| Exhibit R-2a, RDT&E Project Justification | | | | | | | | Date: February 2003 |
|---|---|---|---|---|---|---|---|---|
| Appropriation/Budget Activity<br>RDT&E, Defense Wide/BA 1 | | | | Project Name and Number<br>*** URI/Project P103 PE-0601103D8Z** | | | | |
| Cost ($ in millions) | FY 2002 | FY 2003 | FY 2004 | FY 2005 | FY 2006 | FY 2007 | FY 2008 | FY 2009 |
| URI/Project P103 | 248.997 | 234.778 | 0 | 0 | 0 | 0 | 0 | 0 |

**A. Mission Description and Budget Item Justification:**

*** Beginning in FY 2004, University Research Initiative will be transferred to the Army, Navy, and Air Force for management and execution and will result in a more appropriate policy-level role by OSD. The Army (060113A), Navy (0601103N, and Air Force (0601103F) will each received 1/3 of the funding for Multidisciplinary Research Initiatives and the Defense University Instrumentation program. In addition the Air Force has been designated lead for the undergraduate/graduate education in Science & Engineering programs and will execute this initiative under 0601103F.**

(U) P103, University Research Initiative (URI). This project competitively supports programs at universities nationwide in three interrelated categories that parallel the three primary objectives for the URI program element. In the first category are efforts that have, as their principal purpose, the support of basic research in science and engineering disciplines pertinent to maintaining the U.S. military technology superiority. In the second category, the principal purpose of the efforts is contributing to the research-related education of future scientists and engineers in disciplines critical to defense needs. The principal purpose of efforts in the third category is to help build and maintain the infrastructure needed for high-quality defense research performed at universities.

**B. Accomplishments/Planned Program**

| | FY 2002 | FY 2003 | | |
|---|---|---|---|---|
| Category 1: Research is principal purpose | 139.044 | 133.315 | | |

**(U) <u>FY2002 Accomplishments</u>:**

(U) Programmatic accomplishments:

As a result of a competition for new multidisciplinary efforts, the Services and DARPA made 26 new awards to conduct basic research underpinning high-priority technology areas such as: adaptive coordinated control of multiple platforms, multifunction designer materials, energetic materials, explosive-specific chemical sensors, land-target spectral signatures, optical clocks for precision timing, renewable logistic fuels for fuel cells, adaptive software system interoperability, adaptive materials for energy absorbing structures, scalability of networked systems, and integrated nanosensors. Multidisciplinary and PECASE programs begun in prior years are continuing, with new competitive awards under the PECASE program.

(U) Selected technical accomplishments:

- Vanderbilt University researchers identified the atomic-scale processes responsible for radiation-induced degradation in electronic devices and developed engineering models using these physics results to design high-performance radiation-hardened electronic devices. They obtained the results from recently developed first-principles computational and materials-characterization methods, applying some of them for the first time to radiation-induced defects. The atomic-scale models enable the researchers to calculate the number of point defects of various types that are produced in device materials as a function of the energy and intensity of energetic particles or photon irradiation. The outputs of the atomic-scale models developed under this basic research effort then are used as inputs to models of macroscopic materials processing and device performance, engineering models developed under Military Department and Defense Agency applied research funding. By linking the basic science to the engineering in this way, sensitivity to radiation damage is a parameter taken into account from the outset in device design. Using this new link from first principles to engineering design, the researchers' specific accomplishments include identification of alternative materials to replace silicon dioxide as the gate dielectric in silicon electronic components. Materials with higher dielectric constants are needed as device sizes decrease, reducing gate oxide regions to thicknesses as small as 1-3 atoms. Using their models to calculate radiation damage and validating the calculations with experimental measurements, the researchers identified candidate dielectric materials such as hafnium dioxide that are much less susceptible to single-event dielectric rupture, an important radiation-induced failure mechanism. The researchers' results are informing the electronic industry's update of its roadmap for microelectronics. Radiation-hardened electronics have high potential for applications addressing a broad spectrum of defense needs, including communications, computing, and control systems.

- Researchers at Duke University, the Georgia Institute of Technology, and the Ohio State University (OSU) studied the science underlying land mine sensing. Duke scientists generated signal processing algorithms and electromagnetic modeling tools for wide-area sensing of land mines by airborne radar, enabling one to identify areas with high densities of land mines for subsequent interrogation by ground-based sensors. The models predict scattering signals for various types of mines, allowing one to discriminate between mine types as well as detect them. The university researchers worked with the Army Research Laboratory (ARL) to demonstrate mine-field detection at Yuma and Aberdeen Proving Grounds. The algorithms and modeling tools also transitioned to the DoD High Performance Computing Modernization Office. Georgia Tech pioneered a technique for launching acoustic waves into the soil and using small Doppler shifts of scattered waves to detect buried mines. An important and unexpected result of the Georgia Tech research was that elastic elements of mines (e.g. springs in the firing system) have acoustic resonances, providing distinctive signatures that let one discriminate mines from rocks, roots, or other natural clutter and eliminate false positive signals that plagued earlier detection methods. OSU researchers did the first rigorous analysis to understand infrared (IR) signatures of land mines as a function of soil properties (e.g., surface roughness) and environmental conditions such as temperature and time of day. The researchers' numerical model, which explains many diurnal properties seen in measured imagery, has transitioned to the Army's Night Vision and Electro-optical Systems Directorate (NVESD). NVESD is using the model to guide development of the next-generation IR sensors for land mines.

- A research team led by Cornell University and the University of California at San Diego explored how distinctive material properties of nitrides of gallium, aluminum, and indium (GaN, AlN, and InN) can enhance or degrade semiconductor device performance. Nitride-based semiconductors are emerging as key materials for many defense applications due to their wide bandgaps. Unlike silicon or gallium arsenide, however, they have strong spontaneous and piezoelectric polarization effects due to inherent dipole moments in the unit cell of the crystal lattice. The team quantified the polarization effects using ab initio computation and experimental measurement; for example, photoluminescence and scanning probe measurements with submicron resolution uncovered charge effects of dislocations and spatially varying threshold voltage in transistors, which can degrade device uniformity and current-carrying capability. They also found a way to exploit polarization effects in optimized, AlN-on-GaN heterostructures and create 2-dimensional electron gases with record high sheet charge and mobility and sheet resistance less than half that of conventional structures, which should lead to higher power, lower noise transistors. The researchers made InN films with greater crystallographic quality than before, opening up possibilities for optical emitters and detectors over wider (infrared to ultraviolet) wavelength ranges and for field effect transistors (FETs) able to carry more current and with better ohmic contact to external devices. They demonstrated specially designed energy barriers in nitride-based semiconductor transistors and diodes, based on polarization, that can increase FET speed and reduce noise by optimizing carrier confinement in channel regions. They found that surface charge of nitride materials can be varied with polar liquids, gases and ions; this feature can lead to new types of gas sensors more easily combined with on-chip amplifying electronics, but it also demonstrates the strong need to carefully passivate transistor surfaces. These results are a significant advance in understanding semiconductor devices using recently discovered nitride materials, which have excellent potential for defense applications such as microwave and millimeter-wave power amplifiers, ultraviolet and blue light emitters, and solar blind detectors.

**(U)** **FY2003 Plans:**
The Services and DARPA are conducting a competition for new multidisciplinary basic research efforts underpinning high priority science and technology areas such as: minimal organotypic cell systems, ceramic composites, molecular science of fuel cell systems, integrated artificial muscles for biorobotic undersea vehicles, direct thermal to electric energy conversion, image processing sensors for autonomous vehicles, biological synthesis of ceramic microdevices, hybrid inferencing of fused information, and nanoscale conversion of biomolecular signals. Multidisciplinary and PECASE programs begun in prior years will continue, with new competitive awards under the PECASE program.

| | FY 2002 | FY 2003 | FY 2004 | FY 2005 |
|---|---|---|---|---|
| Category 2: Research-related education is principal purpose | 26.166 | 21.024 | 0 | 0 |

**(U) FY2002 Accomplishments:**

As a result of the FY 2002 competition under the National Defense Science and Engineering Graduate (NDSEG) Fellowship program, 170 new graduate fellowships were awarded for study leading to advanced degrees in science and engineering fields of importance to national defense, such as electrical engineering, computer science, material science and engineering, mathematics, and mechanical engineering.

**(U) FY2003 Plans:**

Competitions will be conducted each year under the NDSEG Fellowship Program. Approximately 155 graduate fellowships will be awarded in FY 2003. In FY 2003, a competition will be conducted for a new ASSURE program to support undergraduate research experiences.

| | FY 2002 | FY 2003 | FY 2004 | FY 2005 |
|---|---|---|---|---|
| Category 3: Research infrastructure is principal purpose | 45.377 | 42.234 | 0 | 0 |

**(U) FY2002 Accomplishments:**

- A competition under the Defense University Research Instrumentation (DURIP) program resulted in 209 awards for the purchase of items of research equipment that are more costly than can be acquired under typical, single-investigator university research awards and that are needed to maintain university capabilities to perform cutting-edge research in areas critical to future military capabilities. DURIP awards thereby provide equipment essential for all DoD-supported university basic and applied research, in which the DoD invests about $1.2 billion annually.

**(U) FY2003 Plans:**

A DURIP competition will be conducted each year to make approximately 200 new awards for the purchase of research instrumentation.

| | FY 2002 | FY 2003 | FY 2004 | FY 2005 |
|---|---|---|---|---|
| Cross-Cut Networking & IT | 12.410 | 11.786 | 0 | 0 |

**(U) Investment in OSTP Cross-cut —Basic Research Underpinning Networking and Information Technology:**

This project supports basic research related to computing and information technology, including high-end computing, human computer interfaces and information management, large scale networking, and software design and productivity. Specific efforts address quantum computing and quantum memories, tutorial dialog for artificially intelligent training systems, mobile augmented battlespace visualization, decision making under information uncertainty, data fusion in large arrays of microsensors, scalability of networked systems, real-time fault-tolerant network protocols, and adaptive system interoperability.

| | FY 2002 | FY 2003 | FY 2004 | FY 2005 |
|---|---|---|---|---|
| Cross-Cut NNI | 26.000 | 26.419 | 0 | 0 |

**(U) Investment in OSTP Cross-cut —Basic Research in Areas Related to the National Nanotechnology Initiative (NNI):**

This project supports basic research in NNI-related nanotechnology areas of importance to DoD, such as nanocomposite and nanoenergetic materials; nanoscale electronics, magnetics, and photonics; nanoprocessing and self-assembly, nanostructured coatings, nanoscale ceramic and metal particles, and nanobiosciences. Specific efforts ddress nanoscale machines and motors, molecular control of nanoelectronic and nanomagnetic structure formation, nano-energetic systems, synthesis and functionalization of carbon nanotubes, nanoscale electronic devices and architectures, polymeric nanocomposites, signal transduction in biomolecular systems, synthesis and modification of nanostructured surfaces, and nanomagnetic particles for biotechnology.

**C. Other Program Funding Summary:** Not applicable.

**D. Acquisition Strategy.** Not applicable.

**E. Major Performers:** This project provides support for research, education and infrastructure at more than 125 institutions of higher education. No one institution received more than $10 million this year.