RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense Wide/BA 1	R-1 ITEM NOMENCLATURE UNIVERSITY RESEARCH INITIATIVE PE 0601103D8Z

COST *(In Millions)*	FY2001	FY2002	FY2003	FY2004	FY2005	FY2006	FY2007		Cost to Complete	Total Cost
Total Program Element (PE) Cost	292.355	248.997	221.610	243.977	265.456	249.536	241.718		Continuing	Continuing
URI/P103	292.355	248.997	221.610	243.977	265.456	249.536	241.718		Continuing	Continuing

(U) A. Mission Description and Budget Item Justification

(U) BRIEF DESCRIPTION OF ELEMENT:

(U) P103, University Research Initiative (URI). The URI has three primary objectives: (1) to support basic research in a wide range of scientific and engineering disciplines pertinent to maintaining the U.S. military technology superiority; (2) to contribute to the education of scientists and engineers in disciplines critical to defense needs; and (3) to help build and maintain the infrastructure needed to improve the quality of defense research performed at universities. Paralleling these objectives, this project competitively supports programs at universities nationwide in three interrelated categories:

- Research. The main thrust of the URI is multidisciplinary research. Multidisciplinary efforts involve teams of researchers investigating high-priority topics that intersect more than one traditional technical discipline; for many complex problems, this multidisciplinary approach serves to accelerate research progress and expedite transition of results to application. The URI also supports the Presidential Early Career Awards for Scientists and Engineers (PECASE), single-investigator research efforts performed by outstanding academic scientists and engineers early in their independent research careers.

- Education. The URI promotes graduate education in science and engineering for U.S. citizens through the National Defense Science and Engineering Graduate Fellowship Program. Beginning in FY 2003, the Awards to Stimulate and Support Undergraduate Research Experiences (ASSURE) program provides research opportunities for undergraduate students in science and engineering fields important to national defense, to encourage them to continue their studies and pursue advanced degrees.

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- Infrastructure. Through the Defense University Research Instrumentation Program (DURIP), the URI contributes to the university research infrastructure that is essential for the performance of cutting-edge defense research. The DURIP allows researchers to purchase more costly items of research equipment than typically can be acquired under single-investigator awards. Through FY 2001, the URI also included the URI Support Program (URISP), which broadens the base of academic institutions participating in defense research by involving institutions that historically have not received much defense funding.

(U) PROGRAM ACCOMPLISHMENTS AND PLANS:

(U) <u>FY2001 Accomplishments:</u>

(U) Programmatic accomplishments:

- Research. The Services and DARPA made 84 new awards as a result of three FY 2001 competitions for new multidisciplinary research efforts. The first competition, resulting in 48 new awards, was for basic research underpinning high-priority technology areas such as: infrared detection; wideband communications; networked and distributed systems; microchemical systems; biological and chemical sensing; smart and adaptive structures; visualization of multi-source information; space weather effects; self-configuring surveillance networks; machine language translation; low-noise, solid state electronics; high-temperature superconductors; nano-engineered coatings; and polymeric, smart skin materials. The second competition was under the Department of Defense portion of the National Nanotechnology Initiative. As a result of that competition, the Services made 16 new awards focused on defense-relevant electronics, materials and biotechnology at the nanoscale. The awards are in areas such as machines and motors; energetic materials; electronic and magnetic structures; quantum computing; carbon nanotubes; and deformation, fatigue, and fracture of interfacial materials. The third competition was for an initiative in critical infrastructure protection. Following that competition, the Services made 20 new awards focused on information assurance and high-confidence adaptable software, including novel network architectures, network surveillance and software protection, high-confidence embedded systems, mobile codes, distributed computing, dynamic network management, and software quality assurance. Multidisciplinary and PECASE programs begun in prior years are continuing, with new competitive awards under the PECASE program. ($194.068 million)

- Education. As a result of the FY 2001 competition under the National Defense Science and Engineering Graduate Fellowship program, 285 new graduate fellowships were awarded for study leading to advanced degrees in science and engineering fields of importance to national defense. Another competition, part of the FY 2001 initiative in critical infrastructure protection, led to 12 postdoctoral fellowship awards. ($43.545 million)

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- Infrastructure. FY 2001 competitions resulted in more than 240 new awards for research instrumentation under the DURIP program and National Nanotechnology Initiative. Efforts begun in prior years under the URI Support Program were completed. ($54.742 million)

(U) Selected technical accomplishments:

- Researchers at Arizona State University, working with researchers from the University of Illinois, the University of Notre Dame, and the University of California at Berkeley found a way to increase metal-oxide semiconductor (MOS) device lifetimes, by substituting deuterium for hydrogen to reduce rates at which damage is caused by electron collisions with hydrogen atoms in the MOS material. Hydrogen atoms are added to MOS materials to eliminate holes that otherwise trap conduction electrons and disrupt device operation. Damage results when electrons, accelerated by the electric field in a device, collide with and ionize the hydrogen atoms. Previously, it was assumed that this damage was caused primarily by a relatively small number of "hot" electrons, electrons accelerated by the field to an energy high enough to ionize the hydrogen. By measuring effects of electron bombardment of MOS material, the researchers surprisingly found that much of the damage was due to a cumulative effect of collisions by a larger number of lower energy electrons. Using computer simulations of the quantum mechanics of device materials, the researchers were able to attribute the result to the electrons progressively exciting the hydrogen to higher energy levels, ultimately culminating in ionization. The researchers discovered through simulation and experiment that they could reduce damage rates 100-fold, and correspondingly increase device lifetimes, by adding deuterium (a heavy hydrogen isotope) to the MOS material, rather than hydrogen. Increases in device lifetimes are greatest in ultrasmall devices but still significant in larger devices, particularly devices used at high frequencies (where deuterium substitution yields either a longer lifetime at a given operating frequency or higher frequency operation with the same lifetime as hydrogen). The computer simulation techniques and deuterium processing technology have been transferred to major semiconductor device manufacturers, which will result in longer-lived and higher frequency devices for military applications.

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- Researchers at Northwestern University extended their revolutionary dip-pen nanolithography (DPN) technique to biological molecules and coupled it with their successful binding of DNA to nanoparticles, opening up new possibilities for nanoassembly and for detection of chemical and biological agents. The DPN method uses an atomic force microscope (AFM) tip coated with an "ink" to write lines on a substrate that are as small as 15 nanometers wide and less than 5 nanometers apart. A detailed understanding of the transport of "ink" molecules through the fluid meniscus formed between the AFM tip and the surface enabled the researchers to deposit biological molecules such as collagen fibers, proteins, and single-strand DNA. The ability to write with single-strand DNA, with linewidths of less than 50 nanometers, is especially important because: (1) the DNA selectively binds to complementary DNA strands; (2) the researchers developed a method to bind complementary DNA strands to nanoparticles; and (3) that enables them to use DNA patterns written on a substrate to attach nanoparticles in precise locations as building blocks for assembling complex, three-dimensional structures of nanometer dimensions. This nano-fabrication technique has important applications in defense-relevant areas such as molecular electronics and compact power sources. In another application, the researchers and the Army tested a portable device using single-strand DNA bound to gold nanoparticles to detect genetic markers for anthrax at levels lower than one part per billion, up to 100 times better sensitivity than current methods; the method is faster and less expensive than existing DNA-based detection methods because it avoids using bulky polymerase chain reaction techniques to amplify and detect the bioagent.

- Yale University scientists used atom interferometry for the first time to detect gradients in gravitational forces, which may help answer a long-standing military need for remote standoff detection of underground structures such as tunnels and bunkers. With sufficient resolution, sensitivity, and noise immunity, gravity gradiometers can detect minute variations in gravitational fields caused by underground voids. Gravity gradiometers using atom interferometry inherently can resolve small-scale features due to the short wavelengths of the matter waves (approximately 10,000 times shorter than visible light). To get higher sensitivity, the Yale researchers used an atom interferometer with atoms cooled to low temperatures using techniques developed for Bose-Einstein condensation. This method for getting a beam with laser-like coherence (i.e., a small spread in atomic velocities that translates into a narrow range of wavelengths) improved the sensitivity of their interferometer relative to previous atom interferometers that used uncooled beams and passed them through slits to narrow the spread of atomic velocities (thereby reducing beam intensity). The resulting sensitivity is ten times higher than conventional gravity gradiometers. Immunity to noise results from the gravity gradiometer's use of two adjacent and parallel atomic beams; that helps the device discriminate against noise from vibrations, which is critical for airborne applications, and other environmental factors (since the factors affect the two beams equally, the interferometer detects no resulting phase difference between the beams that would otherwise interfere with small signals from slight gradients in gravity). The atomic beam gradiometer also has significantly enhanced long-term stability. The resulting performance may allow, for the first time, detection from low flying aircraft at altitudes up to 500 feet of tunnels and bunkers with 5-meter diameters. The researchers are working with the Department of Defense on a field demonstration of the technique. Calculations suggest that sensors based on atomic interferometry have the potential for increased sensitivity that could allow detection of structures from higher altitudes.

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(U) FY 2002 Plans:

- Research. In the second quarter of FY 2002, the Department of Defense will announce the results of the competition conducted by the Services for new multidisciplinary basic research efforts underpinning high-priority technology areas such as: adaptive coordinated control of multiple platforms, multifunction materials, energetic material design, explosive-specific chemical sensors, land-target spectral signatures, optical clocks for precision timing, renewable logistic fuel cells, adaptive software system interoperability, energy absorbing materials and structures, scalability of networked systems, and integrated nanosensors. Multidisciplinary and PECASE programs begun in prior years will continue, with new competitive awards under the PECASE program. ($176.326 million)

- Education. The FY 2002 competition under the National Defense Science and Engineering Graduate Fellowship Program will result in the award of approximately 180 graduate fellowships. ($26.586 million)

- Infrastructure. The FY 2002 competition under the DURIP program will lead to approximately 240 new instrumentation awards. ($46.085 million)

(U) FY2003 Plans:

- Research. Topics for the FY 2003 multidisciplinary research competition will be selected in strategic basic research areas related to transformational and other high-priority technologies, such as research areas related to: biomimetic sensor networks, intelligence information fusion, smart materials and structures, efficient energy and power conversion, high energy materials for propulsion and control, and enhancing human performance for military missions. A new multidisciplinary thrust in FY 2003 will address a need for research and related student training in instrumentation development. Multidisciplinary and PECASE programs begun in prior years will continue, with new competitive awards under the PECASE program. ($155.299 million)

- Education. A FY 2003 competition will be conducted to award approximately 140 graduate fellowships under the National Defense Science and Engineering Graduate Fellowship Program. The first competition will be conducted under the new ASSURE program to support undergraduate research experiences. ($23.118 million)

- Infrastructure. A FY 2003 competition will be conducted to make approximately 230 new instrumentation awards under the DURIP program. ($43.193 million)

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(U) **ACQUISITION STRATEGY:** Not Applicable

(U) B. Program Change Summary	FY 2001	FY 2002	FY 2003	Total Cost
Previous President's Budget Submission	253.627	217.549	217.957	Continuing
Delta	38.659	22.825	0.000	
FY 2002 Amended President's Budget Submission	292.286	240.374	217.957	Continuing
Appropriated Value	295.077	250.874	0.000	
Adjustments to Appropriated Value				
a. Congressionally Directed Undistributed Reduction	0.000	-1.877	0.000	
b. Rescission/Below-threshold Reprogramming, Inflation Adjustment	-2.722	0.000	0.000	
c. Other	0.000	0.000	3.653	
Current FY 2003 Budget Submission	292.355	248.997	221.610	Continuing

Change Summary Explanation:

(U) **Funding:** FY 2001 adjustments reflect Congressional undistributed reductions and a reprogramming action included in the FY 2000 omnibus reprogramming request. FY 2003-2005 adjustments are to establish a stable profile for the multidisciplinary research portion of this program element, with a comparable number of new efforts competitively begun each year.

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(U) **Schedule:** Not applicable.

(U) **Technical:** Not applicable.

(U) **C. Other Program Funding Summary Cost** Not applicable.

(U) **D. Schedule Profile** Not applicable.