PROJECT DESCRIPTION

INTRODUCTION: Historically, Arkansans have relied on a strong rural, agricultural economy and an industrial sector tied to small manufacturing. Over the past several years, the state has experienced a transition with the recognition of two key points: 1) high-tech and knowledge-based industries must replace the traditional manufacturing economy and 2) science and technology must play a key role in the agricultural future. This climate for change permeates the industrial, educational and policy-making sectors of the state. Arkansas leaders realize the value and need for investing in science, engineering, and technology at the industry-university interface, within the university domain, and in the educational pipeline to support these efforts (see letters of support from Arkansas leadership Senator Pryor, Senator Lincoln, Govenor Huckabee, Representative Berry and Representative Snyder).

In keeping with Arkansas' Science and Technology strategies, this RII award will establish the **Arkansas ASSET Initiative** (**A**dvancing and **S**upporting **S**cience, **E**ngineering and **T**echnology) designed to strengthen two specialty areas developing in Arkansas with potential for regional and national significance and with *major economic development potential* (**Figure 1,** color). The **Arkansas ASSET Initiative** is a multi-institutional, interdisciplinary, *state-wide program.* An integral component of the program will be entrepreneurial training and support for commercialization of new technologies.

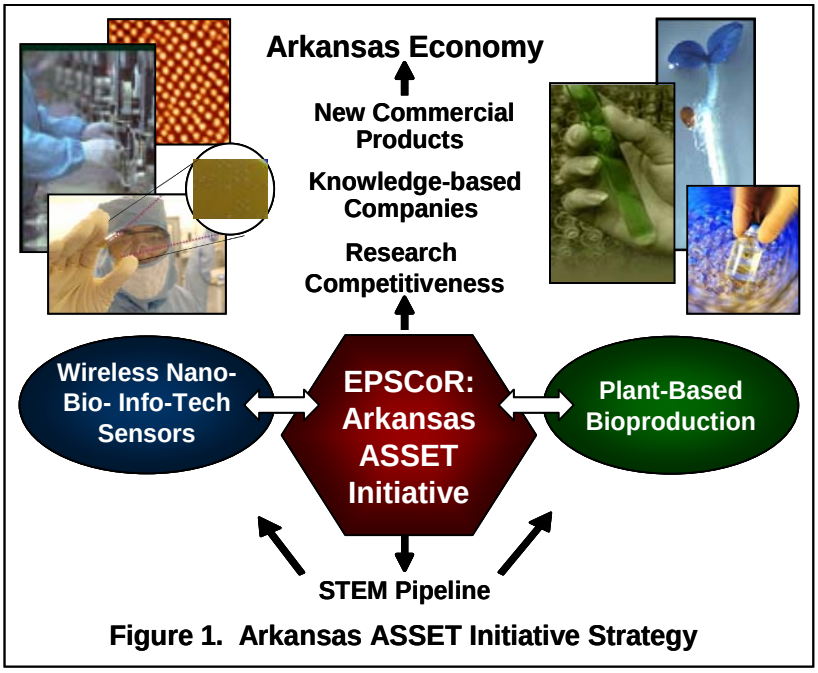

Figure 1. Arkansas ASSET Initiative Strategy

I. STATUS OF ARKANSAS' ACADEMIC R&D ENTERPRISE AND ROLE OF EPSCOR

Arkansas research universities are geographically separated and possess differing research traditions and assets. The University of Arkansas (UAF) located in the northwest corner of the state has become a hub of economic development and is a leader in nanoscience and engineering. Many related spin-off companies have been established at the Arkansas Technology Research Park located at the UAF campus. National recognition and commensurate research funding have grown substantially in this region. Arkansas State University (ASU), located in the northeast corner of the state within the Delta region, has an agricultural tradition. In recent years, university administrators, building on the large infrastructure investment of the Arkansas Biosciences Institute, have developed a budding "entrepreneurial-researcher" community. The University of Arkansas Little Rock (UALR), located in the center of the state and a metropolitan institution, has become a major research hub for systems engineering. The "CyberCollege" within UALR has strong industrial partnerships in central Arkansas and rapidly expanding research capacities. The University of Arkansas for Medical Sciences (UAMS) has evolved into a major competitor for NIH funding with world-renowned health research at the Donald W. Reynolds Institute on Aging, the Arkansas Cancer Research Center, the Jackson T. Stephens Spine and Neurosciences Institute, the Multiple Myeloma Institute for Research and Therapy and the Harvey and Bernice Jones Eye Institute.

Statewide Barriers: Although significant strengths exist in programs on Arkansas campuses, after a statewide review of strengths and weaknesses of the participating campuses, the following were identified as specific barriers to competitiveness:

- Arkansas needs additional facilities and instrumentation for "cutting edge" competitiveness in selected fields;
- Focal areas of regional strength and national importance lack "critical mass" due to gaps in faculty expertise and geographical dispersion of faculty across the state;
- There have been limited multidisciplinary inter-institutional activities;
- Although state universities have invested substantial resources and recruited some well-established investigators and highly competent young scientists, Arkansas lacks the "reputation" which conveys enhanced competitive strength at the national level;
- Heavy teaching loads make it difficult for faculty to cultivate competitive research programs;
- More science and technology (S&T) graduate students are needed in university research laboratories and are difficult to recruit;
- The number of Arkansas students enrolling in STEM undergraduate programs is inadequate and many Arkansas students lack strong math and science skills; and
- Arkansas citizens often lack an adequate understanding of the role of research and its contribution to the Arkansas economy.

II. RESULTS FROM PRIOR NSF EPSCOR SUPPORT

Historical Results of EPSCoR Support. Past EPSCoR investments have yielded substantial results leading to several competitive research programs on the UAF and UAMS campuses. The Center for Protein Structure and Function([1]) at the UAF owes its existence to early funding by NSF EPSCoR. The Center is currently in its second round of NIH COBRE funding. The Nuclear Magnetic Resonance Spectroscopy Core Facility within the Center has state-of-the-art equipment and includes a 700 MHz NMR with a cryoprobe, which is the first to be installed in the United States, and offers significant advantages for the study of large proteins. The Arkansas Mass Spectrometry core facility includes a broad array of modern mass spectrometers, including an IonSpec 9.4 Tesla Fourier transform mass spectrometer equipped with MALDI and ESI sources. Total funding of the Center exceeds $20M. The Molecular Beam Epitaxy (MBE) Laboratory([2]) is also the result of strong funding by NSF EPSCoR. Both facilities reside in new or renovated laboratories. The MBE facility has evolved into a major nanotechnology effort involving not only the University of Arkansas but also the University of Oklahoma. Major funding is currently supplied by NSF and the Department of Defense. Very shortly the MBE will have a high resolution scanning/transmission electron microscope with a focused ion beam capable of sub-angstrom resolution. Red Diamond, the state's first supercomputer which evolved from EPSCoR, is based on a cluster of 256 processors and was funded directly by an NSF MRI grant. This supercomputer, rated at 1.35 trillion floating point operations per second, was among the top 500 supercomputers in the world in June 2005([3]). It is currently being used to capacity to investigate computationally intensive problems arising in quantum chemistry and condensed matter physics.

At UAMS, the Center for Translational Neuroscience([4]) evolved from early funding of Edgar Garcia-Rill by NSF EPSCoR. The existence of the Center for Cellular and Molecular Neuroscience([5]) can also be traced to the early focus on neuroscience at UAMS supported by NSF EPSCoR funding. The Center for Translational Neuroscience is currently funded by an NIH $10M COBRE grant. The Donald W. Reynolds Institute on Aging([6]), with its own stand alone building, grew from initial NSF EPSCoR funding on the molecular aging research headed by Sam Goldstein. This early funding by NSF EPSCoR has clearly led to very vigorous and sustained research in Arkansas.

Current EPSCoR Support. Current RII Infrastructure funding by NSF EPSCoR for the nanoscience group, located primarily at the UAF and led by Dr. Gregory Salamo, has resulted in $18 million in

extramural funding since FY 2002. Included in the funding is a highly competitive MRSEC award with the University of Oklahoma entitled "Center for Semiconductor Physics in Nanostructures". The group was also awarded two IGERTs and a Track 2 IGERT. The University of Arkansas has built two additions in the past three years to the Department of Physics building to house equipment that resulted either directly or indirectly from NSF EPSCoR funding. First, an addition was constructed to house an expansion of the Molecular Beam Epitaxy Laboratory and second, an addition is currently being completed to house a new high-resolution transmission electron microscope with a focused ion beam. This equipment will improve our competitiveness in nanoscience research.

Table 1. Highlights of Arkansas R&D Accomplishments during 2002-2005 EPSCoR Award		
Infrastructure	Buildings	Expansion of UAF physics building
	Research Centers & Facilities	Construction of UAF Innovation Center
	Management	State governing committee reorganized
Human Resources	Students	5 EPSCoR supported graduate students
	Outreach	12 Science specialists permanent positions
	Private Foundations	$2.8 M for Authority education initiatives
	Pipeline	Consolidated effort by numerous state agencies and policy groups targeting STEM pipeline
	State Agencies	S&T strategic plan revisited; transition to coordinated STEM efforts - Arkansas Science & Technology Authority, Arkansas Departments of Education and Higher Education
	Statewide	Organization of STEM Coalition; Technology Task Force
Policy	Legislature	State partial match for federal funds (year 2 & year 3)
	Alliances & Partnerships	Accelerate Arkansas supportive of R&D
	Technology Transfer	3 STTRs
	R&D Support	Arkansas Biosciences Institute investment, Consolidated Incentive Act -Tax credits, Seed Capital funds for commercialization
Industry/State Interactions	Patents	4 patents issued; 17 pending
	SBIR funding	16 SBIRs
	Spin-off Companies	Nanomaterials & Nanofabrication Laboratories, NanoMech, Ocean NanoTech LLC, Minotaur Technologies

III. ARKANSAS' RII STRATEGY AND IMPLEMENTATION MECHANISMS

The concept and structure of the **Arkansas ASSET Initiative** emerged following a review by the Arkansas EPSCoR Governing Committee of the nanoscience EPSCoR initiatives' successes and the state's S&T strategies and a multi-step year-long process that involved scientists and engineers from across Arkansas. After general guidelines (aligned with the state R&D plan) were issued, Arkansas EPSCoR sponsored researcher-orchestrated focus groups and brain-storming sessions. From these sessions, the research direction was developed from the "bottom-up" rather than from "top-down." The cross-institutional collaborations were a natural outgrowth of common interest areas and the excitement created by the prospect of *expanded potential and strength in a united effort*. Following these efforts, initial white papers were submitted and reviewed. The Governing Committee selected three concepts for further review and development of expanded technology-focused proposals. These proposals received external technical review and AAAS was enlisted to do a detailed site review involving UAF, UALR and ASU to assess the strengths and weaknesses of the three research focus areas and their potential to meet EPSCoR goals. Based on this process, the Governing Committee selected two focal areas for emphasis within the **Arkansas ASSET Initiative** with potential to have broad impact on the state (**Figure 2**).

- **Wireless Nano- Bio- and Info-Tech Sensor and System.** This focal area expands previous EPSCoR investment in nanotechnology to interface with biology and sensor technologies and will create a fully-integrated statewide multi-institutional nano-materials and sensor engineering system with enormous immediate economic potential.
- **Plant-Based Bioproduction.** This focal area builds on recent statewide investments of Tobacco Settlement funds into research at the interface of agriculture and health and will develop the "P^3 Center" (Plant-Powered Production), a statewide multi-institutional center with direct implications for the agricultural economy of the Delta region of the Southern states.

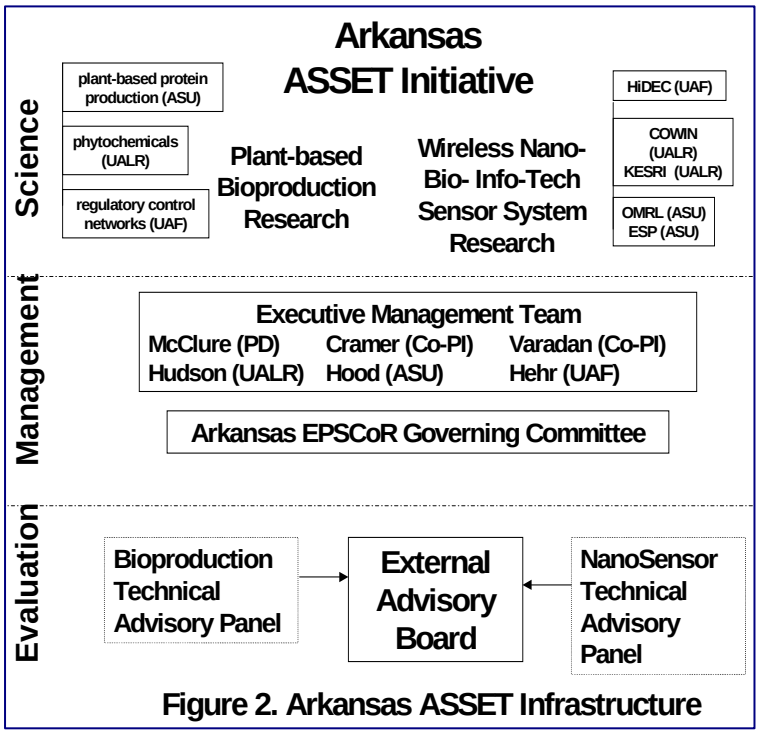

Figure 2. Arkansas ASSET Infrastructure

Both research areas have remarkable technology transfer potential and exhibit cutting-edge technologies that can position each for regional and national prominence.

The **Arkansas ASSET Initiative** has three overarching goals. To accomplish these goals, numerous activities and milestones have been developed.

Goal 1: To build a unifying statewide infrastructure platform within the two projects of Arkansas ASSET Initiative and improve research capabilities to support integrated research collaboration that will enhance Arkansas' national academic research competitiveness.

Goal 2: To establish an entrepreneurial environment and translational mechanisms to drive industry-relevant outcomes and ensure regional economic development.

Goal 3: To create new outreach methods and expand existing programs to increase the Arkansas science, engineering and technology student-pipeline with special emphasis on minorities and women to address the workforce issues of regional and national relevance.

In keeping with the multi-institutional focus on integrating research across campuses, the Governing Committee developed a plan for "**team management**" for a proposed statewide infrastructure investment. The Vice President Research, Arkansas Science & Technology Authority (the Authority), will serve as program director with general clerical and other support for the management team provided through this state agency. Such a management plan ensures extensive *statewide* collaboration that has been lacking in past infrastructure projects. Also, no indirect cost will be charged by the Authority for the fiduciary responsibilities assumed. The Authority provides state matching funds for federal awards, and will continue its commitment to the EPSCoR program with a requested budget of **$4.5 million as state match** for the next award cycle. In keeping with its mission, the Authority also will assist universities in developing university/industry partnerships and in commercialization efforts.

IV. Research Themes of the Arkansas RII and Proposed Activities

Arkansas ASSET Initiative Strategies. The **Arkansas ASSET Initiative** will build **two statewide infrastructure platforms** to support interdisciplinary research that will enhance Arkansas' competitiveness, create added research and training opportunities, attract top scholars, enable Arkansas to

form new links with national and international programs, and create new economic opportunities for industry and entrepreneurship.

Goal 1: To build a unifying statewide infrastructure platform within the two projects of the Arkansas ASSET Initiative and improve research capabilities to support integrated research collaboration that will enhance Arkansas' national academic research competitiveness.

Infrastructure Platform #1: Wireless Nano- Bio- Info-Tech Sensor System and Center will create a collaborative infrastructure for the design of arrays of nanosensors integrated with wireless systems that can be fabricated on a specialized, yet low-cost, nanofabrication technology. Dispersing these tiny, low-cost sensors with radio frequency identification (RFID) systems in various critical locations will enable large-scale monitoring on either a local or national level. This will lead to unique expertise and capabilities making this group highly competitive for additional support from federal and industrial sources and initiate entrepreneurial activities across the state. The proposed efforts will develop and expand the current nano- and micro- fabrication infrastructure of the existing Microelectronics and High Density Electronics Center (HiDEC) at UAF, the Collaborative Optical and Wireless Information Networking (COWIN) and the Knowledge Enterprises for Scalable, Resilient Infrastructures (KESRI) laboratories at UALR, and the Arkansas Biosciences Institute (ABI), Optoelectronic Materials Research Laboratory (OMRL), and Environmental Sciences Program (EVS) at ASU. Besides attracting experts to Arkansas this will facilitate recruitment of excellent faculty in emerging critical areas, enhance basic research infrastructure in the state, build a strong workforce to meet the nation's demand, and promote statewide economic development.

Background and Vision. State-of-the-art sensor and information technologies demand circuits and sensors that feature sizes in the sub-micron level -- only nanotechnology can realize this dream. One of the driving forces in these developments is that one could effectively sense with more accuracy, less material, and with smaller size and power. For the past forty years, *inorganic* silicon and gallium arsenide semiconductors, silicon dioxide insulators, and metals such as aluminum and copper have been the backbone of the semiconductor industry. However, there has been a growing worldwide research effort in developing low cost sensors with "organic electronics" incorporating nanomaterials, nanowires, bionetworking techniques, and carbon nanotubes (CNT) (Sridhar et al. 2006; Zhang et al. 2006; Jung et al. 2006). The high surface-to-volume ratios of nanostructures enable them to have high sensitivity, high selectivity, and short response time. For example, metal oxide, sulfide, or other chalcogenide nanowires/ nanotubes a few tenths of nanometer in diameter would result in superior electronic, chemical, and mechanical properties (Philip et al. 2004; Kong et al. 2000; Sawicka and Gouma 2005; Gao et al. 2003; Collins et al. 2000; Pengfei et al. 2003; Chen et al. 2003). This will enable us to fabricate flexible sensing devices with organic or composite electronics at *much lower costs* that are on the order of 10-20¢/m^2 compared to \$50,000/m^2 of their silicon counterparts.

Although many chemical and biomolecule sensors are now commercially available, they can only individually detect very high concentrations. Most of these conventional sensors are based on chemical interaction, requiring hours to analyze. The evolution of nanotechnology has opened a vast avenue to develop wide varieties of materials and robust systems for accurate sensing and identification. This has also created a need for advanced levels of education and training in nanotechnology to meet the demands of well-trained scientists and engineers in this newly and rapidly developing field. *Therefore, our goal is to create an infrastructure to focus on the design and development of arrays of nanosensors integrated with wireless systems. Specifically, we will focus on development of nanomaterials and technologies onto organic electronic systems (i) for power generation; (ii) to preserve food, boost flavor and to sense spoilage; (iii) for large scale wireless networking of Nanobiosensors and Nanoneural devices; and (iv) for summer programs and advanced level courses in schools and universities.*

The Science: The proposed new center will enable research and development in nanosensors integrated onto organic polymer electronic circuits (see **Figure 3)**. The wireless infrastructure system envisioned in this center includes a low-temperature PECVD system to deposit silicon nitride and/or silicon oxide film that will be the gate dielectric for organic thin film transistors, or serve as the insulator for sensor arrays; a profilometer; a fluorescent microscope; a multimode Atomic Force Microscope (AFM) to obtain topographic, phase imaging and electrochemical information, a metalorganic chemical vapor deposition (MOCVD) system for fabrication of zinc and tin oxide nanosensors for UAF. Procuring multidimensional channel sounder system at UALR along with a compact anechoic chamber and a computing infrastructure will enable us to measure and characterize wireless channels, components and the communication signal processing systems before integrating with nanosensors. Multi-electrodes with multichannel amplifiers integrated with microscopes and data processing software will add new dimensions to the existing neurophysiology measurement infrastructure at ASU. The resulting facilities will be uniquely suited to pursue research related to the following fundamental questions: (i) Is it possible to integrate nanosensors and neurons with organic electronic devices for developing neurosensors, neuro-modulators and delivery devices to the nervous system? (ii) Is it possible to enhance the photovoltaic conversion mechanisms using nanotechnology? (iii) Is it possible to develop a cost-effective wrapper polymer film that can sense a spoiled food sample? (iv) What are the barriers and limitations to integrating novel nanosensor and actuator materials (*e.g.*, organic sensors) with cognitive processing elements? (v) How can we build robust integrated sensor systems to appropriately blend collection and sensing methods with sensor network integration mechanisms to support comprehensive measurements? (vi) How can we integrate wireless capabilities into sensors so that sensor measurements can be transmitted reliably and securely over distances? (vii) What are the limits to the reliability and security of sensor networks and the limits to data transmission in real-world applications? (viii) What barriers and limitations exist in realizing sensor network systems that possess autonomic communications properties of self-awareness, self-healing, self-optimization, and self-configuration? (ix) How do we tailor education and human resource development in nanotechnology aimed at rural and urban development? This EPSCoR center will enhance existing faculty expertise across the three universities to form a nationally recognized research team. With the establishment of the Center, we will aim at developing devices and systems for a cure to millions of people suffering from neurodegenerative diseases. Research in applications of nanotechnology and electrical stimulation in neuron regeneration is warranted to find such cures. Survival and functional plasticity of neurons play crucial roles in maintaining human physiology and behavior. The cost of health care of these patients also imposes a tremendous burden on the society.

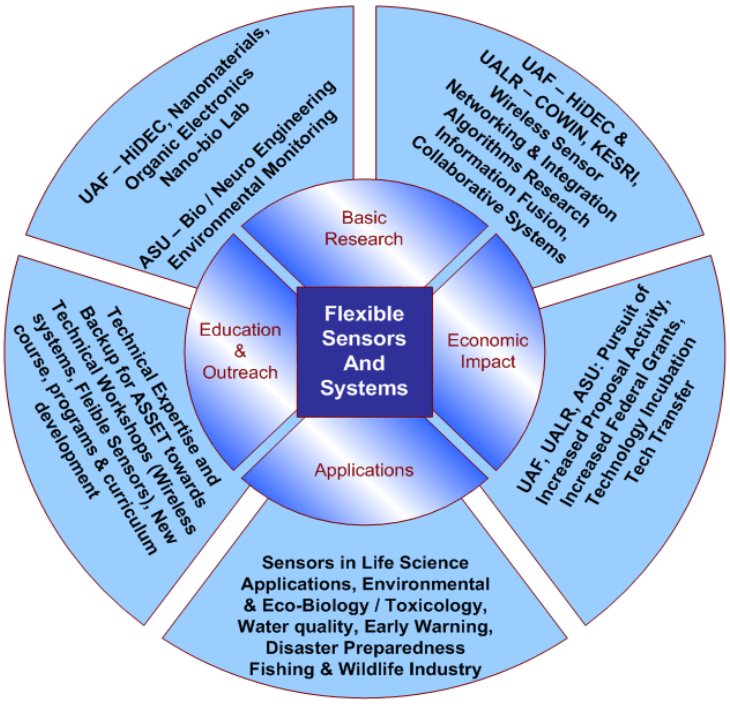

Figure 3. Overview of Proposed Activities (color)

To accomplish the above goals, we will investigate the characteristics of organic films with respect to their grains and morphology deposited on various dielectric films including inorganic and polymeric

materials at different substrate temperatures for different film thicknesses. This should be first addressed prior to the actual development of real devices, in order to better understand the effect of organic materials on the device performance. Later we will develop several types of organic semiconductor-based sensors including *organic thin film transistors*, for chemical, strain, and temperature sensing. Finally, these sensors will be integrated into a sensor array working as a multi-parameter sensor and providing a 2D map of sensing images (see **Figure 4**). All work will be done with polymeric substrates with the goal of fabricating high-performance thin film transistors and integrated sensors with low operating voltages suitable for large area electronic applications.

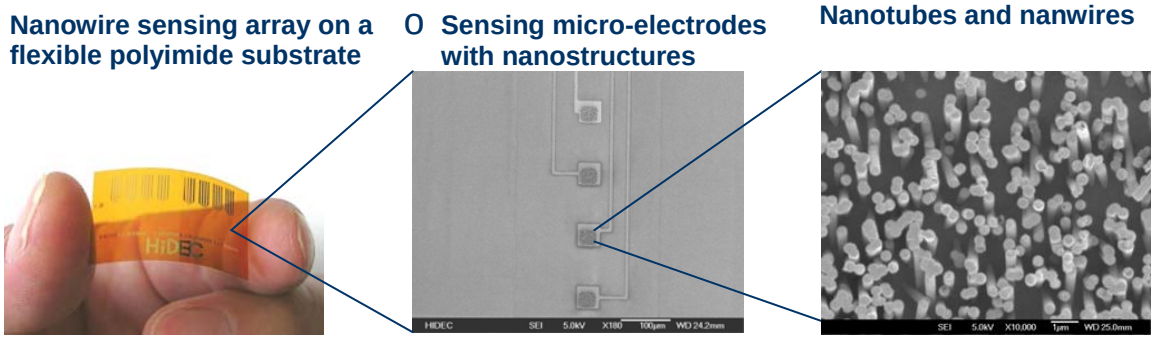

Figure 4. Nanosensors on Flexible Organic Electronics (color)

For health care, we aim at developing an inter-disciplinary research approach combining our expertise in the areas of neuroscience, engineering, computer science, and physiotherapy to 1) understand the underlying mechanisms of survival, growth, synaptogenesis, ion channel function and conduction in the nervous system; 2) explore the interaction and application of nanomaterials, wireless technology, and electrical stimulation in neurophysiology; 3) apply that knowledge to find solutions for neurodegenerative disorders; 4) investigate in detail the long term effects of the interaction of nanomaterials and wireless technology with the nervous system using animal models; and 5) take the successful measures to patients for relief from neurodegenerative diseases and paralysis.

Issues and Challenges: UAF, ASU and UALR have strong faculty expertise in nanotechnology, sensing systems, neurophysiology and wireless devices. Moreover, the infrastructure for the implementation of these nanomaterials and systems particularly on organic polymer electronics for applications such as nanosensors and point-of-care testing devices require expertise as well as *modern tools in fabrication and characterization*. Pockets of expertise are spread across the three campuses and there is a lack of cohesive organizational structure to build collaboration pathways between these various groups. There is an urgent need to overcome these barriers by focused research initiatives (including faculty hires) to benefit from this emerging field. The lack of faculty specialized in nanobioengineering and infrastructure also hinders our ability to provide advanced training in nanobioengineering, nanosystems and infrastructure to our students to contribute to the national need for nanotechnology workers. Moreover, such pervasive and powerful technologies, combined with global market trends, are making wireless portable computing and communication increasingly important for next-generation systems with potential for large-scale deployment of reliable and securely interconnected embedded wireless computing devices.

Strategies to overcome challenges and expected outcome: This multi-campus, multi-departmental research initiative will increase the quality and quantity of collaborative research opportunities and educational initiatives in Arkansas for nanotechnology systems research. The infrastructure development will focus on the following scientific areas; (i) development of a *unique regional nanomaterial-based sensor and sensor system fabrication and packaging user facility*, and statewide enhancement of organic and composite nanoelectronics and nanodevices in multidisciplinary fields such as science, engineering and medicine with the emphasis on flexible low-cost organic and/or thin film sensor-based systems; (ii)

development of a wireless networking infrastructure that will interface with the sensor and sensor systems including bio-networking among sensors, nanodevices, and biosensors; (iii) development of computing and logistics infrastructure that will facilitate state-of-the art techniques for data collection, fusion, and analysis in a distributed networked-environment involving sensors; (iv) strengthening current programs by initiating new nanobioscience and technology 'capstone' projects.

In order to address the above issues, this proposed Center will emphasize research in several strategic areas. The Center will hire an additional faculty member in the area of *hybrid integrated wireless systems* (UAF Electrical Engineering Department) to strengthen our expertise in integrating nanosensors with wireless systems. Additional proposed actions to achieve the above goals are summarized below:

a) Advanced Materials and Their Manufacturing Systems: Develop nanomaterials to boost the power densities of existing lithium batteries and disposable fuel cells; organic displays; nanomemories; and large scale manufacturing technologies. This will strengthen our current programs of CNT storage devices for fuel cells as well as vertically aligned ZnO nanowire photovoltaic devices.

b) Food, Agriculture and Environmental Sciences: Develop technologies to preserve foods; boost flavor and nutritional values; tailor delivery of nutrients; and enhance food packaging technologies, including wrappers with nanomaterials to sense food spoilage. The development of cost effective, environmentally friendly nanocomposites that meet the operational and performance requirements of shelf life and decrease solid waste by recycling or biodegrading will be important. Several polymer nanocomposites such as low density polyethylene, ethylene co-vinyl alcohol and polyethylene terephthalate will be the candidate materials. Significant improvements in barrier properties, thermal stability and Young's modulus will be emphasized. Since the process of food spoilage is known, indicators like the temperature and the presence of certain odors will be keys to development of nanosensors for food safety.

c) Life and Bio-Sciences and Technologies: Develop nanobiosensors and nanoneural devices as non-biological tools to achieve molecular sensors, biosensors, point-of-care diagnostic systems, and targeted drug delivery systems.

d) Information Science and Technology: Exploit pervasive computing technologies for information fusion, a dominant wireless communication network system serving as phone, broadband internet, video, capable of accessing diverse sensor networks and databases with location/tracking capability.

Management and Schedule: This Center facility will be managed and operated as a true, collaborative user facility where everyone has open, full access to the advanced technologies. We expect a majority of the users from the university community in and around the State, along with hundreds of large and small organizations and Arkansas' schools and colleges. The Center will encourage industries in Arkansas to license and commercialize their products for large-scale manufacturing applications. Research staff will work closely with industry partners to develop their technologies from prototyping to large scale production. To accomplish these tasks, a management structure will consist of UAF, UALR and ASU as active collaborators. As co-PI, Dr. Varadan, will serve as the project director and technical manager for this Center. Dr. Ramaswamy from UALR (with 25% release time) will serve as a coordinator between the various team members and providing operational oversight of collaboration of the three campuses. Three, 3-member standing committees will be made up of appropriate representatives from the three campuses. The first committee will be tasked with scheduling the use of acquired resources to support faculty requests for research from across the three campuses as well as addressing other outside requests for training and support. A second committee, made up of appropriate personnel for innovation and protection of intellectual property will be tasked with dealing with related IP and patenting issues. The third committee will pursue technology transfer, small business incubation and building active relationships with surrounding industries. These include telecommunication industries such as Alltel and AT&T, retailing industries such as Wal-Mart, transportation and warehouse industries such as J.B Hunt and FedEx, and food & agri-based industries such as Tyson Foods. In addition, we will also constitute an Industrial Advisory Board and a University Advisory Board. The infrastructure management along with

the major milestones and the Core Research Group (CRG) are included in support documentation provided by the Nanosensor Program Director, Dr. Vijay Varadan (UAF) and Co-Directors Dr. Seshrini Mohan (UALR) and Dr. Robert Engelken (ASU). (see Varadan support letter). Support documentation is included from industry partners and technical advisory panel including: Spiesshoefer (NeoNanoSys); Chalfant(Space Photonics); Spiesshoefer (Evoltech System Solutions); Wang (VP Research Engineering, Florida State University); Dodabulapur (Cenntenial Professor of Engineering, Univeristy of Texas); Nagenswaran (Intel Corporation); Choi (Nano-BEAMS Lab, NASA Langley Research Center); Jayanthinathan (Engineering Systems Solutions); Shah (Shiva Biomeidcal, LLC); and Crolley (AT&T).

Milestones/activities/timeframe: The proposed infrastructure in nanotechnology applications will enhance science and technology research activities in Arkansas particularly at UAF, UALR and ASU. The focus area proposed in this center is the integration of nanotechnology with organic electronics for sensing, power generation, and healthcare point-of-care applications. In short, the collaborative program will develop: *(i)* wireless sensor platforms for the integration of nanosensors *(ii)* software interface and data transmission protocols, *(iii)* testing of the wireless antennas and components**.**
This center will be a user facility and the research plan is described below.

Year I

(a) Optimize the sensing mechanisms by modeling atomistic molecular dynamics (UALR, ASU)
(b) Research on organic thin film transistors and devices. (UAF, UALR)
(c) Enhance nanomaterials performance to power generation (UAF, UALR).
(d) Determine the potential of nanotubes for neurite growth (UAF, ASU)
(e) Evaluate potential of nanotube substratums for neuronal electrical property evaluation (ASU, UAF)

Year II

(f) Design sensor network for point-of-care physiological monitoring devices. (UAF, UAMS, UALR)
(g) Design organic flexible wireless sensors and point-of-care testing devices. (UAF, UALR)
(h) Develop functionalized nanotubes to use as guidance cues for nerve fibers (UAF, ASU)
(i) Develop animal models of spinal cord injury and neurodegenerative disorders (ASU)
(j) Develop nanobiosensor-integrated food wrappers to sense food materials. (UAF, ASU)

Year III

(k) Develop wireless gas and biohazard sensors and biosensors for sensing pathogens in clinical, food and environmental samples. (UAF, ASU, UAMS)
(l) Study nanomaterial and nervous system interaction and ligand-receptor binding in neurons (ASU)
(m) Develop and evaluate sensors for their efficacy in speed and sensitivity to detect and quantify environmental toxins (UALR, UAF, ASU)
(n) Develop fuel cells and photovoltaic devices for power generation (UAF)
(o) Develop s ensors integrated with flexible organic ICs. (UALR, UAF)

Table 2: Center Milestones

Solicit proposals for post-docs	Aug 2007	Order 90% of the yearly equipment, establish recharge accounts	Oct 2007
Start searches for post-docs	Jan 2008	Submit at least six proposals to Federal Agencies (including NSF)	Jan 2008
Make offers to post-docs	Jun 2008	Submit at least three NSF career proposals	Jun 2008
Acquire last 10% of the yearly equipment	Jul 2008	Submit at least 12 proposals to Federal Funding Agencies (including NSF)	(12 per year)
Conduct entrepreneurial workshop and external advisory meeting	Yearly (May)	Conduct externally invited research seminars	10 / year
Sponsor at least six undergraduate research projects	6 / year	Conduct internal research seminars	10 / year

Infrastructure Platform #2: Plant-based Bioproduction and the Arkansas P^3 (Plant-Powered Production) Center

Background and Vision: The synthetic capacity of plants is exceptional in harnessing light energy for biosynthesis of a vast array of unique chemicals. There is significant interest in harnessing this biosynthetic capacity to produce bio-based products for medical and industrial applications. With recent advances in genomics and metabolic engineering, significant progress has been made in using plants as bioproduction "factories" for complex proteins and unique chirally-specific bioactive compounds. This technology will impact human and animal health by producing new medicines and improving the health benefits of food; the industrial arena by providing enzymes, chemical feedstocks, and biofuels; and agriculture and rural development by fostering new high-value specialty products. However, key limitations that hinder progress toward commercialization reflect our limited understanding of the underlying biology mediating the biosynthetic capabilities of plants. Our goal in this EPSCoR program is to generate the intellectual and infrastructure resources to address the fundamental biology of plant-based bioproduction in a way that integrates geographically dispersed programs, mentors a group of promising young researchers to ensure competitiveness in this arena, builds a national reputation of leadership in plant-based bioproduction, and drives economic development.

The Science. Multi-disciplinary teams will coordinate through the P^3 Center (Plant-Powered Production) to bring diverse technologies to bear on key challenges in a) plant-based production of proteins, b) metabolic engineering and bioproduction of important phytochemicals, and c) exploiting plant stress responses to direct and optimize biosynthetic capabilities.

Protein bioproduction -- addressing biological elements that limit protein production, accumulation and quality [Project coordinator: C. Cramer (ASU)]. Product yield from transgenic plants (i.e., the overall accumulation of bioactive product) is impacted by many factors and remains the major technical limitation in bringing plant-derived proteins to commercialization (reviewed in Cramer et al., 2000; Ma et al., 2005; V.Gomord et al., 2005). The goal of the **Protein Bioproduction Group** is to bring diverse expertise to bear on several key issues that universally hinder progress in developing plant-made pharmaceutical and industrial proteins. Understanding the biological mechanisms that limit or enhance the production, accumulation and stability of proteins in plants requires innovative application of new technologies and has the potential to be translational in both knowledge and application. Projects, supported through EPSCoR infrastructure investments and a competitive seed grants program, will build on unique experimental systems that have been developed among our P^3 Center faculty including: 1) well characterized Cre/Lox transgenic lines for precise genome integration (Chawla et al., 2006), 2) plant-derived recombinant proteins [e.g., IL-12, IgGs, vaccine carrier proteins (Medina-Bolivar et al., 2003)] to address *in planta* product stability, proteinases and their inhibitors, and impact of accumulation site, 3) transgenic maize germplasm (e.g. high-and low-expressing inbred lines with same laccase transgenic

event (Hood et al., 2003) enabling a genomics approach to identify novel factors that limit or enhance protein production, and 4) a systems biology platform (ArrayTrack; Tong et al., 2003; Tong et al., 2004) integrating microarray data analyses with metabolomic/proteomic data. We anticipate that these analyses will yield valuable new insights into factors driving protein accumulation and fundamental plant processes involving transgene stability, protein targeting, protein stability in different organelles, transcriptional regulation, mRNA stability, proteases and protein turnover, as well as factors that have not yet been considered and should be broadly applicable to plant-based bioproduction platforms.

Metabolomics, genomics, and bioinformatics empowered platform for metabolic manipulation and engineering [Project coordinator: G. Thompson (UALR)]. The growing demand for complex, biologically active molecules for medicines, materials, and agrochemicals is driving efforts to understand and manipulate plant metabolism. Whole genome-level DNA sequence information and improved methods for profiling natural products, now make possible combined genetic and biochemical approaches for addressing natural product function, deciphering biosynthetic networks, and engineering novel pathways in transgenic plants. Understanding gene-to-metabolite networks through integration of gene expression patterns (transcriptomics), protein signatures (proteomics), global metabolite dynamics (metabolomics), and sophisticated bioinformatics-based data mining tools is crucial for the identification of novel gene function and enhanced production of useful compounds in plants. The comprehensive profiling of the plant metabolome also offers opportunities to characterize genes of unknown function by using metabolic changes to infer the identity of genes following manipulation of their expression. Researchers at UALR, ASU, and UAF have developed powerful experimental models to study the complex phenylpropanoid and isoprenoid synthetic networks including 1) a *Synechocystis* micro-algal system for "reconstruction" of phenylpropanoid synthesis (Burja et al., 2003), 2) "hairy root" culture systems supporting rapid elicitation, profiling, and transgenic manipulation of phytochemical pathways (Medina-Bolivar & Flores, 1998), and 3) whole plant approaches utilizing *Medicago truncatula* and *Arabidopsis thaliana* to interface metabolomics with the powerful genetic and genomics resources available in these species (Korth et al., 2006; Lorence & Nessler, 2006). The fundamental biology is linked with compelling chemical targets (*e.g.*, an anti-Parkinson disease sesquiterpene, the anti-malarial artemisinin, anti-cancer caffeate derivatives, flavonolignans that target atherosclerosis-related low density lipoprotein oxidation) providing opportunities for industry interactions. The EPSCoR competitive seed grants program will support strategies to understand and improve production of specific metabolites by addressing the following aspects: 1) elucidation of signal transduction pathways leading to biosynthesis of target metabolites; 2) identification of transcription factors and their regulation mechanisms, including genetic manipulation of regulator genes to improve production of target metabolites; 3) cloning of secondary metabolite

Figure 5. "Emerging" and "Support" Faculty involved in the P^3 Center (color)

biosynthetic genes, and genetic modification of key genes to engineer the metabolic flux to target compounds; 4) analyzing metabolic flux and profiling metabolic intermediates to understand metabolic pathways and overall regulation of target compound accumulation; and 5) profiling and analyzing global gene expression under different conditions to understand physiological factors involved in the regulation of key metabolic pathways. Robust bioinformatics tools will be developed or integrated from the open source community for storage, retrieval, analysis, and modeling of metabolomic datasets. (see bioinformatics support letter from Dr. Jennings, UALR).

Exploiting stress-induced metabolite accumulation to enhance plant bioproduction. [Project Coordinator: K. Korth (UAF)]. Plants have evolved highly effective response mechanisms to survive biotic and abiotic stresses. Elicitation of these responses by cues such as drought, pathogens, and insects causes dramatic shifts in transcript accumulation, protein expression, and metabolite profiles (Thompson & Goggin, 2006). This ability of plants to rapidly accumulate large amounts of specific proteins and metabolites in response to defined external factors illustrates both the plasticity and the potential of plant bioproduction (Korth et al., 2006; Lorence & Nessler, 2006). Such responses to external stimuli may yield novel strategies for enhancing plant-based bioproduction. Our objective here is to understand and exploit plant stress signaling to drive discovery of new ways to control and optimize plants as biofactories by linking the expertise and tools developed in defense signaling of relevant crop plants (*e.g.*, rice, alfalfa) with "hairy root" bioproduction and metabolic profiling capabilities. P^3 Center researchers have developed significant expertise: 1) in identifying proteins, genes and gene regulatory mechanisms that control these processes; 2) in manipulating defense signaling at the genetic and molecular levels through transgenics and RNAi strategies to enhance or modify responses *in planta*; and 3) in creating flexible controlled *in vitro* systems enabling precise induction and sensitive response readouts. By supporting seed projects linking precise manipulation of the signaling network that orchestrates these complex defense responses with assessment tools to analyze impacts on metabolic pathways at the transcriptome and metabolome levels, we hope to gain critical insight into the master regulators that impact the outcome of these signaling pathways and their application in directing plant-based bioproduction.

Barriers and Challenges. Although Arkansas has significant strengths in the area of plant-based bioproduction, its development in this area is relatively recent, geographically dispersed, and lacks the organizational framework required to coordinate and build the infrastructure, collaborations, and reputation to support a nationally competitive center. Specific barriers include 1) gaps in instrumentation, 2) gaps in faculty expertise, 3) lack of seed funding to develop nationally competitive programs and promote cross-institutional collaborations, and 4) lack of national recognition for the Arkansas programs. The following strategies will be used to effectively address these barriers through EPSCoR funding;

Instrumentation Infrastructure. Strategic equipment acquisition will address key infrastructure needs for supporting plant growth (environmentally controlled chambers at UAF and UALR), protein and small molecule analytics (MS, FPLCs, TLC and add-on components to expand metabolic profiling capabilities), and bioinformatics (servers, workstations, software). We will build on existing strengths and instrumentation at each institution (UAF – protein structure/function; functional genomics; ASU - protein analytics; bioproduction scale-up; UALR - metabolic profiling, bioinformatics) and develop advanced capabilities in phytochemical detection and characterization with strong emphasis on supporting cross-institutional collaborations. Advanced instrumentation clusters will be maintained locally but managed as collaborative user facilities to provide training and access to researchers across the state.

Intellectual/Expertise Infrastructure. To address gaps in faculty expertise, three new faculty will be hired); NFS funds will support faculty start-up packages. UALR will hire a plant biologist at the interface of metabolomics and molecular genetics (see Dean Gealt support letter). ASU will hire a biochemical engineer with expertise in down-stream processing of proteins or phytochemicals; bioreactor design, optimization and scale-up; or related fields that would strengthen EPSCoR goals and outcomes (see Cramer support letter). The Division of Agriculture has committed to hire at least one faculty member at UAF working in the area of functional genomics/transgenics with a research emphasis supporting plant-

based bioproduction (see Roeder support letter). A strong emphasis will be placed on recruiting minority faculty and faculty that will effectively complement and strengthen P^3 Center faculty expertise. In addition to hiring new faculty and integrating current faculty, workforce development programs targeting PhD students and postdocs will be critical to building a sustainable regional center of excellence that will support technology spin-offs and promote positive economic outcomes. The P^3 Center will actively recruit a group of highly-motivated students who will be involved in multi-institutional projects, which will involve active participation in workshops, technology "intensives", and outreach programs. The Center will utilize existing McNair Scholars and NSF RISE programs to ensure that minorities are strongly recruited into the program. Undergraduate research opportunities will be supported through summer research internships. The Collaborative Seed Grant Program will be used to fund project-specific postdoctoral associates who will work across labs and institutions (see below).

Collaborative Seed Grant Program. The Plant-based Bioproduction focal area will use competitively awarded collaborative seed grants to solidify cross-disciplinary/cross-institutional projects that will address the three key challenge areas of protein bioproduction, metabolic engineering, and defense signalliing/bioproduction enhancement. The challenge areas were developed through an interactive process to identify specific research interests and capabilities of the participating faculty that collectively could provide translational technologies and discovery to move Arkansas into the forefront of the bioproduction field. The goal of the Collaborative Seed Grant Program is to enable researchers within the Center to develop the “preliminary data” and publications needed to prepare nationally competitive proposals within the challenge areas. The seed grant program will target “emerging faculty” for project support, infrastructure needs, and teaching release time. Mentoring by “supporting faculty” will greatly facilitate their ability to be competitive for federal grant support (see Figure 5 and CVs for emerging and supporting faculty).

Seed Grant Submission. Emerging and new faculty within the Center are eligible to serve as the primary investigator of a seed grant, and supporting faculty are eligible to serve as co-investigators. Competitions will be held during the first and second years of the overall EPSCoR project. The two-year awards can be used to support postdocs, graduate students, undergraduate researchers, faculty summer salary, and research supplies. Successful grants will address one or more of the key challenge areas and emphasize innovative cross-disciplinary research teams with postdocs and students actively involved at multiple labs and locations. A required outcome of each grant is submission of at least one competitive grant to a federal funding agency.

Seed Grant Evaluation. Each grant will be peer reviewed by a minimum of three experts within the field. Ad hoc mail reviews will be solicited from the national or international scientific community. The Plant-based Bioproduction Steering Committee will discuss the reviews and make funding recommendations. The review criteria will include the: 1) scientific merit, 2) plan and likelihood for obtaining non-EPSCoR funding, 3) potential for significant contributions to the area of plant-based bioproduction, 4) strength of collaborations and integrations of EPSCoR resources and expertise, 5) innovation/potential for translational applications, 6) contribution to regional workforce development, and 7) broader impacts to the community. Each PI will receive copies of the confidential ad hoc reviews and a summary review from the steering committee.

Grant Mentoring and Enhancement. To facilitate the effectiveness of this process, grants workshops will be held and senior “supporting faculty” [including two recent NSF Program Directors, Elizabeth Hood (ASU) and Gary Thompson (UALR)] will play an active role in mentoring the PIs in publishing and grantsmanship. In addition, all members of the Center will be eligible to apply for travel funds that will allow interactions with program directors at federal funding agencies. Interactions among researchers will be facilitated through frequent research meetings in Little Rock (centrally located) and Access Grid video conferencing. The bioinformatics core at UALR will develop and maintain a secure web-portal to

support data exchange. The P^3 Center will interface with existing RISE and McNair Scholar programs (active at UAF, UALR, and ASU) to jointly recruit students of excellence and diversity and to provide opportunities for cross-institution training of students including technology short courses and "biotechnology applications" (interfacing science and business students with food/medical/Ag industry).

Reputation Building and Sustainability. The P^3 Center will orchestrate efforts to raise the visibility and national/international recognition of the Center's research and participating faculty. During statewide discussions to develop the P^3 Center concept, "being in Arkansas" was identified as a barrier to success, especially among researchers recently recruited into Arkansas from non-EPSCoR states who are finding it noticeably more challenging to obtain funding. Since 2003, Arkansas has utilized its Tobacco Settlement funds to invest in research at the interface of agriculture and medicine, supporting impressive new buildings, state-of-the-art core facilities, and faculty hires. This investment has not yet produced strong multi-institutional interactions or a national reputation. The following approaches will be taken to raise our profile: 1) institute a seminar series that brings distinguished speakers and technology innovators in the bioproduction arena with presentations rotating among institutions and projected to all sites via the Access Grid, 2) utilize the Technical Advisory Panel to develop a group of key academic and industry leaders and experienced grant reviewers vested in the success of the program, 3) support publications in quality journals and presentation at national meetings, 4) bring NSF personnel and researchers from the multi-state region for grants and technology workshops, 5) develop compelling ads and website presentation to recruit new faculty, postdocs, and graduate students, and 6) take the lead in further developing an international consortium in Plant-based Bioproduction (already initiated with researchers in Mexico, Argentina, Peru and several US institutions).

The overall goal of this program is to move Arkansas to sustainable national competitiveness and leadership in the area of plant-based bioproduction. Outcomes of EPSCoR investments will include 1) a group of PIs that have obtained competitive PI-initiated grants from NSF and other agencies; 2) translational applications including patents, licenses, and SBIR and STTR funding, and 3) development of program grants including NSF's Partnership for Innovation, Partnerships for International Research and Education, Science and Technology Center grant, and potentially partnering in the Plant Science Cyberinfrastructure Collaborative. ASU was a partner in a 2004 STC grant in Plant- and Fungal-based Bioproduction that progressed to full proposal stage but was not funded. EPSCoR funding will be instrumental in creating the "critical mass", dynamic multidisciplinary teams, and partnerships to be competitive for these large programmatic grants.

Table 3. Milestones for the *Plant-based Bioproduction* Focal Area

Initiate multi-institutional seminar series	Aug 2007	Purchase remaining equipment	Jan 2009
Award first competition seed grants (3-5 grants)	Jan 2008	Award second competition seed grants (4-5 grants)	Jul 2009
Purchase and install 80% of equipment	Jan 2008	Submit PI-initiated NSF proposals	2009-10
Make offer to 3 new faculty hires	May 2008	Entrepreneurial workshop	Nov 2009
Grants Workshop	Nov 2008	Submit program grants (PFI, Centers)	2009-10
Technical Advisory Panel Meeting linked with 1 day research symposium	Every Sept	International Plant-based Bioproduction Workshop	2010

Management and Milestones: Carole Cramer (ASU; 20% time commitment), Ken Korth (UAF; 15%), and Gary Thompson (UALR; 15%) will manage the program aided by a steering committee consisting of Yvonne Dragan (NCTR), Dan Berleant (UALR), Brad Murphy (UAF) and Pamela Weathers (ASU). An executive director will be hired to coordinate and communicate the P^3 Center activities and manage inter-

institutional interactions and instrumentation access. Dr. Joe Chappell (Univ. Kentucky) has agreed to chair a five member **Bioproduction External Technical Advisory Panel** that will include both academic and industry scientists (see Cramer support letter) and will meet annually to review the program and provide recommendations. Two of these advisors will also serve on the **Arkansas ASSET Initiative External Advisory Board**. Milestones of the program are highlighted in the **Table 3**.

V. HUMAN RESOURCE DEVELOPMENT (HRD) AND COMMUNITY OUTREACH PLAN

Goal 2: To establish an entrepreneurial environment and translational mechanisms to drive industry-relevant outcomes and ensure regional economic development.

Development of knowledge- and technology-based economies to augment Arkansas' traditional rural/ light manufacturing economy is critical to the State's future economic competitiveness. Arkansas has recently been successful in mobilizing EPSCoR investments into knowledge-based commercial outcomes. For example, the previous EPSCoR grant yielded 21 patents (4 issued, 17 pending); several technology spin-off companies (Nanomaterials & Nanofabrication Labs, NanoMech, Ocean NanoTech LLC, Minotaur Technologies) that successfully competed for 3 STTR awards and 16 SBIR awards, 6 of which have progressed to Phase II funding; two successful NSF Partnership for Innovation Grants in nanotechnology; and supported the development of the Genesis Technology Incubator located at the Arkansas Research and Technology Park in Fayetteville, Arkansas. This incubator currently houses 17 companies with an additional 9 companies located within its Innovation Center. The potential to drive further knowledge-based economic development was among the key criteria in selecting our EPSCoR focal areas for the current proposal and we will build on this highly successful model to ensure "translational" productivity in these new target areas.

Within this context, "Sensor" infrastructure will establish a unique statewide user-friendly nanoscience, bionetworking, nanoengineering, fabrication and packaging center capable of producing technological breakthroughs in nanoelectronics and nanodevices for multiple commercial markets (medical, food, security industries). UA's High Density Electronics Center (HiDEC), a unique laboratory with a stand-alone 4,000 square feet class 100/1,000 clean room, currently supports large-scale synthesis of multi-walled carbon nanotubes and nanowires, active nanosystems, 3D nanostructures and polymer nanosystems. The EPSCoR Sensor Center will be fundamental in translating these nano building blocks into applications ranging from biological sensors for point-of-care (POC) diagnostics, chemical and gas sensors, magnetic storage, and flat panel displays to devices that can be implanted in the human body. Thus, we expect many industrial partners to license/market the nanosensors and technologies developed under this project. Several industries have already shown interest in wireless neural systems / biosensors (NeoPharma Inc.); nanobiosenors (Quantum Polymer Technology Corp.); biosensors/glucose sensors (Engineering Systems Solutions Inc); and wireless systems (Acxiom, Space Photonics, Alltel, InvoTek). (See support letters Chalfant (Space Photonics), Jayanthinathan (Engineering Systems Solutions), and Crolley (AT&T).)

The EPSCoR R&D investments in plant-based bioproduction will also drive regional economic initiatives and ensure Arkansas' leadership in development of plants as safe, cost-effective, and scalable biofactories. Arkansas has recently recruited internationally recognized leaders (e.g., see letters from Michael Phillips, BIO; John Howard, ABI, Inc.) and entrepreneurs in plant-made pharmaceuticals (Cramer) and industrial enzymes (Hood), plant transformation (Phillips), and plant bioreactors (Weathers) as well as promising young faculty in metabolic engineering, hairy-root-based bioproduction and protein chemistry that complement existing strengths across the state. The industry/entrepreneurial experience of these researchers was instrumental in developing research goals for the P^3 Center that specifically target the key technical barriers currently limiting commercialization in this arena. Cramer and Hood previously served as CSO's for *CropTech* and *ProdiGene*, two early leaders in plant-based protein production

[licensed Cramer technology has completed Phase I clinical trials; *ProdiGene* developed the first four plant-produced proteins to be commercialized] and currently serve as founders and CSOs of *BioStrategies LC* and *Infinite Energy LLC*, respectively. Maureen Dolan and Fabricio Medina-Bolivar are co-founders of *Nature Diagnostics* (DNA- and protein-based diagnostics/speciation in food industry) and Nature West (neutriceuticals, herbal diagnostics and phytochemical production). Robyn Hannigan recently co-founded *Hyphenated Solutions* (analytical technologies) and many of our participating faculty have strong interactions with other industrial partners. We believe this collective entrepreneurial experience is a significant and unique asset for the P^3 Center that will drive applications-oriented research, patenting, and technology transfer, and facilitate entrepreneurial training of student, postdocs and faculty. The technologies to be developed with the P^3 Center are not crop or product specific and thus have the potential to provide significant value to biotech start-ups already functioning in the state (*e.g*., BioDefense Technologies, Nature West, Infinite Energy, LLC, InterveXion, BioStrategies LC) as well as others in the biotechnology arena. Safety and quality testing technologies have broad applications in agricultural biotechnology and could be developed into service capabilities for data supporting the regulatory process (e.g., bio-equivalency assessments) for food/feed biotech crops as well as servicing the protein bioproduction sectors. The food and pharmaceutical industries have expressed interests in specific phytochemicals ranging from an anti-Parkinsons sesquiterpene to phenylpropanoid antioxidant additives for sports drinks. Plant-based bioproduction represents an exciting interface between agriculture and high-tech, knowledge-based industries and the P^3 Center will create the entrepreneurial environment, innovative technologies, human resources, and intellectual properties to drive technology transfer and economic development and attract private sector participation.

ESPCoR programs *at the state level* will be designed to coordinate Human Resource Development (HRD) capacity building with economic impact. A number of special efforts will be employed to cultivate the "entrepreneurial mindset" and expand the knowledge base needed by researchers to pursue commercialization of intellectual property and innovative devices. Special training opportunities will be provided to researchers at special workshops (which will be rotated across campuses) and available as podcasts focused on: 1) assistance with SBIR/STTR grants, and 2) information on Arkansas Consolidated Tax Incentive Program for supporting industry investment in university R&D and the Authority's Technology Transfer Assistance Grant Program for preparing SBIR proposals and marketing research (see support letters for hosting these workshops from Larry Walthers, Arkansas Department of Economic Development and Ms. Mildred Holley, Small Business Development Center). A special "interactive chat function" will be developed at the Authority website will connect young faculty with mentors to provide patent support information for new devices and intellectual property. Increased researcher interaction with business/industry will be supported through: 1) Funds to match industry partnerships to create internships giving student's "real-world" workforce experiences in high-tech and startup companies; 2) Summer stipends to encourage interaction of "MBA business students" and S&T students/faculty on three campuses to develop business plans and do marketing analysis; and 3) Opportunity for these summer MBA student/S&T student projects to be showcased at the annual student business plan competition and/or at statewide business events. The Authority website will be expanded to provide a "one-stop shop" of on-line resources targeting commercialization and entrepreneurism. Finally, the year three budget has special funds set aside for enhanced travel to send faculty and students to 1) key conferences where their innovative research may be showcased to increased national prestige (Keystone Symposium, Gordon Conference, etc) and 2) to national meetings at the university/industry interface (Biofusion and NSTI Nanotechnology Conference) where commercialization opportunities from these projects can be showcased to increase research notoriety and entrepreneurial opportunities for project staff and to attract venture capital. Seed money for some commercialization support will also be available through the Authority's Seed Capital Investment Program and Technology Development Program (see support documentation from Dr. John Ahlen, Arkansas Science & Technology Authority.) It should be noted that the ASSET Management Committee will be very proactive in working with the Universities' Research and Technology Transfer Officers at the outset of this project to develop appropriate Memoranda of

Understanding and Agreement between participating institutions to support strong inter-institutional collaborations, entrepreneurial activities, and joint intellectual property development.

Goal 3: To create new outreach methods and expand existing programs to increase the Arkansas science, engineering and technology student-pipeline with special emphasis on minorities and women to address the workforce issues of regional and national relevance.

As stated at the outset of this proposal, many of the specific barriers to competitiveness in our focal areas include human resources and workforce development issues:

- Heavy teaching loads make it difficult for faculty to cultivate competitive research programs;
- Existence of a thin STEM pipeline
    - The number of Arkansas students enrolling in STEM undergraduate programs is inadequate and many Arkansas students lack strong math and science skills;
    - More STEM graduate students are needed in university research laboratories;
- Arkansas citizens often lack an adequate understanding of the role of research and its contribution to the Arkansas economy.

Due to the "disconnect" in STEM pipeline efforts statewide, we spend significant time and effort on outreach—an obviously critical activity. Several EPSCoR statewide activities will address barriers to STEM research success in Arkansas. In addition, specific foci to integrate research and education and to build capacity have been developed for each scientific program. In addition to the human resource development and outreach funded by this EPSCoR award, private foundation funding directed to K-12 education components is leveraged to supplement this project. These foundation funds **($2.8 million in grants to the Authority for STEM educational initiatives)** are fully described in supplemental material and a brief overview of the relationship to the EPSCoR themes is included below.

Activities for Building Faculty Capacity:

- Four new faculty positions will be added in key areas building on the strengths delineated in this proposal—one per campus in the bioproduction project and one new hire at the UAF campus for the Nanosensor Project. The UALR nanosensor project is moving one recent hire into the project. Women and minorities will be specifically targeted for all new hires.
- A "room and board" site at each campus will be established to facilitate faculty and graduate student exchanges.
- Special Access Grid seminar series will be established—Program-specific speakers on one campus will be available to other program members through the Grid.
- NSF program directors will be invited for grant-writing and other specialty workshops targeted to junior faculty.
- Each campus will host a discipline-specific regional/national meeting during the project funding period.
- Site visits by junior faculty and their mentors to potential collaborative laboratories nationwide will be made.
- Support for acquisition of library materials, particularly access to electronic journals will be targeted (see letter of support from Judy Ganson, Arkansas EPSCoR Science Information Group).

Activities for Filling the STEM Pipeline (Integrating Research and Education):

- **Graduate programs**: Private foundation funds will be sought to supplement funding level for fellowships for minorities making graduate school stipends more lucrative.
- **Undergraduate programs**: ASSET funds will provide stipends to increase the number of students, particularly minorities and first generation college students, served by these REU programs—George Washington Carver, GEM, McNair Programs, RISE and STRIVE that exist on various campuses

- **K-12 programs**: Elementary science specialists (created by 2002 NSF EPSCoR award) **have been sustained** as part of Arkansas state agency programs, and will be utilized to disseminate materials and training developed through program-specific outreach activities.

PROGRAM-SPECIFIC OUTREACH:

There are unique opportunities that exist for targeting diversity within the state. ASU has some strong young faculty of Latino origin with exceptional student motivational skills that can be used as **role models** to target Hispanic students. Also, ASU is located within the Arkansas Delta area. Ten counties making up this core region have a 46.9% African-American population, which is one of our target recruitment groups. Two of our twelve science specialists in the K-12 program are coordinated through this university and focused on **K-12 STEM education** in Delta schools. Additionally, northwest Arkansas where UAF is located, has one of the fastest growing Hispanic populations in the country. Our K-12 outreach efforts in these regions will target these minority populations for **STEM undergraduate** programs. This targeted focus on Hispanic students is designed to increase our **STEM student pipeline** for all universities throughout the state, not just those within this research proposal. Finally, our metropolitan university, UALR, has a 32% African American enrollment and provides an opportunity to target minorities for **graduate student** recruitment. In all programs **women** will be targeted as an untapped resource for both STEM undergraduate and graduate students. One final untapped resource for graduate students is the statewide two year college system within Arkansas. The Executive Management Team will work with the Director of Workforce Education and the Director of the Arkansas Association of Two-Year Colleges to recruit talented young people into these STEM programs and funnel them into graduate programs. Support documentation has been included from Mr. John Wyvill, Director of Arkansas Workforce Education and Dr. Ed Franklin, Executive Director of the AATYC.

A. **Targeting the Nano- and Bio-Device Pipeline -- Developing the Workforce.**

The goal is to develop a better understanding of, and to create an interface between, biology, engineering, and nano- neuroscience in the state, and to train more students for the workforce of the future. Integrated into the entire effort will be a major emphasis on improving diversity.

Summer Workshops:.

- Summer institutes (3-4 weeks each) for junior and senior high schools will be developed
- Summer institutes for public school teachers will be developed for an opportunity to be exposed to nanotechnology, nanobiotechnology and organic electronics.
- Lesson materials in nanoscience and nanoelectronics appropriate for K-12 (for SMART Portal described in Authority outreach) will be developed.

Graduate and Undergraduate Education:

- A student exchange program will rotate graduate students to expand training opportunities
- A faculty exchange on participating campuses will share teaching loads to broaden experiences.
- Undergraduate and educational modules in nanotechnology will be developed and implemented.
- The proposed Center will have a significant role in the new M.S. and Ph.D. programs in electronic-photonic materials and devices supported under the NSF IGERT program, plus
  - AM.S degree program in biomedical engineering that will include courses and practical contents in neuroscience, nanosensors, business, and industry and
  - Develop a joint M.D./ Ph.D. program between UAF and UAMS.

Community Outreach.

- A neuro-nanobiology and wireless technology expo and industry forum will be hosted for the local community (and rotated across campuses) to increase public awareness in the developing technology and its application; develop a university-public partnership; and promote interest in math, science and engineering education and related careers among the public. Industry representatives and the public

will be invited to tour facilities at these open forums to discuss their needs in areas of expertise and training of our workforce.

B. Linking Plant-based Bioproduction to Multi-Institutional Science K-14 Outreach

With a strong agriculture and food science tradition in Arkansas, new and progressive educational venues can build upon this history and integrate the agriculture-medical focus of this multi-institutional research center. This presents a unique opportunity to introduce our next generation of Arkansans to biotechnology that will continue to impact this state and the world. The academic institutions involved in this EPSCOR proposal will build upon existing outreach programs and commitments (see text box below).

EXISTING PROGRAMS – BUILDING ON A STRONG COMMITMENT TO SCIENCE OUTREACH

ASU ABI Biotechnology Outreach Program: ~100 K-12 visitors bi-weekly for tour of a biotechnology facility and hands-on activities like extracting DNA from strawberries; CSI Summer Camp for high school students; Science teacher/pre-service teacher workshops/professional development

UAF USDA-RiceCAP-funded outreach program for middle/high school teachers providing hands-on training in techniques and exercises related to plant genomics, crop breeding and computer-based DNA analysis; modular workshop facilitates transition of basic biotechnology skills and current ag-biotech topics into the classroom.

UALR coordinates the Arkansas STRIVE program that places middle/high school science, math and computer teachers into summer research positions at universities and industries to provide teachers with hands-on, real-world, research experiences that expand technological knowledge and develop inquiry-/problem-based lessons for the classroom. The INBRE Bioinformatics Core also sponsors summer internships for computer science students to work in life science laboratories.

Network of Centers for Math and Science Education meet with regional middle/high school math/science teachers –Southeast Arkansas Science Teacher Association (SEASTA); Grants from No Child Left Behind (NCLB), STRIVE, AR Department of Education, and AR Space Grant Consortium (ASGC) K-12 program to provide math/science teaches with discovery leaning skills or research activities in the summer

These established programs serve as the foundation to create new, innovative agriculture-biomedical-biotechnology outreach opportunities. Building upon the P^3 Center institutions' strengths in biotechnology as applied to agriculture and medicine, the following multi-institutional, educational outreach initiatives are proposed:

Summer teacher workshops:

- Workshops will rotate among the three sites to ensure statewide opportunities.
- Workshops will highlight the EPSCOR research area(s) of the sponsoring institution.
- Workshops will involve researchers, including graduate students, from all locations and build from year to year.
- Teachers will learn: "Classroom-adaptable" skills/techniques used by plant biotechnologists, basic computer and data management skills central to biotechnology, and real-world applications of this technology and issues surrounding its application.
- Teachers will be instructed in the procedures and serve as active partners in testing the experimental modules for the Biotech-in-a-Box program (see below).

Biotech-In-A-Box Program at the Agriculture-Medicine Interface:

- Biotechnology curriculum modules, i.e., "Biotech- in-a-Box", will be developed in the context of both P^3 Center specialties and the Arkansas science "frameworks" to be integrated into home classroom activities.
- Biotechnology equipment, procedures and supplies for advanced biotechnology activities in the classroom will be developed, maintained and made available to trained teachers.
- New Biotech-in-a-Box modules will be added yearly.
- Geographically distinct venues in Arkansas will drive curricula to instruct teachers on these various classroom outreach kits.

CSI Camps: We will seek new private foundation support for "CSI camps".

- The five-day "Crime Scene Investigation (CSI)" program features realistic scenarios.
- Workshops will target junior and senior high school recruits to encourage STEM career education and channel students into STEM undergraduate majors.

Partial Support for an Outreach Coordinator: A Biotechnology Outreach Specialist (50% salary requested) will manage this multi-institutional education program, organize and support the workshops, and oversee the assembly, distribution and teacher instruction of the "Biotech-in-a-box" program. This person's home institution will be ASU and ASU's ABI will match NSF support with 50% salary (see Cramer support letter).

***STEM OUTREACH SUPPORTED BY PRIVATE FOUNDATION FUNDS*:**

A number of Authority activities support the EPSCoR HRD and outreach above and these resources are being leveraged to help build capacity. (Detailed breakdown of **Winthrop Rockefeller Foundation grants** to the Authority and the subsequent support for K-12 STEM Outreach that are targeted are included in supplemental material, Dr. Gail McClure and letters of support from the Mr. Bill Rahn, Winthrop Rockefeller Foundation and Dr. Ken James, Commissioner, Arkansas Department of Education.) The objectives of these educational initiatives that are complementary to EPSCoR outreach goals include the following targets:

- *Arkansas STEM curriculum must be strengthened in K-12 with more experiential activities and use of technology rich curriculum to obviate remediation needs*. Multiple grant programs, including teacher grants programs; Summer Science Academy; EAST/STEM Curriculum Development Model, will be used.
- *Improve Arkansas teachers' instructional techniques and use enhanced technology curriculum through additional professional development*. Authority grants will be used for specialized professional development workshops and development of SMART lesson plan portal.
- *Expand the BEST Robotics programs with team competition making it available in all geographic regions of the state*. Authority grants will be used to establish university-based BEST Robotics Hubs to benefit schools in unserved areas of the state.
- *Experiential instruction will be increased in Arkansas classrooms to strengthen the STEM skills of and to increase interest level of K-12 students in STEM careers.* Arkansas industry, with the assistance of the STEM Coalition, has been heavily involved in this effort and will continue to be enlisted to help identify the 21st Century Skills essential to our workforce and promote integration into the classroom curriculum. (Support letter from John Chamberlin, Technology Task Force Chair, and the state Senator Capps related to SMART portal projects are included.)
- *Professional development for Arkansas STEM teachers is an on-going educational collaborative effort of the Authority that is complementary to the EPSCoR goals*. EPSCoR project researchers will assist in developing lesson materials targeting curriculum relevant to plant-based bioproduction, nanotechnology, sensors and nano-neurobiology that will be incorporated into the SMART web-database of lesson plans for Arkansas teachers.

***DISSEMINATION & COMMUNICATION STRATEGIES AND PUBLIC OUTREACH*:**

- Arkansas ASSET initiative will develop a communication system to connect researchers within the Arkansas network with the outside scientific community.
- Support and training workshops will be developed for effective collaborations and media interactions.
- Use of Access grids for seminars and monthly meetings will be increased.
- Website resources will be expanded to support such efforts.
  - A password-protected interactive "Research Chat" mechanism will be developed at the Authority website to connect outside researchers with project researchers.
  - Regional grant-writing interactive and professional development workshop invitations will be posted with follow-up podcast of events.
  - Separate "Entrepreneurial interactive Chat" directed at commercialization, and notices of and podcast of SBIR/STTR workshops.
- Arkansas EPSCoR will host Research Day at the Capitol to educate legislators on value of R&D (2007 & 2009). A video will be produced highlighting successes resulting from R&D investment for use in 2009.
- Campus media specialists will work with the Authority communication officer to promote research and entrepreneurial successes at the website, in new media and other communication outlets.
- Regular radio 20-second successes will be featured during heavy commute periods.

VI. ARKANSAS NSF EPSCOR PROJECT MANAGEMENT PLAN

GENERAL OVERSIGHT:

Project Monitoring and Assessment: The Executive Management Team and External Advisory Board will monitor the on-line database of the evaluation progress metric for development in the research focus areas. The Arkansas EPSCoR Executive Management Team will provide technical and administrative oversight to ensure successful accomplishment of project milestones by effectively implementing, coordinating, measuring, and documenting project activities. This team is responsible for: 1) monitoring the progress of projects in meeting annual benchmarks, metrics and outcomes, 2) performing mid-course management corrections as needed, 3) ensuring effective stewardship of funds, 4) ensuring response to emerging opportunities as they develop, and 4) promoting collaboration, evaluation, visibility and program competitiveness.

EPSCoR Governing Committee: The Arkansas EPSCoR Governing Committee is an effective dedicated group of professionals responsible for establishing policies, criteria and procedures and providing oversight to ensure that project goals and objectives are met. The membership consists of twelve voting-members and additional ex-officio membership, representing program directors/management of numerous EPSCoR programs. A list of the EPSCoR Governing Committee membership and their representation is included in Support Documentation from Dr. Keith Hudson, UALR, Director of Graduate Institute of Technology and Chair of the state committee. Committee characteristics represent government, academic institutions, and private industrial sector. Committee member, Dr. John Ahlen, President, Arkansas Science & Technology Authority, is a member of the Governor's Cabinet. Members of the EPSCoR Governing Committee are recommended to, and approved by, the Board of the Arkansas Science & Technology Authority. The Arkansas EPSCoR Governing Committee has oversight of all EPSCoR federal grants (NSF, NIH, NASA, DOE, DOD and EPA) awarded to Arkansas researchers.

Project Director and Executive Management Team: The Arkansas EPSCoR Executive Management Team is headed by **Program Director**, Dr. Gail McClure who will serve as the PI for the Arkansas ASSET Initiative RII. Dr. McClure is Vice President Research, Arkansas Science & Technology Authority, and has several years experience as clinical project director/administrator in human clinical and translational studies. Dr. McClure will be responsible for all outreach and oversight of professional development efforts. Dr. Carole Cramer, Director of the Arkansas BioSciences Institute, ASU, and Dr. Vijay Varadan, 21st Century Endowed Chair in Nano- and Bio-Technologies and Medicine, UAF, will

serve as **Co-PIs and Technical Leaders**. The Co-PIs are responsible for research leadership, inter-university collaborations, and mentoring. Dr. Elizabeth Hood (ASU), Dr. Keith Hudson (UALR), and Dr. John Hehr (UAF) will serve as **Campus Coordinator/Administrators** to ensure project implementation and information flow between campuses and the Arkansas Science & Technology Authority.

The **Program Administrator** (to be hired) is responsible for the day-to-day program operations, including database management and tracking of project performance, assisting with financial transactions and general organization of events. This individual will have the dual responsibility of Outreach Program Manager and will focus on expansion of outreach capacity of EPSCoR funded programs and also management of private foundation funds (Winthrop Rockefeller Foundation grants) targeting the STEM educational pipeline in Arkansas. A **graduate student** intern will assist the Arkansas Science & Technology Authority Communications Director with the expanded communication and information dissemination efforts outlined above and in the evaluation metrics. General administrative staff support will be furnished by the Authority.

TECHNICAL ASSISTANCE AND MONITORING PLAN:

Technical Advisory Panels: These panels specific to the research projects and composed of individuals with unique expertise to the individual research fields will serve as technical advisors. Each panel will meet at six-month intervals via teleconference to evaluate progress and provide candid technical assistance. Summaries of these progress reports will be forwarded to the Executive Management Team and the Arkansas ASSET Initiative External Advisory Board. Membership of the External Technical Advisory Panels is address in the letters of support from the project-specific PIs (see Cramer and Varadan support letters).

Arkansas ASSET Initiative External Advisory Board: The External Advisory Board will conduct yearly site visits to each campus, regularly review the database for project progress, and provide overall technical/scientific review and guidance. This committee will be composed of six members: two with extensive EPSCoR experience and two experts specific to each project with unique technical experience. This Board will be responsible for the progress evaluation and will use the progress metrics (detailed in supplemental material) to provide guidance. Dr. James Coleman, Vice Chancellor for Research, University of Missouri, has agreed to chair our External Advisory Board. Dr. Coleman has many years of EPSCoR experience having previously served as NSF Program Director in Nevada (A letter from Dr. Coleman is included in support documentation).

Reverse Site-Visit: At approximately eighteen months into project, the executive management team and select researchers will travel to NSF offices for formal presentation of project progress for the reverse site visit. This event will provide opportunities to interact with NSF program directors and receive guidance from the NSF office.

VII. COMPREHENSIVE EVALUATION AND ASSESSMENT PLAN WITH MILESTONES

Evaluation Responsibilities of the Executive Management Team: Research leaders/Co-PIs will meet monthly with research unit senior mentors and/or research groups on the three campuses, either directly or via access grid, for coordination and monitoring of projects. The results of the monthly meetings will be entered into the Authority database (by Co-PIs and senior mentors) and the Executive Management Team will monitor program data entry and review raw data and metrics regularly. The monthly progress report will be summarized into quarterly reports by the Program Director. These quarterly reports will be reviewed by the Executive Management Team and forwarded to the External Advisory Board and the Arkansas EPSCoR Governing Committee. Quarterly meetings of the Executive Management Team will be used to assess short-term objectives and benchmarks to measure progress toward long-term goals.

Evaluation Responsibilities of External Evaluators: Arkansas ASSET Initiative will be reviewed according to the schedule above and evaluated on two fronts**:** 1) Project level progress will be reviewed

by the External Advisory Board annually during a three-day site visit touring each of the three research locations. 2) Specific technical progress will be reviewed by the External Technical Advisory Panels at six-month intervals via teleconference. The two separate technical advisory panels will focus on the individual science and mentor the individual research groups. Written reports of these six-month reviews will be forwarded to the Arkansas ASSET Initiative External Advisory Board. The Executive Management Team and the External Advisory Board will review the project's management performance by conducting implementation and progress evaluations (see supplemental materials) to assess level of competency within the overall evaluation categories below. The report prepared by these review committees must be shared in a timely manner with the NSF EPSCoR Office.

Evaluation Metrics: The **Arkansas ASSET Initiative** will include a number of evaluation components that will be used by both the two Technical Advisory Panels, the Arkansas ASSET Initiative External Advisory Board and by the project's Executive Management Team to determine whether projects are meeting the goals and objectives described in the RII proposal. These evaluation components include **Formative elements** (both implementation and progress evaluations) to provide information for monitoring the project during the award period and also **Summative evaluation elements** to assess the project's success as the project becomes established.

Project Monitoring and Assessment Plans (six general metric categories): The Arkansas Science & Technology Authority will develop an Arkansas Asset Initiative Progress Evaluation Database with restricted on-line entry for collecting the detailed evaluation metrics to measure progress toward the goals of the projects (Progress Metric Tables are included in the MOU prepared by Information Network of Arkansas included in supplemental documents - Brinsfield). These detailed metrics will incorporate data that will be collapsed to measure six areas of success in achieving statewide infrastructure aligned with NSF EPSCoR objectives, the **Overall Evaluation Metric** below. Detailed progress metrics will be updated monthly and data will be automatically summarized for review by the Executive Management Team and research leaders. The characteristics of the Overall Evaluation Metric are correlated with those drafted by EPSCoR Evaluation Working Group. These six categories encompass the three goals of the Arkansas ASSET Initiative Progress Evaluation Database and the database will be used to extract the evaluation categories below for formal reporting to the NSF EPSCoR office.

EVALUATION PLAN

***Implementation Evaluation*.** Implementation evaluation provides specific goals, milestones, metrics and outcomes developed to assess whether the project is being conducted as planned. The External Advisory Board will assess the implementation metrics yearly, and the plan and the milestones will be revised and improved as directed to ensure success of the project and adequate monitoring by both the Executive Management Team and the NSF EPSCoR office.

Progress Evaluation. The specific progress metrics of the database included in support documentation will assist the Executive Management Team, the External Technical Advisory Boards and the Arkansas ASSET Initiative External Advisory Board in assessing the project's progress toward project goals.

Summative Evaluation. During year three, the External Advisory Board will work with the Executive Management Team to analyze and summarize the key project outcomes/impacts as a summative evaluation. These key metrics will come from the **detailed progress metrics** and will be refined during the first two years of the project at the direction of the External Advisory Board. A subset of the most significant aspects of the progress evaluation will be used during year three to develop the summative report. Data collection and quarterly summaries of Arkansas EPSCoR maintained by the Arkansas Science & Technology Authority will be accessible for the External Advisory Board's routine monitoring and summary reviews. The final report of the External Advisory Board will include qualitative and quantitative summary data of the project

accomplishments toward meeting the three goals outlined in the project: infrastructure/capacity building, collaboration and student human resource development.

Overall Evaluation Metric

Research Production	Number of publications in major journals
	Number of productive patents, new products, and other forms of intellectual property
Research Portfolio Quality	Number of NSF Centers or center-like R&D organizations established within jurisdiction
	Number and nature of successful awards from NSF and other agencies (e.g., NIH, DOD, etc.)
Human Resource Development	Number of faculty and staff supported in part by EPSCoR who are engaged in research
	Number of undergraduates, graduate students, post-docs and others engaged in research and development
	Number of K–12 outreach efforts with some *reliable evidence* of an impact
Research Investments and Materials	Total dollars raised to support research (annually and cumulatively)
	Ratio of total research dollars to EPSCoR funding
	Total dollars spent on research facilities and equipment (e.g., purchasing of equipment, renovation of facilities, etc.)
	Number and amount of start-up or seed packages for new faculty
	Number, amount, and nature of co-funded awards
Research Collaboration and Networking	Number of functioning projects with faculty and researchers from multiple institutions
	Number of collaborative efforts that have produced proposals for centers
Research Climate, Culture, and Communications	Amount of annual state funding allocated to research
	Amount of annual university funding allocated to research

VIII. PLAN FOR LONG-TERM SUSTAINABILITY

Funding Strategy and Sustainability: Arkansas researchers will be provided many competitive advantages through EPSCoR, and they in turn are accountable for their growth in research competitiveness (which will be charted individually). Within the specific research focus area of Arkansas ASSET Initiative, researchers will have ample opportunities to interact with research partners, expand collaborations including interjurisdictional and national/international connections, and learn from external mentors and nationally recognized seminar guests. Arkansas EPSCoR and the Executive Management Team will strive to increase the outreach visits of federal agency program directors to Arkansas campuses, to educate federal personnel of Arkansas capabilities, and to improve researcher responsiveness to funding opportunities. Arkansas ASSET Initiative participants will have many opportunities for communication within the network (Access grid and regular meeting events), as well as through EPSCoR-funded professional exchanges and travel opportunities for professional development. The Executive Management Team will monitor the progress of all participants to ensure that all are taking full advantage of these numerous venues to expand research activities and capabilities, share best practices, develop manuscripts, and plan and prepare proposals for future funding opportunities.

To ensure future competitiveness and **sustainability** of the strengths that the EPSCoR funding support brings to Arkansas, two additional targets supporting future competitiveness will be provided: 1) "reassigned time" from teaching responsibilities to allow development and expansion of competitive research focus areas; and 2) opportunities for proposal "pre-review" prior to submission. Support letters (Supplemental documents from Dr. Joel Anderson & Dr. Susan Allen are included) from

university administrations assuring ample reassigned time for designated writing teams of multi-university research collaborative efforts developing large (> $1,000,000) interdisciplinary proposals have been included in supplemental materials. Financial support will also be established for very large multi-million dollar proposals to provide "intense external pre-review" process. Such "pre-review" would entail external review by targeted experts/mentors in the scientific field, expert panel visits to the state, and a series of workshops and other interactive sessions to address all critiques before finalizing submission. Junior faculty will be assisted by successful proposal writers throughout this process to help in analyzing reviewer comments and addressing weaknesses. Arkansas universities will assist in support of this effort and continue in their support after EPSCoR funding ends.

Center Strategy and Sustainability: During year three of this proposal, the two research infrastructure platforms will have the opportunity to make application to the Authority to establish "Centers for Applied Technology" within their specific research focus area. The Arkansas Science & Technology Authority Centers for Applied Technology Program was created to *identify, designate, and fund* Centers in technological areas with significant potential for economic growth and development in Arkansas, or in which the application of new technologies could significantly enhance the productivity and stability of Arkansas enterprises. The purpose of this program of the Authority is to encourage greater collaboration between private enterprises and Arkansas colleges and universities in the development and application of new technologies. In addition to financial support for the state, the establishment of such a Center of the Authority allows a long-term R&D plan under which universities can partner with industry to leverage the 33% industry tax credit on all industry research investment to expand their financial research support.

Outreach Strategy and Sustainability: The Program Director of the Arkansas ASSET Initiative is directly responsible for the Outreach Programs of the project. The Program Director will co-chair a State HR-Outreach Committee, along with EPSCoR Governing Committee Member, Dr. Karen Wheeler, Associate Director, Arkansas Department of Higher Education. This committee will head up a professional group that will help coordinate opportunities for outreach on university/college campuses statewide. This committee will identify funding opportunities targeting human resource development, identify HR strengths and weaknesses on campuses statewide (including all 2-year and 4-year campuses), and work to expand involvement of Arkansas colleges and universities in funded activities. This committee will take immediate steps (with the assistance of university grant-writing staff) to: 1) expand REU programs (McNair, STRIVE, RISE and others) on participating campuses, 2) expand information about and applications to a state grants program known as SURF (Student Undergraduate Research Fellowships), and 3) target expanding participation of 2- and 4-year colleges in summer research experience programs.

In addition to campus-based programs, Arkansas EPSCoR will continue to work with science specialists (established by the 2003 EPSCoR and now funded by state government) at each of the twelve regional science and math education centers. Since these centers are geographically distributed throughout the state, these science specialists will focus on strengthening science curricula and professional development of STEM teachers at the local level.