleted UF_6 inventory. This strategy includes converting the depleted UF_6 to two components (i.e., a stable uranium compound, such as an oxide or uranium alloy, and a fluoride compound) and implementing commercial uses of these components. Although several processes now exist for these conversions, additional technology development is needed for the fabrication and use of uranium-based materials in order to make the processes cost effective. Identifying beneficial uses of the products would not only contribute to this goal, but would also satisfy the Department mission and be in the public interest. **Grant applications are sought only in the following subtopics:**

a. Advanced Non-Aqueous Chemical Processes for Production of High-Value Fluorine Compounds—All approaches for utilization of the uranium in the stockpile of depleted uranium hexafluoride require treatment to produce either uranium metal or one of the oxides of uranium. The net costs of processes under consideration could be greatly reduced if the fluorine component of this resource could be captured in forms which are suitable for resale as high-value compounds of suitable purity and quantity. Grant applications are sought to identify non-aqueous chemical processes for production of high-value products from the fluorine component of the existing inventory of depleted uranium hexafluoride. In addition to potential improvements over existing processes for the production of anhydrous HF, applicants are encouraged to address direct production of fluorine compounds which either possess current market value or may be of significant commercial value in the future. As part of this effort, research to identify compounds of potential high value is expected. Compounds of potential interest include, but are not limited to: elemental fluorine, fluorocarbons, hydrogen fluoride, and the fluorides of Si, Al, Ni, Ag, and Cu.

b. Use of Uranium Compounds in Spent Fuel Storage—It has been proposed that materials made from depleted UF_6 would be suitable for use as a packing material in buried canisters for spent nuclear fuel. The depleted

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uranium would act as a radiation shield, allowing the safer manipulation of the waste as well as an increased lifetime of the storage canister. Also, an excess of depleted uranium in the canister would avoid criticality problems with the remnant fissionable U235. However, there are environmental uncertainties if the canister were breached and its contents exposed to groundwater. Would the fissile material remain immobilized even if the canister fails? Will the uranium compound surface adsorb solubilized radionuclides? To what degree will the uranium compounds solubilize? Physical properties important for maintaining canister integrity include adequate thermal conductivity and low thermal expansion.

To answer these questions, grant applications are sought to identify and characterize suitable uranium-based compositions for use as packing material in spent fuel storage. Grant applications must address the stability of suitable compounds in water. Information is required on dissolution rates, which species are solubilized, the dependence of solubility rates and products on temperature and radiation level, as well as the adsorption of radionuclides and other ions found in spent fuel and groundwater. Candidate materials should also exhibit thermal conductivity at least as great as that of air, and thermal expansion should not exceed that of, e.g., type 304 stainless steel.

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2. Fissile Materials Disposition Program:
http://www.ornl.gov/etd/FMDP/pdfs/13417.pdf

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* See Section 7.1

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PROGRAM AREA OVERVIEW - BIOLOGICAL AND ENVIRONMENTAL RESEARCH

http://www.er.doe.gov/production/ober/ober_top.html/

The Biological and Environmental Research (BER) program invests in peer-reviewed research at national laboratories, universities, and private institutions in order to develop the knowledge and resources needed to identify, understand, and mitigate the long-term health and environmental consequences of energy production, development, and use. The major objectives of the BER program are to contribute to a healthy citizenry, contribute to the cleanup of the environment, and understand global climate change.

To contribute to a healthy citizenry, BER supports fundamental research and technology development needed for mapping the fine structure of the human genome, which will provide the valuable information needed to identify disease genes and develop broad therapeutic and diagnostic strategies. BER projects also develop advanced imaging and other medical technologies, including highly sensitive radiotracer detectors, radiopharmaceuticals and boron compounds with affinities for tumors. In support of the nation's biomedical, pharmaceutical, and environmental activities, BER projects make use of unique facilities at the Department of Energy national laboratories to determine biological structure and how it relates to function at the molecular and cellular level.

To contribute to cleanup of the environment, BER supports fundamental research necessary for the development of advanced remediation tools for cleaning up DOE's contaminated sites, particularly in support of DOE's Office of Environmental Management.

To understand global environmental change, BER projects acquire the data and develop the understanding necessary to predict global and regional climate changes, which may be induced by increasing atmospheric concentrations of greenhouse gases.

22. ADVANCED ENVIRONMENTAL MONITORING TECHNOLOGY

Characterization and monitoring of the subsurface environment are important elements of Department of Energy (DOE) research efforts. Objectives include determining the fate and transport of wastes generated from past weapons production activities and from current energy production activities, evaluating the risks of energy-related contaminants to human health and ecosystems, and assessing and controlling processes to remediate contaminants. This topic is limited to new and innovative field-applicable technologies that advance monitoring capabilities in the subsurface, with groundwater the highest priority. These monitoring capabilities are needed at several scales of interest: the pore-scale (i.e., molecular to tens of microns scale), the core-scale (typically at the single digit meter scale), and the field-scale (typically greater than single digit meter scale).

Subtopics a and b focus on particular monitoring needs in the subsurface, while subtopics c and d focus on the development of particular types of sensors. Grant applications that address more than one subtopic should be submitted only to the most relevant. For all subtopics, the emphasis is on the development of rugged, field-capable, low-maintenance, autonomous sensors and equipment for the *in situ* monitoring of biological, geochemical, and hydrogeologic properties of natural and contaminated subsurface systems, and on the analysis of these subsurface systems using specific characterization techniques.

Grant applications must detail why and how proposed *in situ* field technologies will substantially improve the state-of-the-art and include bench tests to demonstrate the technology. Projected dates for likely operational field deployment must be clearly stated; new or advanced field technologies that can

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be deployed in 2-3 years will receive selection priority. Grant applications must describe, in the technical approach or work plan, the purpose and specific benefits of any proposed teaming arrangements with government laboratories or universities. Claims of commercial potential for proposed technologies must be supported by information such as endorsements from relevant industrial sectors, market analysis, or identification of commercial spin-offs. Grant applications that propose incremental improvements or enhancements to existing technologies are not of interest and will be declined, as will enhancements to predictive models. **Grant applications are sought only in the following subtopics:**

a. Contaminant Availability and Bioavailability—Contaminants in sediments and aquifer materials can cause human health and other ecological problems only if the contaminants are both available (able to escape from the media in which it is contained) and bioavailable (able to bind with human and other environmental receptors). Innovative treatment technologies such as bioremediation may not completely remove or immobilize all contamination from these sediments and groundwater, particularly if contaminants are strongly sorbed or sequestered in aged soils or sediments. Nonetheless, bioremediation may be effective in decreasing risk to an acceptable level if it causes a significant reduction in the availability or bioavailability of the residual contaminant fraction.

Grant applications are sought to develop methods and technologies for *in situ* use that will assist in determining the availability of contaminants in the saturated subsurface zone. In developing these methods and technologies, possible approaches might include: (1) determining characteristics and rates of contaminant leaching, desorption, and/or transport, (2) simulation and testing of natural leaching conditions, and (3) accounting for the impact of intrinsic bioremediation on contaminant leaching to, and transport in, groundwater.

Grant applications are also sought to develop field methods, processes, materials, or equipment for *in situ* use that will assist in determining the bioavailability of solid phase-bound contaminants to indigenous or introduced microorganisms. Media of interest include contaminated sediments and groundwater.

Grant applications must address organic or inorganic contaminants of concern at DOE sites; priority will be given to technologies that apply to complex metal/radionuclide mixtures. Grant applications must demonstrate substantial improvements over existing capabilities and these improvements must be described quantitatively and in detail. Minor adaptations of existing methods, processes, materials, or equipment will not be considered responsive and will be declined. Although proposed technologies must be able to determine contaminant availability in a rapid, cost-effective, and reproducible manner, applicants should recognize that successful commercialization may ultimately require endorsements from regulatory agencies.

b. Bioremediation Analysis—Subsurface remediation technologies have expanded steadily and improved over the last decade. Soil washing, bioremediation, chemical treatment, and thermal treatment have grown by over 40 percent in the past 15 years. However, the effectiveness of bioremediation cannot be assessed *in situ* during and following bioremediation because of a lack of sensing and process-control techniques, and because of the difficulty of obtaining uncompromised microbiological samples from subsurface sediment cores. Grant applications are sought to develop the following technologies to support accelerated bioremediation in the field: (1) innovative methods, processes, and/or equipment for *in situ* assessment of field-scale bioremediation processes (e.g., to determine the effectiveness of microbial biotransformation and biodegradation rates), and for the determination of alterations in microbial community populations and structure; (2) field deployable methods, including data display techniques or three-dimensional imaging equipment, that precisely determine and display *in situ* physical, chemical, and microbiological processes from geologically-distinct subsurface environments; and (3) new and innovative bacterial cell tracking methods to provide real time tracking capability of microorganisms injected into the subsurface.

For (1) and (2) above, priority will be given to grant applications that utilize uncompromised core samples. For all three, grant applications that offer minor adaptations of

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readily available materials or approaches, or which are not relevant to field application and deployment, will not be considered responsive and will be declined.

c. Biosensors and Genetic Probes for Subsurface Measurements—Many new technologies in biomolecular and gene probe-based assessment have been created in the laboratory; yet, beyond the clinical environment, few have reached the standardized, instrumented, or automated state required for applications in the field. Grant applications are sought to develop: (1) robust but sensitive biosensor devices (devices employing biological molecules or systems in the sensing elements), or critical technologies for them, that can be used for *in situ* monitoring of subsurface processes or parameters. Biosensor systems may incorporate, but are not limited to, whole cells, enzyme or immunologically-linked detection systems, membrane lipids, or DNA/RNA probe technology with amplification and hybridization; (2) integrated biosensing and controller/signal processing systems for autonomous or unattended measurement applications; and (3) new nucleic acid probes/primers for detecting specific microorganisms useful in subsurface contaminant remediation. In detecting these microorganisms, the probes/primers may target either the genes themselves or the level of expression of the genes. The environmental significance of the microorganism must be described and related to DOE's subsurface remediation needs, and the targeted level of discrimination (i.e., genera, species, or subspecies) must be rationalized.

Grant applications must address the environmental significance of the process or parameter to be monitored by the biosensor or genetic probe. For applications such as bioremediation of hazardous waste sites and waste-water analysis, there is a need for sensitive, accurate, and real-time monitoring of biological organisms in the environment. A specific need is the ability to monitor the spatial arrangement, physiological status, and taxonomy of microorganisms. Priority will be given to those applications that address techniques for *in situ* use, particularly at the pore- and core-scale in the subsurface environment. Minor adaptations of readily available materials or hardware for these uses are not of interest and will be declined.

d. Fiber Optic, Solid-State Chemical, and Silicon Micro-Machined Sensors for Subsurface Measurements—Fiber optic sensors offer several advantages over conventional sensors including inherently high sensitivity, large dynamic range, intrinsic immunity to electromagnetic interference, geometric flexibility, and light weight. Solid-state chemical sensors and silicon micro-machined sensors also offer several advantages over conventional sensors due to their small size, relatively low cost in production quantities, linearity, and rapid response time. The benefits of deploying these small-scale monitoring devices in the subsurface include the low cost of field deployment in remote locations and an enhanced ability to monitor processes at finer levels of resolution. Grant applications are sought to develop: (1) robust but sensitive fiber optic, solid-state chemical, or silicon micro-machined sensors or sensor arrays, or critical technologies for them, for field-monitoring of pore- and core-scale subsurface environmental processes or parameters; and (2) integrated sensing and microprocessor/signal processing systems for autonomous or unattended subsurface biogeochemical measurement applications that use fiber optic, solid-state chemical, or silicon micro-machined sensors (either a single sensor or a suite of sensors).

Sensors and systems proposed must be able to detect hydrogeological and biogeochemical processes that control the transport, dispersion and transformation of contaminants in the subsurface environment, with priority to groundwater systems. Needs include the ability to measure mass-transfer processes and rates within and among individual pores in the subsurface. Innovative integration of components (such as micro-machined pumps, valves, and micro-sensors) into a complete sensor package with field application in the subsurface will be considered responsive to this subtopic. Substantial progress has been made in fiber optics and chemical sensing technology in the last decade; minor adaptations of readily available materials or hardware for subsurface biogeochemical analysis use, and grant applications that can not demonstrate substantial improvements over the current state-of-the-art, will not be considered responsive.

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* See Section 7.1

23. ATMOSPHERIC MEASUREMENT AND SAMPLING TECHNOLOGY

World-wide energy production is modifying the chemical composition of the atmosphere and is linked with environmental degradation and human health problems. The radiative transfer properties of the atmosphere may be changing as well. Various technological developments are needed for high accuracy and/or long term monitoring of these changes to support a strategy of sustainable and pollution-free energy development for the future. The following subtopics focus on these needs. Subtopics a and b concern the development of launch and sensor systems, respectively, for balloon sondes. Subtopics c and d concern the development of new radiometric and reflectance measurements.

Grant applications must propose Phase I bench tests of critical technologies. Critical technologies are those components, materials, equipment, or processes that significantly limit current capabilities in the specific subtopic area. For example, grant applications proposing only computer modeling without physical testing will be considered non-responsive. Grant applications should also describe the purpose and benefits of any proposed teaming arrangements with government laboratories or universities in the technical approach or work plan. Applications for all subtopics should support claims of commercial potential for proposed technologies, (e.g., endorsements from relevant industrial sectors, market analysis, or identification of potential spin-offs). **Grant applications are sought only in the following subtopics:**

a. Automatic Launcher System for Balloon Sondes—A cost-effective capability is needed to launch a series of balloons with sensors over periods of time, i.e., a day or days, at unattended locations. Grant applications are sought to develop a balloon launch system for unattended operations with a capability to launch a minimum of eight sondes in succession, acquire the data from each flight, and make the data available for network data transfer to a centralized data acquisition facility. Grant applications that make only incremental improvements to existing technologies will be declined.

b. High Accuracy Sensors for Routine Balloon-Borne Measurements of Atmospheric Thermodynamic Properties—High accuracy measurements of atmospheric parameters, particularly water vapor, are required from balloon-borne, disposable, lightweight, low cost, high precision instruments to support atmospheric and climate research. Grant applications are sought to develop sensors for balloon-borne, high accuracy measurements of wind velocities and direction, temperature, pressure, and water vapor concentrations from point of launch to at least 20 km altitude. The sensors must achieve one percent accuracy with high resolution, low cost, and be contained in a light-weight package. For winds, temperature, and pressure, these requirements represent modest improvements over current systems. However, for the water vapor sensor, which is of primary interest, a fundamentally new approach is required to provide high accuracy measurements up to very high altitudes, low water vapor concentrations, and temperatures down to at least minus 60 degrees centigrade. One percent accuracy with high time resolution is desired for relative humidities near 100 percent at minus 60 degrees.

Although this subtopic focuses on the development of new water vapor sensors, integration into a lightweight, cheap, and environmentally sound sensor package must also be demonstrated. The total sensor package must be expendable, must not exceed the current radiosonde weight of about eight ounces, and must meet Federal Aviation Administration requirements. Sensors must recover quickly from possible wetting by clouds and rain. Utilization of the Global

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Positioning System is required for navigation, if necessary. Reflecting the large number of launches desired, a total unit cost near that of current sondes is desired. Grant applications that make only incremental improvements to existing technologies will be declined.

c. Radiometric Instrumentation—Measurements of shortwave solar radiation (0.3 to 3.0 micrometers) and thermal radiation (3 to 100 micrometers) provide necessary information about the chemical and physical state of the atmosphere and earth's surface. Current broadband solar instruments include pyranometers, pyreheliometers and shadowband radiometers while solar spectral instruments include scanning filter photometers, shadowband radiometers, and spectroradiometers. Thermal instruments include broadband infrared radiometers, interferometers, and grating spectrometers. Grant applications are solicited to develop radiometric instrumentation or radiometer components that: (1) improve current performance of broadband shortwave radiometers (e.g., it is desirable to achieve consistent one percent accuracy by eliminating the need for domed covers and/or other sources of uncertainty such as angle of incidence, temperature, pressure, and humidity effects on detectors, optical components, and windows); (2) significantly reduce drift, poor angular response, dome and window contamination (e.g., dust and water) errors, nighttime offsets, thermal imbalance errors, leveling sensitivity or other sources of error; (3) significantly reduce the cost of ancillary equipment such as solar seekers and trackers without degrading performance; or (4) extend the range of low-cost spectral instrumentation into the ultraviolet B spectrum (0.28 to 0.32 micrometers) and near infrared (2 to 50 micrometers) regions. Applicants may focus on critical components and ancillary equipment for radiometers including detectors, radiation standards and calibration methods, filter systems and monochromators, and solar tracker/seekers. Applications that make only incremental improvements to existing radiometric devices will be declined.

d. Surface Optical Reflectance Meter—Grant applications are sought for cost-effective measurements of the surface reflectance of solar radiation in selected narrow wavelength bands in order to provide "ground truth" for observations from satellites and for continuous radiometric observations of surface conditions. The narrow wavebands must include those used on channels 1 and 2 of Advanced Very High Resolution Radiometers and should anticipate the existence of wavebands in more sophisticated, future satellite radiometers. The fields of view must include those for hemispherical sensing of downwelling radiation, a fairly broad view pointing downward, and selected fairly narrow views at a 3-4 azimuths and 1-2 elevations angles. The system must be durable and is intended for multi-year outdoor operation. The sensitivities and responses of the sensors and optical filters drift must be less than 2 percent over a two-year period in the field environment. The sensing head must be lightweight so that it can be installed on standard 10-m meteorological masts. The option of data logging in an environmental chamber is required.

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24. CARBON CYCLE MEASUREMENTS OF THE ATMOSPHERE AND THE BIOSPHERE

Eighty-five percent of our nation's energy results from the burning of fossil fuels from vast reservoirs of coal, oil, and natural gas. These processes add carbon to the atmosphere, principally in the form of carbon dioxide (CO_2). It is important to understand the fate of this excess CO_2 in the global carbon cycle in order to assess the terrestrial ecosystem response, the sensitivity of climate, and the potential for sequestration in natural carbon sinks of lands and oceans. There is increasing national and international interest in finding natural mechanisms to mitigate the current atmospheric rise in CO_2 levels, and the Department of Energy is focusing increasing attention on novel approaches for carbon sequestration. Therefore, improved measurement approaches are needed to quantify carbon changes in components of the global carbon cycle, particularly the terrestrial biosphere which offers the potential for future carbon sequestration. New and innovative methods of measuring intrinsic carbon quantities are also needed. This topic seeks sensor technology and measurement approaches for detecting changes of carbon quantities of terrestrial (including biotic, microbial, and soil components) and atmospheric media.

Grant applications should demonstrate performance characteristics of proposed measurement systems, and show a capability for deployment at field scales ranging from experimental plot size (meters to hectares) to areal extents of ecosystems (hectares to square kilometers). In addition, Phase I must perform feasibility and/or field tests of proposed measurement systems to assure high degree of reliability and robustness. Combinations of remote and *in situ* approaches will be considered. **Grant applications are sought only in the following subtopics:**

a. Sensors for Measurements of Terrestrial Carbon Sinks and Sources—Measurement technology is required to quantify carbon sequestration by natural vegetation and ecosystems (i.e., carbon sinks) as well as CO_2 emissions to the atmosphere from natural or industrial sources. Grant applications are sought to develop remote, ground-based sensors (and associated system technology, if appropriate) to detect and quantify annual net carbon changes of terrestrial vegetation for large areas, or to measure and verify the magnitude of CO_2 emissions from various sources. For the measurement of CO_2 sinks, the sensor system must be applicable for forests, grasslands, shrub lands, agricultural lands, and wetlands and have the capability of producing spatially resolved aggregate estimates of terrestrial carbon changes to an accuracy of 10 to 25 $g/m^2/yr$ (or approximately 0.25 tonnes of carbon per hectare per year), with less than 25 percent uncertainty. For measuring emissions, the sensor system must be located at a point remote from the actual site of CO_2 release and provide an accuracy of approximately 0.5 ppm or less.

For both source and sink measurements, information must be provided on the accuracy (e.g., in percent of emissions and tonnes per day) of the apparatus proposed. The sensor system must be durable in the full range of normal environmental conditions and exposures including exposure to dust, rain, snow, heat, extreme cold, and fog. Operation in unattended, remote locations for weeks at a time, without degradation of the measurement, is also required; however, daily communication with the system for monitoring performance and detecting potential operational problems would be desirable.

The interest is in measurement systems which are different from, or which substantially augment, existing eddy flux (covariance) and routine monitoring of atmospheric CO_2 concentrations. In particular, grant applications proposing *in situ* or in-stream measurement of flue gas emissions will be declined, as will applications that offer only incremental or marginal improvements to existing measurement systems.

b. Novel Measurements of Organic Substances in Terrestrial and Atmospheric Media—Grant applications are sought to quantify volatile organic compounds (VOC) in the atmosphere, organic matter in soils and other solid substrates, and the carbon content of biological tissues in various components (e.g., phytomoss, detritus) of terrestrial ecosystems. These measurements are needed to better

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characterize processes involving carbon transformations of soil, vegetation, and associated ecosystem components and exchanges with the atmosphere. For VOC measurements, grant applications must demonstrate that the measurements will contribute to quantification of fluxes of major photochemically reactive compounds applicable to ecological research and air quality monitoring. For measurements involving the quantification of organic matter and the carbon content of biological tissues, grant applications must demonstrate applicability to studies of changing carbon quantities and/or fluxes involving major components of ecosystems, as well as an accuracy on the order of 10 grams per square meter or less. Quantification of spatially resolved aggregate estimates of terrestrial carbon changes should have an accuracy of 10 to 25 $g/m^2/yr$ (or approximately 0.25 tonnes of carbon per hectare per year), with less than 25 percent uncertainty.

Proposed new measurements must be accomplished by *in situ* and/or non-invasive means and/or remote sensing of organic carbon forms across a range of both temporal scales (from seconds to days) and spatial scales (from millimeters to kilometers), depending on the system being observed. Instruments must be portable and deployable in remote locations, and must not adversely impact the site of deployment.

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25. MEDICAL APPLICATIONS

The DOE Medical Applications program covers a broad range of energy-related technologies including nuclear medicine research. DOE is interested in innovative research involving nuclear medicine technologies to facilitate and advance the current state of diagnosis and treatment of human disorders. Current areas of research in nuclear medicine focus on the development of: (1) radiolabeled molecular probes as radiotracers to study *in vivo* chemistry, metabolism, cell communication, and gene expression in

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normal and disease states; (2) new radionuclide-imaging systems; and (3) new boron-labeled compounds targeted for use in neutron capture therapy of cancer. **Grant applications are sought only in the following subtopics:**

a. Radiotracer Development and Molecular Radiopharmaceutical Therapy Compound Development Technologies—Grant applications are sought for the development of: (1) radiolabeled compounds that could have applications as radiotracers for radionuclide imaging technologies such as single photon emission computed tomography and positron emission tomography; and (2) radiopharmaceuticals for targeted molecular therapy. Radiochemical, synthetic, and molecular approaches should be given consideration in developing molecular medicine technologies capable of providing a product for nuclear medicine use.

b. Boron Neutron Capture Therapy Compound Development—Grant applications are sought for boron-labeled compounds that are capable of concentrating in tumor cells *in vivo* and delivering lethal radiation after neutron irradiation.

c. Advanced Imaging Technologies—Grant applications are sought for new, sensitive, high resolution instrumentation for radionuclide imaging, which advances the application of radiotracer methodologies for imaging molecular biology, including cell communication and gene expression *in vivo*. Areas of interest include development of new detector materials, detector arrays for three-dimensional imaging, software development for rapid data processing, and image reconstruction.

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26. GENOME, STRUCTURAL BIOLOGY, AND RELATED BIOTECHNOLOGIES

The Department of Energy (DOE) supports research to acquire a fundamental understanding of biological and environmental processes. This research includes the characterization of genomes and gene products from humans and other organisms; structural biology research using beamlines at synchrotron sources and other facilities; as well as studies in computational structural biology, computational genomics, and biological information systems. Knowledge gained in this research is used to exploit genomic information, determine the structure of biological macromolecules, integrate advances in computational and mathematical sciences into biology, understand protein folding mechanisms, and clarify the relationships between genes, gene product structures, and biological function. Such knowledge should enable the public and private sector to: (1) markedly improve human health care and promote worker and public safety; (2) promote application of DNA-based biotechnology to environmental applications, like bioremediation; (3) facilitate the isolation, characterization,

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and treatment of factors involved in human diseases and disorders; and (4) promote cleaner industrial processes using biotechnology. Close interactions with one of the DOE laboratories or projects can be beneficial in the development of a grant application. **Grant applications are sought only in the following subtopics:**

a. Technologies that Support DNA Sequencing and DNA-Based Diagnostics—Increased use is being made of DNA sequencing in biotechnology, microbiology, medical applications, and environmental applications. Grant applications are sought for improvements in DNA sequencing technologies so that an already-determined DNA sequence from one species (e.g., of microbe) could be used to determine the homologous sequence from a taxonomically-related species. Applications are sought that could exploit this approach for polymorphism detection in human DNA sequences. Applications must significantly improve, integrate, or automate steps associated with large-scale DNA sequencing or DNA-based screening. Developments might include: 1) improved approaches to comparative sequencing; 2) determination and mapping of sequence variations or polymorphisms between homologous genomic regions from humans, or related species of environmental microorganisms; 3) automation of handling and processing of the results from DNA sequencing instruments.

b. DNA Mapping Methods for Chromosome Analysis—DNA optical mapping and DNA fibre FISH (fluorescence *in situ* hybridization) are two emerging technologies for genomic analyses. They support annotation of genomes and/or chromosomes with sequence based markers at kilobase resolutions, while retaining long range DNA continuity information. This annotation is useful for clarifying the chromosomal constituents of a species, intrachromosomal structure analysis, and quality control of the algorithmic assembly processes of DNA sequencing. Grant applications are sought to further develop or to transfer these technologies to interested customers. Biochemical, instrumental, and computational analyses are all considered relevant. Grant applications for novel technologies (in addition to DNA optical mapping and DNA fibre FISH) which will achieve the same objectives will also be considered.

c. Understanding and Detecting Gene Expression and Gene Function—Considerable activity is already underway to market technologies which involve microarrays of DNA oligonucleotides for polymorphism detection, resequencing, and DNA-based diagnostics. Grant applications are sought for comparable protein arraying technologies that can potentially be used to assess bio-active molecules to monitor metabolic status, biochemical processes, or exposure to external materials. Areas of interest include the development of microarrays of uncharacterized gene products (for functional analysis), microarrays of gene products to assess interactions with other biomolecules (including nucleic acids), or microarrays of gene products to assess physiological states. Grant applications should include discussions of how output signals or data will be processed so that successful microarray technologies could potentially be incorporated into automated systems.

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6. National Institute of Health
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http://www.ncbi.nlm.nih.gov

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W.M. Keck Laboratory for Biomolecular Imaging
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http://www.nyu.edu/projects/genomics/omm.html

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The Nucleic Acid Database
http://ndbserver.rutgers.edu/NDB/ndb.html

PROGRAM AREA OVERVIEW - BASIC ENERGY SCIENCES

http://www.er.doe.gov/production/bes

The Basic Energy Sciences (BES) program supports fundamental research in the natural sciences leading to new and improved energy technologies. The program's purpose is to create new scientific knowledge by supporting basic, peer-reviewed research in areas of materials sciences, chemical sciences, geosciences, plant and microbial biosciences, and engineering sciences that are relevant to energy resources, production, conversion, and efficiency. The results of BES-supported research are routinely published in the open literature.

A key function of the program is to plan, construct, and operate premier national user facilities to serve researchers at universities, national laboratories, and industrial laboratories, thus enabling the acquisition of new knowledge that cannot be obtained in any other way. The scientific facilities include synchrotron radiation light sources, high-flux neutron sources, electron-beam microcharacterization centers, and specialized facilities such as the Combustion Research Facility. These national resources are available free of charge to all researchers based on the quality and importance of proposed nonpropriety experiments.

A major objective of the BES program is to promote the transfer of the results of our basic research to advance and create technologies important to Department of Energy (DOE) missions in areas of energy efficiency, renewable energy resources, improved use of fossil fuels, mitigation of the adverse impacts of energy production and use, and future fusion energy sources. The following set of technical topics represents one important mechanism by which the BES program augments its system of university and laboratory research programs and integrates basic science, applied research, and development activities within the DOE.

27. HIGH-DENSITY, MULTIGENE ASSAY OF GENETIC INFORMATION IN PLANTS AND NON-MEDICAL MICROBES

Although photosynthetic plants and bacteria normally produce large amounts of only a few storage reserves, such as starch and oils, they are capable of synthesizing a broad range of chemicals. Gene expression studies at the multigene level could reveal how the network of metabolic pathways might be manipulated so that the organism acts to influence environmentally sensible energy conservation and production (e.g., by accumulating high-value chemical feedstocks and biofuels or by synthesizng useful biomass-related compounds). Recent developments in large scale genome sequencing now allow an ever increasing number of genes to be identified, isolated, and characterized, and the resulting data can be used to survey and monitor the presence and expression of multiple genes.

For example, nucleic acid hybridization assays (a well-established approach for analyzing genes and gene expression) have been developed as a high density array

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technology (a nanotechnology) by attaching orderly arrays of thousands of different probes (i.e., reference molecules--short oligonucleotides or longer length gene segments of DNA) to a microscope slide. The resulting "DNA-chip" or "gene-chip," as such reference slides are now being called, can be used to identify a series of multiple genes that occur in a sample of DNA, or messenger RNA, by hybridizing the sample against the chip. Fluorescent tags and sophisticated microscopic and computer-based techniques are used to detect the specific molecular hybridizations that occur between probes attached to the chip and corresponding molecules in the sample.

Such DNA-chips are one example of the advantage of miniaturizing assays to increase data analysis, reduce the cost per test with cheaper disposable devices, and achieve high sample throughput. They promise to provide an effective and more economical way to simultaneously identify and track the presence or activity of multiple genes. Such high density arrays could be designed for a variety of specific assay purposes and have the potential to enormously speed studies in gene identification, gene expression, and gene function (references 1-7, 9-11). In addition to DNA-chips, other gene assay techniques (e.g., arrays of nucleic acid primers for the polymerase chain reaction) may also accomplish these objectives (references 8, 12). **Grant applications are sought only in the following subtopic:**

a. High-Density, Multigene Assay Systems—Grant applications are sought to create high density, multigene assay systems, specifically for tests on plants and non-medical microbes, in order to develop genetic information that could be used to influence some important aspect of the national energy picture. The effort must not only demonstrate proof-of-concept but also demonstrate how the particular genes assayed would be manipulated to significantly impact an energy relevant system. Grant applications must also address: (1) the novelty and utility of the probes themselves (i.e., the series of short oligonucleotides or longer gene-length segments to be assayed), (2) the ability of either the chip design or other high-density array to utilize the available genomic sequence data, (3) how data generated from the high density array will be handled and analyzed (e.g., the informatics), (4) the significance of the approach to plant and microbial research as well as to the related energy advantage, and (5) the outlook for economic benefits. Grant applications that focus only on engineering incremental improvements in instruments used to create the high-density array are not of interest and will be declined.

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28. METAL FORMING

Metal forming operations are among the most common materials processing steps in industry, both for the production of semi-finished products and for the manufacturing of consumer goods and military hardware. Expenditures for capital investment in plant equipment and for operation costs are enormous. In addition, these processes are extremely energy intensive. Major technological changes are on the horizon which will require significant advances in the science and technology of metal forming.

Note: The Materials Sciences Division of the Office of Basic Energy Sciences supports the DOE Center of Excellence for the Synthesis and Processing of Advanced Materials. This is a virtual center, with members distributed throughout many research institutions, including the DOE national laboratories. The Center's project on Metal Forming contributed to the subject matter of this topic. Potential applicants requiring further clarification of this topic should contact:

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Depending on the nature of the proposed research, potential applicants to this topic may want to consider taking advantage of the availability of one of the DOE user facilities. For more information, see section 1.6.2 of this solicitation. **Grant applications are sought only in the following subtopics:**

a. Semi-Solid Forming—Semi-solid forming consists of heating an alloy into the two-phase, liquid-solid regime where both solid consistency and easy formability (using either casting or forging) are possible. The advantage of semi-solid casting is less shrinkage (voiding) and lower casting temperatures, which allow for less die wear, fewer defects, and near-net-shape. Forging can be accomplished at much lower stresses without losing the "consistency" of a solid. Previous research indicates that semi-solid forming will be effective when the solid-phase morphology is spherical rather than dendritic. Traditionally, this has been accomplished by electromagnetic stirring. Grant applications are sought to develop alternative semi-solid forming techniques that can reduce the costs associated with producing and forming alloys, while improving material properties.

b. Economical Superplastic Forming—Superplasticity is usually described as high tensile ductility of a material (greater than 600%), leading to very favorable forming characteristics. Although superplastically formed parts are now commercially available, particularly in the aerospace industry, widespread application has not occurred -- most likely due to the relatively high cost of superplastic forming. The expense is associated with both the thermal and mechanical processing (needed to produce a refined grain size that will lead to superplastic formability) and the relatively long time required for the superplastic forming step. The time requirement is lengthy because the

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superplastic deformation that leads to high tensile ductilities is usually only observed at low strain rates. Grant applications are sought to employ one of two strategies for bringing superplastic forming into more widespread use: (1) developing new alloys or processing techniques that would lower the costs associated with thermal and mechanical processing, and (2) utilizing alloys (which have recently been discovered) that can be formed superplastically at relatively high rates of strain. One area of interest is the development of methods to produce fine-grain superplastic aluminum alloys for a variety of applications, including automotive parts.

c. Alternative Metal Forming—Alternative processes may also be candidates to replace conventional metal forming practices. Grant applications are sought to develop novel metal forming processes (other than semi-solid and superplastic forming) which utilize rapid prototype techniques, powders, sprays (both liquid and solid), or plasmas.

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29. PROCESSING FOR SURFACE HARDNESS

There exists a broad range of applications for which the ability to produce an adherent, hard, thin, wear-resistant coating plays a vital role. For applications such as engine and machine components, hardened surfaces can mitigate the effects of corrosion, a major source of energy loss for the economy. Other applications include orthopedic devices, textile manufacturing components, hard disk media, micro-machined sensors and actuators, optical coatings, and cutting and machining tools. This topic addresses the development and improvement of surface hardening processes which are environmentally benign and which provide flexible control over the surface structure and chemistry.

Note: The Materials Sciences Division of the Office of Basic Energy Sciences supports the DOE Center of Excellence for the Synthesis and Processing of Advanced Materials. This is a virtual center, with members distributed throughout many research institutions, including the DOE national laboratories. The Center's project on Processing for Surface Hardness contributed to the subject matter of this topic. Potential applicants requiring further clarification of this topic should contact:

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Depending on the nature of the proposed research, potential applicants to this topic may want to consider taking advantage of the availability of one of the DOE user facilities. For more information, see section 1.6.2 of this solicitation. **Grant applications are sought only in the following subtopics:**

a. Development of Ultra-Hard Thin Film Materials—Grant applications are sought to develop equipment and processes for producing novel ultra-hard, thin layers of hard carbon- and boron-based materials for tribological applications. Proposed projects must include the production and characterization of materials with high hardness (>30 GPa), high density, low friction and roughness, good adhesion, and the prospect of economical scale-up over large areas. Grant applications dealing with paints or thermal spray coatings are not of interest and will be declined.

b. Conformal Plasma Surface Hardening of Materials—Grant applications are sought to develop unique conformal plasma-based surface modification techniques and demonstrate processing and characterization for the surface hardening of at least one candidate tribological material (i.e., polymers, metals, and ceramics). Designs and processes must be conformal to nonplanar surfaces and must incorporate all components of a useful surface modification process (surface cleaning or etching, ion implantation, and plasma-based thin film deposition) at ion energies within the entire range from tens of eV to 50 keV in a single chamber. Semiconductor materials are not of interest and will be declined. Also, line-of-sight plasma-based processes will not be considered.

c. Novel Modeling and Characterization Techniques for Tribological Properties of Ultra-Hard Thin Films—Currently, static tests, such as nanoindentation, are widely used to assess the film quality of hard coatings. However, an understanding of the deformation process itself is important for the proper analysis of the nanoindentation process, especially on multi-layer structures of ultra-hard materials. In addition, dynamic tribological properties are also of interest at the nanoscale. Therefore, grant applications are sought to develop modeling processes for static or dynamic nanoindentation behavior on ultra-hard materials (>30 GPa) and demonstrate applicability to testing equipment for characterizing dynamic thin film behavior at the nanoscale (below 1 micron). Of particular interest are such parameters as scratch loading and adhesion.

d. High-Flux, Large-Area, Low-Energy Ion Source—While there has been much activity in the development of large-area (200 mm diameter), low energy ion processing equipment, particularly for etching applications, there is a particular need to apply this technology to the generation of hard, thin films. Grant applications are sought to develop new ion processing hardware and associated processing strategies for the production of tribological thin films. The process must feature low energy ions (below 200 eV) and be capable of generating high uniform fluxes (at least 1 milliamp per square centimeter with a 5 percent uniformity) over large areas (at least 200 mm in diameter).

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30. MATERIALS JOINING

Joining is a critical, enabling technology in many industrial sectors (e.g., automotive, petro-chemical, electronic and power generation) that has problems of concern to the Department of Energy. Examples range from welding two large structural components together for a nuclear or fossil power plant to making the smallest possible solder joint for high density integrated circuits. Joining is not only necessary to this wide range of technological endeavors, but the reliability of joints is often the limiting factor in the performance of the overall system. A graphic example was seen in the early 1980's, when a number of nuclear reactors came perilously close to shutting down due to intergranular stress corrosion cracks in primary water cooling piping. Not as publicly visible, but equally significant, is the fact that the absence of reliable techniques to join ceramic materials to themselves and to metals precludes the assembly of some structures (gas turbines, thermoelectric devices, etc.) that might otherwise realize the improved high-temperature performance that exists within the separate components.

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Depending on the nature of the proposed research, potential applicants to this topic may want to consider taking advantage of the availability of one of the DOE user facilities. For more information, see section 1.6.2 of this solicitation. **Grant applications are sought only in the following subtopics:**

a. Friction Stir Welding—Friction stir welding (FSW) is a newly developed solid state joining process which shows excellent potential for fabricating butt and lap joints in sheet and plate material. It uses no filler metal, avoids cracking problems in hard-to-weld materials, and gives very little post-weld distortion. The weld is formed by a rotating shoulder-shaped tool which generates sufficient heat and force to move plasticized material to the rear of the joint, creating a dense, porosity-free weld zone. If too much heat is generated, the tool itself may melt or deform. As a result, the process can only be used with low-melting-temperature alloys such as aluminum; the tool steels presently used to produce welds in aluminum alloys cannot be used to weld higher melting point alloys. Grant applications are sought for innovative approaches to applying the FSW process to materials other than aluminum. One possible approach is to develop a model for the FSW process which predicts important parameters (e.g., temperature and strain distributions, residual stresses) in the tool, weld, and base materials as a function of the materials used and the tool geometry. The model could be used to suggest combinations of tool materials and geometries which would produce viable welds of higher melting point alloys. Where appropriate, experimental verification of the model should be performed.

b. Joining of Vanadium Alloys—Certain vanadium alloys like V-5Cr-5Ti wt% not only have good mechanical/structural properties but also offer advantage in fusion power reactor environments (i.e., low activation potential by deuterium-tritium, excellent chemical compatibility with liquid lithium). Building structures from vanadium alloys would be greatly facilitated by the development of joining technologies such as welding and brazing. Grant applications are sought for innovative approaches to joining components made of vanadium and vanadium alloys to dissimilar materials, including ceramics and other structural alloys such as austenitic stainless steels. Proposed efforts should include a determination of relevant microstructure-mechanical property relationships, including

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the relationship between joining process parameters, microstructure, and mechanical properties. Commercially viable joining processes should be identified and evaluated so that those of greatest promise and utility can be further pursued.

c. Materials for High-Temperature, High-Toughness Joints Between Ceramics and Similar or Dissimilar Materials—In order to more fully realize the advantages of ceramic materials in critical high-temperature structural applications, grant applications are sought to develop improved joining materials and material combinations for both oxide (e.g. Al_2O_3) and non-oxide (e.g. Si_3N_4 and SiC) ceramics, including oxide and non-oxide ceramic composites (e.g., fiber-reinforced ceramic composites), joined either to each other or to metals/alloys. Examples of possible approaches include "expansion-matched" materials (that allow joints to accommodate large residual stresses due to thermal expansion differences) and self-reinforced joining materials (produced by reactive joining methods or other techniques). Joints must be capable of service temperatures exceeding 1000°C, possess good mechanical strength, and have a fracture toughness comparable to or greater than the materials to be joined. For example, in joining fiber-reinforced ceramic composites, joints with high fracture toughness would allow the overall structural design to take full advantage of the composite properties; joints containing extremely brittle intermetallic phases would be less than optimal. In addition, all joints must possess adequate oxidation and corrosion resistance so that the joined component is not compromised in that regard. Grant applications should also address the mechanical and structural characterization of the joint and the methods used for characterization.

d. Advanced Processing Techniques for Dissimilar Materials Joining—Grant applications are sought to develop advanced processing science and technology for the synthesis of joints between ceramics and similar or dissimilar materials. Processing methods of interest include advanced powder processing methods, use of pre-ceramic polymers with reactive metal fillers, liquid infiltration, innovative heating methods for local heating of the joint only, and reactive sintering methods. Of particular interest are advanced joining methods that can be used in the field and in repair situations, where the environment would be less well controlled than in a laboratory. In these situations, the joining process should result in very clean (uncontaminated) joints that are easy to apply, and applicability to the joining of buried interfaces should also be addressed. The use of new materials and material combinations is encouraged. Grant applications should also address what characterization methods will be used to determine joint quality.

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31. SUPERCONDUCTIVITY MATERIALS FOR ELECTRIC POWER

High temperature superconductivity (HTS) for energy applications was identified as a critical technology by the 1991 National Critical Technologies Panel. HTS wires have the potential to carry 100 times the electrical current of conventional (copper) wires without energy losses, leading to advanced electrical systems that are half the size and have only half the losses of conventional systems with equivalent power ratings. HTS electric power equipment is now under development and is expected to lower the cost and pollution associated with electricity generation, delivery, and use early in the next century. However, substantial technical barriers must be overcome before the commercial application of HTS becomes a reality. In particular, material processing innovations are needed to improve HTS wire performance. The two most viable approaches, Powder-In-Tube (PIT) and coated conductors, could be significantly improved through processing innovations. Applicants must demonstrate a capability to fabricate long lengths of conductor (5 meters or greater) and to characterize the critical current densities of conductors adequately by the end of Phase II.

Depending on the nature of the proposed research, potential applicants to this topic may want to consider taking advantage of the availability of one of the DOE user facilities. For more information, see section 1.6.2 of this solicitation. **Grant applications are sought only in the following subtopics:**

a. Powder-In-Tube (PIT)—In the PIT process, wires are produced by packing HTS-precursor powder into a silver tube and thermo-mechanically treating the tube to draw it into long lengths. Grant applications are sought for the development of innovative processes and process quality management technologies for manufacturing HTS PIT wires that will substantially raise the performance and/or lower the cost of PIT wires. Approaches of interest include reducing the amount of silver required, raising the current density of the superconductor, and increasing the ability of the superconductor to withstand magnetic fields at liquid nitrogen temperatures.

b. Coated Conductors—In the newer coated conductors process, metal strips are prepared, buffer layers are added, and then subsequent coatings of HTS films are deposited. If the process is optimized, the crystal structure in the HTS film will be directionally aligned and the film will carry large electrical currents. Grant applications are sought for processing innovations which will improve the performance (i.e., increase the current, especially at higher magnetic fields) of coated conductors. Approaches of interest include both coating improvements and improved preparation of the underlying metal strip. Coating improvements include faster coating processes, thicker films with higher current densities, and improved uniformity in long lengths.

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* See Section 7.1

32. NEUTRON INSTRUMENTATION

The Department of Energy supports a number of large-scale, national user facilities that provide intense beams of neutrons. As a unique and increasingly utilized research tool, neutrons have made invaluable contributions to the physical, chemical, and biological sciences. The Department is committed to enhancing the operation and instrumentation of its present and future neutron science facilities so that their full potential is realized.

Depending on the nature of the proposed research, potential applicants to this topic may want to consider taking advantage of the availability of one of the DOE user facilities. For more information, see section 1.6.2 of this solicitation. **Grant applications are sought only in the following subtopics:**

a. Neutron Detectors—Grant applications are sought to develop improved neutron detectors and associated electronics needed for DOE's existing and proposed steady-state and pulsed neutron scattering facilities (References 1,2,5). New detectors must represent substantial improvements in one or more of the following parameters: efficiency at short wavelengths, high counting rate capability, high spatial resolution in one or two dimensions, cost per unit area, or adaptability to unique geometries. Detectors for pulsed neutron applications must be able to identify the time of arrival of each neutron. All detectors must have low intrinsic dark count rates and low sensitivity to gamma radiation.

b. Neutron Optical Components—Grant applications are sought to develop novel or improved neutron optical components for use in neutron scattering instruments (References 2,3,5). Such components include, but are not limited to, neutron choppers, neutron guides, neutron lenses and focusing mirrors, neutron monochromators, or neutron polarization devices including ^{3}He polarizing filters. Applications are also sought for novel use of such components in neutron scattering instruments.

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33. ALTERNATIVE SYNTHETIC PATHWAYS FOR ENERGY EFFICIENT AND ECONOMIC INDUSTRIAL CHEMICAL MANUFACTURE

The U.S. chemical industry's response to the competitive challenges of a global economy will depend, in large measure, on fundamental advances in chemical synthesis and catalysis. Synthesis is the efficient conversion of raw materials, either organic or inorganic, into useful molecules and products. Because molecular conversions can be advantageously accelerated by adding a catalyst, catalyst-based synthesis now accounts for 60 percent of products produced by the chemical industry and 90 percent of current chemical processes.

The interaction between synthesis, catalysis, and process engineering provides the technical foundation for the chemical industry's manufacturing capabilities. Advances in chemical synthesis and catalysis could lead to major improvements in energy efficiency, decreased costs, and reduced environmental impact and could also contribute to significant savings in the energy "embodied" in each molecule that ends up in a waste product. These waste products cause a drain on our economy from: (1) the cost associated with attempts to manage these wastes, and (2) the increasing cost of raw materials needed to produce not only the intended products but also the waste.

This topic seeks to develop new catalysts and alternate synthetic pathways, as well as improved computational methods for modeling and simulating these processes, that will increase the efficiency of feedstock utilization and minimize by-products and waste. Proposed efforts should not only be innovative but also should address the fundamental chemistry of the catalysts and alternate synthetic processes. Grant applications must explain how or why the proposed catalyst or catalytic system would provide significant improvements in synthetic pathway efficiencies that would lead to improved utilization of carbon-based resources, to reductions in waste products, and to significant energy savings. **Grant applications are sought only in the following subtopics:**

a. Novel Catalysts for Highly Selective Conversion of Light Alkanes, CO, and CO_2 to Higher Molecular Weight Products—The atmospheric release of light hydrocarbons and carbon dioxide causes environment problems and wastes valuable carbon resources. Highly selective catalysts that effectively convert these molecules into useful products could create new synthetic pathways and products that result in the environmentally benign utilization of resources and energy. Grant applications are sought to develop novel catalysts that selectively convert CO_2, CO, CH_4, and other light alkanes to useful intermediates and higher molecular weight products. In the specific case of methane, the emphasis should be placed on conversion into clean petrochemicals and feedstocks rather than fuels.

b. Novel Selective Oxidative Catalytic Systems—Catalytic oxidation represents another approach for converting methane and other lower alkanes to higher value products. Grant applications are sought to identify and develop novel catalytic systems for the selective catalytic oxidation of lower alkanes (C_1 -C_5) to useful intermediates and higher molecular weight products using molecular oxygen. Reaction pathways of interest include oxidative dehydrogenation, oxidation with incorporation of oxygen into the organic molecule, and ammoxidation.

c. Improved Computational Methods—Grant applications are sought for new computational methods for the molecular modeling and simulation of new reaction pathways for the conversion of lower alkanes (C_1 -C_5) to higher value products (e.g., the reaction pathways associated with subtopics a and b above). The emphasis of these methods should be on understanding the specific reaction pathways on catalytic surfaces, including the activation of molecular oxygen and the diffusion and transport of reactant and product molecules. The computational methods should contribute to an improved understanding of the molecular dynamics of the catalysts, the conditions under which they operate, and to potential improvements in process design.

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34. REACTIVE SEPARATIONS

Reactive separations utilize close coupling of separation and chemical reactor systems, often in a single unit, to improve the yields of the reaction, the production of desired products, and/or to lower energy consumption and capital investment. Reactive separation systems may take many forms and may not resemble conventional chemical reactors and separations equipment. Reactors could be catalytic or homogeneous, continuous or batch. Any separation method could be used including adsorption, distillation, or extraction. A simple example of a reactive separation is a tubular reactor that utilizes a selective membrane tube filled with catalyst--the membrane selectively permeates a desired reaction product, and the removal of that product along the reactor length continuously shifts the chemical equilibrium among the potential products and reactants, increasing both the utilization of reactants and the production of the desired product.

Improvements from combining separations and chemical reactor operations can be substantial. In conventional systems, the yields of desired products are often limited by the equilibrium constant, and a product's concentration is usually determined by a thermodynamic equilibrium distribution of products and reactants. By combining a reactor with a separation operation that removes the most desired product, as in the above example, the utilization of reactants can be improved and the reaction can provide significantly higher yields of the most desired product. Energy savings can also be realized when products from one reaction step can be separated and used as reactants in a second reaction step. When one reaction step is exothermic and the other reaction is endothermic, the energy from the exothermic reaction can be used to drive the endothermic reaction.

Unfortunately, effective reactive separation systems usually are highly system specific, and particular combinations of separation and reactive systems are required for each potential application. For numerous low yield systems, no effective reactive separation systems are likely to be found. (Part of the difficulty is that reactive separation systems not only must include both reactor and separation capabilities, but also both functions must take place at approximately the same temperature and pressure, at least if they are to be incorporated in the same equipment.) Therefore, each grant application must identify a particular application -- one with the potential for large savings of energy and materials, and/or for significant reduction in waste products. Grant applications aimed at demonstrating reactive separation systems that have been studied extensively in the past, or

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those limited to testing a particular system under a specific set of conditions, are not of interest and will be declined.

Proposed efforts should not only be innovative, but also should seek to understand the dynamics of the reactive separation system. Grant applications must explain how or why the proposed reactive separation concept would result in improved raw material utilization (reactor yield) and energy savings compared to current (or currently proposed) approaches to producing the target products. Grant applications should also address the likelihood of further development or commercialization beyond Phases I and II (e.g., by identifying particular industries, government agencies, or even companies, that not only would benefit from the technology development but also may contribute follow-on funding). **Grant applications are sought only in the following subtopics:**

a. Reactive Distillation—Forty thousand distillation columns are used today in manufacturing 90 to 95 percent of all products in the continuous process industries. Advances in distillation could increase productivity, reduce costs, enhance product purity, and increase overall energy efficiency. Reactive distillation offers the possibility of reducing capital costs by combining reaction and distillation in one process step. The best candidate reactions involve reversible exothermic reactions with favorable kinetics at temperatures of separation. Several reactive distillation processes for the preparation of ethers, such as ethyl *tert*-butyl ether (ETBE) and *tert*-amyl methyl ether (TAME), have been commercialized already, and efforts to broaden the application of reactive distillation to other reaction systems have begun. However, the advantages of reactive distillation can be off-set by kinetics, equilibrium, and mass transfer issues, catalyst placement, and the compatibility of separation and reaction conditions for a given system. Grant applications are sought to adopt the reactive distillation process to other reaction systems to improve energy efficiency and product yield. Proposed efforts must provide an understanding of process fundamentals and show how and why the above technical barriers will be overcome.

b. Membrane Reactors—Membrane reactors have been proposed in a variety of configurations employing polymeric, ceramic, metallic or liquid membranes for coupling and combining process reactions and separations. The membrane reactors can improve process performance through equilibrium shifts, reducing product inhibition, the use of catalyst activated membranes, etc. However, to be competitive with conventional technologies, membrane reactors must be shown to have superior economics (e.g., reduced material and energy intensity, lowered pollutant dispersion) over a full life cycle. Unfortunately, it will not be enough to simply apply membrane technology to existing reactor processes. Rather, it will be necessary to identify and exploit new, more efficient chemical pathways that membrane reactors would make possible. Grant applications are sought to develop improved membrane reactors for particular applications with outstanding economics compared to existing technology. Areas of interest include developing membrane materials with improved reliability and performance (e.g., with better selectivity, permeability, stability), and developing unique approaches to engineering membrane contacting devices.

c. Reactive Separations For Waste Reduction—Most industrial interest in reactive separations is due to its potential to increase product yields and improve the economics of a number of important synthesis processes. However, the increased product yield also provides an opportunity for decreasing waste generation. Grant applications are sought to develop reactive separation systems which provide significant reductions in waste generation and pollutant dispersion. Areas of interest include reductions in net CO_2 production, solvent use, and the release of persistent, bio-accumulating, toxic materials into the environment, and the improvement of waste treatment efficiencies.

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35. INNOVATIVE R&D FOR ADVANCED, LOW-EMISSION, ELECTRIC AND HYBRID VEHICLE TECHNOLOGIES

The widespread commercial use of electric and hybrid vehicle technology has been limited by the performance of power sources and the availability of on board vehicle emissions controls. In addition, the excessive cost of the technology has also impacted the introduction of electric and hybrid vehicles to the buying public. The Department of Energy (DOE) Advanced Automotive Technologies and Heavy Vehicle Technologies Programs are interested in identifying and developing innovative concepts for batteries, fuel cells, and compression-ignition engine emissions controls that will improve performance, extend the life, and significantly reduce the cost of the vehicles. Grant applications must should show how proposed innovations would result in significant advances in performance and cost reduction over state-of-the-art technologies. **Grant applications are sought only in the following subtopics:**

a. Alternative, Low-Cost Salts/Separators for Lithium-Based Rechargeable Batteries—As technology for rechargeable lithium-ion (Li-ion) systems advances, so does the need for lower cost components. Presently a major contributor to the expense of Li-ion based cells is the high cost of producing the conductive electrolytic salts and separators, including materials costs. Grant applications are sought for salts and/or separators that can be inexpensively manufactured and easily substituted into current systems. The cost of salts should be estimated on a $/g-mole basis and the cost of separators on a $/m^2 basis. The performance characteristics of the salt should be evaluated in terms of the specific conductivity of electrolytes prepared from the salt when it is combined with standard Li-ion cell solvents. The key performance measure for the separator should be the specific conductivity of the separator/electrolyte system when it is used in combination with a standard Li-ion electrolyte system. Ultimately, when the salt/separator is used in the Li-ion cell, performance must be at least comparable to existing Li-ion technology (in terms of power density, expected life, etc.), in the temperature ranges to which current systems are exposed (see references 5 and 6). In addition, chemicals used must not be incompatible with current systems, must not be harmful to the environment, and must be completely recyclable.

b. Non-Flammable, Low-Cost Electrolytes for Lithium-Based Battery Systems—Safety is a necessary requirement for any battery system, especially if it is to be used in a passenger vehicle. Therefore, batteries for electric or hybrid electric vehicles must pass stringent abuse tests. Li-ion technology has the potential to be a very safe system if appropriate safe guards are developed. Grant applications are sought to develop new non-flammable or flame retardant electrolytes that can be easily incorporated into existing Li-ion technology. The electrolyte not only must be

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ignificantly less flammable, but also must have a specific onductivity equal to or higher than electrolytes used in urrent Li-ion cells. Possible approaches include developing ew electrolytes or modifying existing electrolytes using dditives or alternative solvents. Any new additives or olvents must be compatible with existing systems and xhibit comparable performance and low costs (which should stimated on a $/liter basis). Finally, it must be demonstrated that the final product is not be harmful to the environment and that it is completely recyclable.

c. **Oxygen Reduction Catalysts for Proton Exchange Membrane (PEM) Fuel Cells**—To meet DOE performance and cost targets for fuel-flexible automotive fuel cells, the operating voltage of PEM fuel cells must be increased. The primary technical barrier to achieving higher operating voltage is the large cathode overvoltage due to the low activity of the oxygen reduction catalyst. With currently used platinum catalysts, platinum loading on the cathode is only 0.15 mg/cm^2. Therefore, the reformate/air fuel cells, which operate at 0.8V and 80°C, are limited to cell current densities in the range of 0.2-0.3 A/cm^2 (i.e., power generation of 1.0-1.5 W/mg Pt). To achieve target performance levels, cell current densities of 0.8 A/cm^2 will be needed. Grant applications are sought to develop oxygen reduction (cathode) catalysts, for PEM fuel cells at the same operating conditions, with 3 times higher activity than state-of-the-art platinum catalysts (leading to power generation of 3.0 - 4.5 W/mg Pt). Possible approaches include developing of improved platinum electrode structures, platinum alloy catalysts, nonprecious metal catalysts, and combinatorial methods for screening new compositions. The research and development effort should lead to significant improvements over conventional catalysts while ensuring competitive cost. Efforts leading to incremental improvements are not of interest and will be declined.

d. **Novel Emissions Control in Compression-Ignition Engines**—Grant applications are sought to control emissions from high-efficiency compression-ignition engines by developing onboard vehicle technologies that produce low molecular weight fuels from conventional fuels, including diesel fuels. The low molecular-weight fuels, which could be ignited by compression or by pilot injection of conventional fuel with a high cetane number, could alter the nature of the combustion process inside the cylinder and lower particulate and NO_x emissions (or produce more favorable trade-offs between the two). The research effort should seek to understand the physical and chemical phenomena that underly the emissions reduction process. Proposed technologies must demonstrate high power density, fast response (50 milliseconds or less), low energy consumption, high dynamic range (highest power over lowest power greater than 10), and significant reductions in engine-out No_x emissions (by two orders of magnitude without exhaust treatment). Ultimately, devices must be commercially viable with long lifetimes (100,000 miles), minimal soot production, high conversion efficiency, and minimal overall system power requirements. For diesel engines, the overall fuel efficiency is critical; therefore, any net decrease in overall efficiency should be less than a few percent (including decreases due to using electricity to power the emissions control device).

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** Available from the Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096. Telephone: 724-776-4841. Web site: http://www.sae.org

36. COMPUTATIONAL GEOSCIENCES

To promote the environmentally sound use of our energy resources, the Department of Energy supports research on processes active in the near-surface region of the earth's crust which modify and alter the physical and chemical state of earth materials. Research areas include geophysics, geochemistry, resource evaluation, hydrogeology and their subdivisions, including earth dynamics, properties of earth materials, rock mechanics, underground imaging, rock-fluid

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interactions, and modeling, with emphasis on interdisciplinary studies. The goal is to advance the scientific foundation that underlies both current and future energy and environmental technologies.

The geophysical characterization of the structure and properties of the earth's shallow crust is of particular interest. The advent of new computational capabilities presents an opportunity to develop advanced seismological and electromagnetic imaging methods. Within this context, innovative computational algorithms with high spatial resolution are needed for 3- and 4-D (dimensional) geophysical imaging of energy resources (geothermal, oil, and gas) and their temporal variation within the shallow continental regions of the solid earth. Proposed research must represent a significant advance that will lead to improved algorithms for high-resolution, geophysical imaging. **Grant applications are sought only in the following subtopics:**

a. High-Resolution Seismic Imaging—Grant applications are sought to develop computational algorithms for the detection and spatial resolution of subsurface fractures in geothermal reservoirs from both seismic P- and S-wave data. These algorithms must be able to compensate for sample bias from the placement of receivers, and they should be able to process both refracted seismic signals and reflected signals in order to produce three-dimensional imaging. Areas of interest include computational methods for: (1) three-dimensional seismic wave propagation in anisotropic media and in laterally varying media; (2) improved migration (pre-stack as well as post-stack) for steeply dipping faults; (3) improved static correction routines for severely weathered media and laterally varying near-surface media, and (4) 3-D reflection imaging routines for generalized placement of geophones.

b. High-Resolution Electromagnetic Imaging—Grant applications are sought to develop computational algorithms for the detection and resolution of subsurface fractures and of conductive fluids in reservoirs from electromagnetic (EM) borehole-to-borehole surveys or from EM single borehole surveys. The computations must be usable in highly inhomogeneous, anisotropic geologic systems (e.g., steeply dipping fractured systems) in order to produce three-dimensional images of the structure. Advances are sought in efficient 3-D forward modeling code, based on integral equation or differential equation methods. Considering the large volume of EM data involved for characterizing fluid-filled fracture systems, advances are also sought in approaches involving the full 3-D inversion relying on massively-parallel computing resources, and on rapid approximate methods for standard computing capabilities.

c. Advanced Geophysical Visualization—Grant applications are sought to develop computational display algorithms for the rectification and presentation of four-dimensional visualization of 3-D reservoir simulations through time. The visualization is to allow the easy manipulation of parameters to better fit the reservoir data. Areas of interest include, but are not limited to, display of reservoir boundaries and wellbores, grid generation with special emphasis on irregular grids, grid refinement, assignment of initial and boundary conditions, automatic generation of input files for simulators from visually oriented information, and output and visualization of simulation results.

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PROGRAM AREA OVERVIEW - COMPUTATIONAL AND TECHNOLOGY RESEARCH

http://www.er.doe.gov/production/octr

The Computational and Technology Research program supports research in computational technology, laboratory technology research, and advanced energy projects, subprograms that underlie a variety of Department of Energy missions.

The Mathematical, Information and Computational Sciences subprogram includes research in applied mathematics, high performance computing and communications, and information infrastructure. The program has two major strategic thrusts: (1) the National Collaboratories Program which develops tools and capabilities to permit scientists and engineers working at different facilities to collaborate as easily as if they were in the same building, and (2) the Advanced Computational Testing and Simulation Program which develops an integrated set of algorithms, software tools, and infrastructure to enable computer simulation to better complement experiment and theory.

The Laboratory Technology Research subprogram funds high-risk, multidisciplinary research partnerships between the DOE's Office of Science multi-program national laboratories and private industry. Projects supported explore applications of basic research advances in the investigation of problems, over a full range of scientific disciplines, whose solutions have promising commercial potential. Partnerships with industry include Cooperative Research and Development Agreements, personnel exchanges, and technical consultations with industry scientists and engineers.

The Advanced Energy Projects (AEP) subprogram funds research to establish the feasibility of novel, energy-related concepts that span the Department's mission. These concepts are usually derived from recent advances in basic research, but require additional research to establish feasibility. In funded AEP projects, it is often the case that new, or previously neglected, research results become linked, for the first time, to a practical energy payoff for the nation.

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37. HIGH PERFORMANCE NETWORKS AND APPLICATIONS

The DOE currently supports research in advanced computing, high speed networking, and advanced scientific applications. Grants applications are sought that will enhance and augment this research. Grant applications must clearly state how the proposed research and development will enhance or augment the current research being done in the Department or clearly define the proposed benefit to the DOE. **Grant applications are sought only in the following subtopics:**

a. Gigabit Networks–In order to support the aggregation of multiple 100 megabit networks with advanced scientific applications, as well as applications requiring end-to-end gigabit bandwidths (i.e., where the bandwidth is maintained between applications running on separate hosts), the switching and trunking fabric of the network must efficiently operate at speeds ranging from gigabits to terabits, and must also be flexible in de-aggregating high speed tributaries. Grant applications are sought for the development and implementation of: (1) ultra high speed end system (host) gigabit interfaces (e.g. HIgh Performance Parallel Interface (HIPPI 64)), (2) operating system and network protocol software to support end-to-end gigabit applications, (3) innovative approaches to the switching and trunking infrastructure, and (4) very high speed network monitoring, debugging, and analysis tools. Areas of interest include research on wave division multiplexing (WDM), Synchronous Optical NETwork (SONET), and other optical, electrical, and hybrid (optical and electrical) technologies, especially those supporting application level access to a capability which can securely and dynamically create virtual private networks from these network objects. Since DOE's work in this area compliments activities at the Defense Advance Research Projects Agency (DARPA), applicants must ensure that the proposed work is complimentary to or augments the gigabit to terabit research currently supported by DARPA.

b. Network Technologies–Development of 155 megabits per second (mbs) and gigabit networks will allow Internet speeds to increase by orders of 100 and 1000, respectively, from current speeds of 1.5 mbs. The utilization of this capability on the future Internet will require the development and deployment of smarter and more adaptable networking technologies to support the varied requirements of a heterogeneous set of applications and end users. Grant applications are sought to develop such networking technologies in three areas:

Network engineering, in which advanced tools and services are required to: (1) monitor, analyze, and manage multiple layers of Heterogeneous networks; (2) perform effective and scalable routing/switching, including best effort and priority traffic, reliable multicast, real time, and variable or flat accounting/costing mechanisms and protocols for differentiated services; and (3) manage lead user infrastructure, which entails the dynamic and secure concurrent support of production and network research traffic (i.e., multiple policy traffic that may be in conflict with one another) on the same infrastructure, as well as the de-aggregation of tributaries.

Privacy and security throughout the network, requiring development of tools and techniques for (1) secure and fair means for enabling application and user access and control of network resources; (2) smart network management (i.e., highly capable network management agents, tools and stations) that adapt to a dynamic network infrastructure; and (3) secure and private high speed nomadic or remote access. Grant applications in this area must address appropriate public key infrastructure (PKI) research that supports these efforts and which is interoperable and consistent with industry driven PKI.

Quality of Service (QOS), which includes such functions as developing: a baseline QOS architecture and semantics; secure admission control mechanisms, including prioritization and accounting/costing; and QOS application program interfaces (APIs) that support cross layer propagation of QOS status and control, exposure of QOS controls directly to the application, and an appropriate set of service monitoring, discovery and validation tools. These characteristics are expected to be deployed in layer 3 IP (Internal Protocol), e.g., RSVP (Resource Reservation Protocol), as well as layer 2 ATM (Asynchronous Transfer Mode), e.g., NNI (Network to Network Interface) signaling.

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QOS grant applications must also account for two emerging technologies: (1) **seamless infrastructure,** which will require enhanced current peering and interconnection tools, technologies, protocols, and mechanisms for participants in future advanced applications located on various telecommunication carrier and agency networks (areas of interest include inter-carrier and inter-network considerations such as: route peering and data delivery interconnection; user friendly and accessible network management, monitoring, and analysis; QOS and class of service propagation, validation, accounting, and costing; and privacy and security domain and protocol support), and (2) **Ipv6,** currently proposed as the common bearer service of the future, for which QOS grant applications must be coordinated (e.g., through joint proposals or coordinated development) with advanced applications (to at least address specific requirements) and networks (so that the research will have an appropriate test vehicle).

c. **Application Demonstrations**–Ultimately, the higher speed networks, described in subtopic a, and the tools and services, described in subtopic b, will be validated by their ability to handle advanced applications that are beyond the capability of the existing infrastructure. Grant applications are sought for application demonstrations that are important to the mission areas of the DOE, broadly classified as energy resources, national security, environmental quality, and science and technology that will aggressively utilize the technologies described in subtopics a and b. (Note that applications linked to any of the topics addressed in this document are within these mission areas.) Application domains of particular interest include: (1) scientific research, in which scientists and engineers across the country work with each other and access remote scientific facilities as if they were in the same building - such "collaboratories," combining video-conferencing, shared virtual workspaces, networked scientific facilities, and data bases, will increase the efficiency and effectiveness of our national research enterprise; (2) environmental monitoring, in which virtual worlds would be constructed to model and monitor defined ecosystems; and (3) climate research, in which scientists, researchers and policy makers examine the effects of proposed actions to the long-term evolution of our environment - models would become available to and usable by all interested parties.

Grant applications must include the following elements: (1) an application domain related to an important federal mission and recognized by the public as such, (2) an application that requires high-performance internetworking technologies and services, (3) networking concepts and technologies, embodied in the application testbed, which are extensible to other application domains and scalable to the future commercial Internet, and (4) interaction with the application community which will supply resources for the application-specific technologies component of the testbed.

d. **Middleware Tools Enabling Applications**–Grant applications are also sought for the development of tools in the technology areas of collaboration, distributed computing, digital libraries, remote operations and privacy and security that enable applications. This tool development should be targeted for commercial deployment, optimally "plug and play." Advances are required in the following areas: (1) **security** - a large number of applications will rely on the capability to maintain privacy, confidentiality, and integrity of proprietary data; (2) **data sharing** - digital libraries and other science/technology information banks will be required for network-based applications such as the Genome Data Base; (3) **software sharing** - the capability for scientists at different locations to conveniently share software that supports data analysis, visualization, and modeling; (4) **controlling remote instruments** - communicating with remotely-sited equipment or instruments is required for design and use of remote science facilities, such as advanced light or photon sources, across a network; (5) **remote visualization** for viewing the results of computational simulations (advanced visualization technologies, such as network-integrated, immersive virtual reality devices, would allow multiple design or experimental teams to work together across distances to simultaneously observe or analyze data, images, etc.); (6) **scalability** - network technologies used by wide-area applications must be able to be scaled up to support applications at the national scale far better than is possible today; (7) **high end computation and computing resources** -testbeds will need to integrate supercomputers and computational technologies for remote experimentation (where supercomputers may be used for real-time diagnostics, for instrument recalibration, or for real-time modeling of experimental data); (8) **self-organizing networks** -to provide self-adaptation when the physical

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configuration or requirements for network resources have changed; (9) **nomadicity** - the ability to move resources as needs dictate, including "mobility of access rights" so the network will know how to treat a new resource (this may range from full rights to complete denial of access); (10) **rapid resource discovery capability** - where current network administrators painstakingly document resources, assign rights, and monitor use, in the future, network resources would be discovered as needed (an extreme case would be during the response to a natural disaster or other crisis); (11) **portability and interoperability of applications** - as networking and computing become more ubiquitous, the idiosyncrasies of networks and computers should become transparent to users; (12) **virtual subnetworking** - providing the ability to establish specialized communities of interest (e.g., researchers collaborating on a climate model, prime and sub contractors working on a new product, or a task force developing a new policy); (13) **ease of use** - where the ability to add resources to networks will be as easy as it is to plug in a phone today; and (14) **reliability** - although advanced networking services will be fragile, and suitable only for research when first implemented, the designs must eventually be scalable to full commercial and even military robustness.

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PROGRAM AREA OVERVIEW - NONPROLIFERATION AND NATIONAL SECURITY

http://www.nn.doe.gov

The Nonproliferation and National Security (NN) program conducts applied research, development, testing, and evaluation of science and technology for strengthening the U.S. response to threats to national security and world peace posed by the proliferation of nuclear, biological, and chemical weapons and special nuclear materials. Activities center on the development, design, and production of operational sensor systems needed for proliferation detection, treaty monitoring, and nuclear warhead dismantlement, in both cooperative and non-cooperative environments, and on support to intelligence activities. In addition, research and development activities are pursued to counter nuclear smuggling and terrorism.

The specific NN objectives are to: (1) develop and demonstrate technologies to detect the early stages of proliferant nations' weapons development programs; (2) develop and demonstrate technologies to detect and deter the diversion and smuggling of nuclear weapons, components, and special nuclear materials in non-cooperative environments; (3) address the detection and mitigation of biological and chemical weapons during a domestic incident by modifying and applying technologies developed for nuclear non-proliferation and by exploiting DOE expertise in the biological and chemical sciences and the Human Genome Project: (4) provide the U.S. Government with sensor technology needed to monitor and verify nuclear treaties, by detecting, locating,

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identifying, and characterizing nuclear explosions underground, underwater, in the atmosphere, and in space; (5) develop and demonstrate technologies for nuclear materials protection, control, and accounting and for the monitoring of nuclear warhead dismantlement; and (6) exploit emerging technology to maintain the capability required to address emanating threats and other future needs.

Small businesses awarded under the following topics will be required to collaborate (formal or informal) with DOE national laboratories. The objective is to help the small businesses get a better understanding of DOE's requirements and to help integrate each company with the potential DOE-related users of the technology. Phase I applications are not required to list a collaborator; contacts will be set up after awards are made.

38. ADVANCED SENSORS AND DATA ANALYSIS TECHNIQUES FOR NATIONAL SECURITY APPLICATIONS

The United States Department of Energy (DOE) is responsible for the development of systems for detecting the proliferation of weapons of mass destruction, including nuclear, chemical, and biological weapons. In both cooperative and non-cooperative environments, it is necessary to have the capability to detect the production, storage, transportation, and testing of such weapons. DOE's overall objective is to provide this capability by putting state-of-the-art technologies and tools in the hands of the treaty verification, law enforcement, and other relevant communities. **Grant applications are sought only in the following subtopics:**

a. Miniature Chemical Sensors—Hand held chemical vapor detection technology (i.e., sensor arrays and/or lab on a chip) is needed to detect signatures of weapons of mass destruction. Examples of current approaches include acoustic techniques (surface acoustic wave, flexural plate wave, etc.) with sorbing polymers, chemically sensitive field effect transistors utilizing both sorbing polymers and chemically selective enzymes, chemiresistors, and optical wave guides and fibers with sorbing polymers. Grant applications are sought to develop improvements upon these and other existing techniques, as well as to develop unique, high-risk approaches. Specifically, improvements are required in sensitivity, size, weight, and/or cost while maintaining selectivity in complex operating environments (e.g., in the presence of mixtures containing interferants). The final design for the integrated sensing system and operating electronics must be suitable for laboratory testing and eventual use as a component in handheld instruments. Although these systems may have dual uses for environmental and other applications, they will be evaluated on their ability to detect chemical vapors associated with the proliferation of weapons of mass destruction (nuclear, chemical and biological).

b. Biological Detection—Novel technologies are needed for detecting biological agent contamination on objects or people. Grant applications are sought to develop such technologies for ultimate use in detectors with rapid response times (minutes or less), high sensitivity (e.g., detection limits of 10 - 1000 cells/cm^2 for bacterial pathogens), high selectivity (to allow discrimination between the pathogens of interest and common background interferents), small size (pocket calculator size), and low cost. Overall, the characteristics of the detector should be consistent with its anticipated use -- the rapid determination of the extent of contamination following a biological incident. Although all classes of biological threat agents are of interest, submissions targeted at a single class of agents will also be considered.

c. Compact, Reflector Telescope for Short Range Portable Lidar Applications—Grant applications are sought to develop a compact, reflector telescope for short-range (i.e., two meters to fifty meters), portable, lidar chemical sensors. The function of the telescope is to collect scattered laser light and focus it onto the entrance slits of a spectrometer. Currently available commercial telescopes are unsuitable for this application because they are designed for astronomical imaging, where object distances are virtually infinite. The lidar telescope must be capable of imaging objects at any distance within its working range (typically

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from two meters to tens of meters) with minimal effort by the lidar operator. Additional criteria for the telescope are the following: 20 to 25 cm aperture; total optical throughput greater than 80 percent for wavelengths from 220-400 nm; shadowing of the primary optics by the secondary optics must be less than 10 percent for an object distance of 2 meters; telescope length less than 70 cm for all object distances; encircled energy (spot size at the focal plane) of approximately 200 mm diameter at a wavelength of 300 nm; 1 degree field of view; effective f-number equal to 4; and total weight less than 7 kg.

d. Effluent Plume Chemical Analysis Algorithms Using Hyperspectral and Ultraspectral Data—Chemical detection techniques using MWIR (mid-wave infrared) or LWIR (long-wave infrared) hyperspectral imagery (HSI) or ultraspectral point sensors generate massive data sets which complicate the detection and analysis of chemical plumes. Hyperspectral imagery data sets require days to months to pull useful information from a scene; in order to be useful for many non-proliferation activities, the turn around time must be drastically shortened. Ultraspectral sensors have extremely high resolution (as low as 0.1 cm^{-1}) but lack the spatial information found in imaging spectrometers; this provides a different set of challenges for pulling chemical information out of the background. Grant applications are sought to develop algorithms which operate on these data sets in order to improve the detection and analysis of chemical plumes in a scene quickly and accurately. Areas of interest include algorithms for: (1) signal-to-noise reduction which will reduce the residual errors due to calibration and atmospheric removal down to the 0.1% - 0.2% level; (2) rapid data analysis techniques to reduce the time required to analyze a scene down to hours at a minimum and to near real-time as a goal; (3) combining both spatial and spectral information to increase the overall chemical analysis capabilities achievable using HSI data cubes. In Phase I, the use of simulated data, or data from other sources, is encouraged for proof-of-principle testing and demonstration; if needed, data will be made available from the DOE.

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39. ADVANCED RESEARCH IN SUPPORT OF THE COMPREHENSIVE NUCLEAR-TEST BAN TREATY

The U.S. Department of Energy (DOE) is responsible for research and development necessary to provide the U.S. Government with the capabilities to monitor and/or verify compliance with the Comprehensive Nuclear-Test Ban Treaty (CTBT). This includes the development of technology, algorithms, hardware, and software for integrated systems that detect, locate, identify, and characterize nuclear explosions at threshold and confidence levels that meet U.S. requirements in a cost-effective manner. Program priorities focus on the advancement of seismic, hydroacoustic, infrasound, and radionuclide knowledge and capabilities. Further background on the DOE CTBT research and development program and the full treaty text are available at the following web site: http://www.ctbt.rnd.doe.gov. **Grant applications are sought only in the following subtopics. Although specific examples are sometimes focused towards one technical approach, all subtopics are seeking advancements in the four technical areas (i.e., seismic, hydroacoustic, infrasound, and radionuclide).**

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a. Monitoring System Calibration—To monitor compliance with the CTBT, the current treaty language calls for an International Monitoring System (IMS) consisting of a network of various types of data collection stations. The goal of the monitoring network is to detect and locate possible events. However, some factors (regional geology, meteorological conditions, man-made events, etc.) can introduce perturbations into the observations, thereby degrading routine analysis of the data and leading to inaccuracies in the results. Grant applications are sought for high quality ground truth information/data, pertinent to IMS stations, which can account for the above factors and be used to calibrate the monitoring system.

b. Identification Algorithms—Discrimination between earthquakes, man-made events, and nuclear explosions is problematic at best and complicated when the events are small and poorly observed. Grant applications are sought to develop innovative techniques for identifying these phenomena and to demonstrate their applicability to a particular geophysically distinct region.

c. Enhanced Detection—Global monitoring for compliance with the CTBT is dependent on high quality detectors and detection algorithms that operate with small amplitude signals. Grant applications are sought for innovative sensor designs that are compact, inexpensive, easily manufactured, reliable under adverse conditions, robust, simple to maintain, and have low power requirements. Grant applications are also sought for both new signal-processing techniques that can improve detection with low signal-to-noise ratios, as well as innovative noise reduction systems for new or existing sensors.

d. Data Fusion and Exploitation—Grant applications are sought to improve the ability to extract useful information from large volumes of multi-technology CTBT data. Areas of interest include techniques for cross-technology data fusion as well as innovative approaches for accessing, viewing, and interacting with large volumes of data.

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40. ADVANCED RESEARCH AND DEVELOPMENT INTO DETECTION AND CLEARANCE TECHNOLOGIES FOR UNEXPLODED ORDNANCE

In a cooperative effort, the U.S. Department of Energy and the U.S. Department of Defense are working to solve an International problem of unexploded ordnance (UXO) and land mines. Based on several reports to Congress and a recent report of the Defense Science Board, increasing focus is being placed on the development of new and innovative technologies to address the UXO and landmine issue. Five mission areas have been identified: (1) Active Range Clearance, (2) Countermine, (3) Explosive Ordnance Disposal, (4) Humanitarian De-mining, and (5) UXO Environmental Remediation. Although each category represents a different mission area, some technical approaches may find application in several of these areas. Grant applications should identify all of the potential applications, while explicitly recognizing the different environments, operational situations, and technical challenges encountered during UXO detection, characterization, and clearance. Designs must account for maintenance, repair, and parts availability in order to facilitate deployment. Also, possibilities for automation should not be overlooked. The ultimate goal is to automate and expedite what would otherwise be a dangerous, tedious, and labor intensive process; possibilities for automated systems should also be addressed. Finally, applicants should take the social and cultural environments in which UXO is found into account in their proposals. **Grant applications are sought only in the following subtopics:**

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a. Wide Area Detection - "Go/No-Go"—Only a few mines or items of UXO in a given area, or even the suspicion that UXO exists, can render the entire area unusable. The current means of assessing areas of concern is slow, painstaking, tedious, and expensive. The ability to quickly certify that particular areas are free of UXO and mines would substantially reduce the overall cost of UXO and mine assessments. Grant applications are sought for innovative approaches for the rapid screening of wide areas (at rates of square meters per minute) to assure the absence of UXO/mines in cluttered, but non-combat, environments. Approaches to consider include airborne or vehicle mounted sensor technologies appropriate to the detection of UXO and/or land mines over a large area. Proposed technologies must take into consideration transient climate phenomena, topographic characteristics, and clutter, as well as cultural and economic concerns. Considerations should also be made for problems arising from dense vegetation cover resulting from lack of use. For this situation, detection sensitivity is a higher priority than spatial resolution.

b. Characterization—Once an area is suspected to contain UXO, the UXO must be identified and characterized. Current techniques are slow, unreliable, and very narrowly focused. Improvements in false alarm rates during clearance operations is central to increased efficiency and reduced cost. Grant applications are sought for novel techniques to detect, identify, and characterize UXO. Approaches that integrate a number of detection methods to overcome the above problems are encouraged. Proposed solutions should augment the UXO field operator's capabilities, streamline operations, improve detection efficiency, and significantly reduce clearance costs.

c. Disablement and Neutralization—Once it is determined that UXO is located in a particular area, it would be preferable to disable or neutralize the UXO in place without knowing the precise location of each mine or UXO. Grant applications are sought to develop innovative techniques to accomplish this task. Methods may include, but are not limited to, vehicle mounted technologies that can destroy mines and UXO, and biodegradation of explosives in mines or UXO. Of particular interest are technologies that allow for the rapid neutralization of mines and UXO, and operate in areas with vegetation cover or other obstacles. Techniques proposed must consider appropriate environmental and safety standards. Operational environments could include combat tactical minefield breaching, UXO cleanup, active range clearance, and humanitarian demining situations.

d. Vegetation Cover and Obstacle Clearance—Many areas contaminated with land mines and/or UXO contain vegetation cover and other obstacles making it difficult to perform field clearance activities. Grant applications are sought to develop innovative approaches for the safe removal of vegetation or other obstacles in order to facilitate cleanup activities. Techniques must be low cost, allow for easy repair and maintenance of equipment, and be capable of working under a variety of field conditions. To reduce the risk to field personnel, the use of robotic controlled devices is of particular interest. Techniques proposed must consider appropriate environmental and safety standards.

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http://www.hnd.usace.army.mil/

* See Section 7.1

Please note: (1) The technical topics are to be interpreted literally; DOE personnel are not permitted to further interpret the narrative descriptions of the technical topics. (2) The award selection process is extremely competitive. Last year only 1 out of 6 grant applications were awarded. Only those applications with the highest scientific/technical quality will be competitive.