RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE June 2001
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense Wide/BA 1	R-1 ITEM NOMENCLATURE UNIVERSITY RESEARCH INITIATIVE PE 0601103D8Z

COST *(In Millions)*	FY2000	FY2001	FY2002						Cost to Complete	Total Cost
Total Program Element (PE) Cost	223.366	292.286	240.374						Continuing	Continuing
URI/P103	201.853	292.286	240.374						Continuing	Continuing
DEPSCoR/P104	21.513	0.000	0.000						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. Two multidisciplinary thrusts beginning in FY2001 are university research for the National Nanotechnology Initiative and for critical military infrastructure protection. 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.

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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 includes 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. These programs complement the infrastructure building of the Defense Experimental Program to Stimulate Competitive Research that was in project P104 of this program element through FY 2000.

(U) P 104, Defense Experimental Program to Stimulate Competitive Research (DEPSCoR). The DEPSCoR helps build research infrastructure at academic institutions in states that historically have not received much Federal research funding. In FY 2001, the DEPSCoR moved from project 104 within this URI program element into a new program element (PE 0601114D8Z).

(U) PROGRAM ACCOMPLISHMENTS AND PLANS:

(U) FY2000 Accomplishments:

(U) Programmatic accomplishments:

- Research. The FY 2000 multidisciplinary research competition conducted by the Services resulted in 20 new awards in high-priority basic research areas of multi-Service interest related to: data fusion in microsensor arrays; adaptive learning technology; decision making in the presence of uncertain information; battlespace visualization; real-time, fault-tolerant network protocols; solitonic information processing; quantum communications and memory; mobile wireless networks; electronics and optoelectronics; ultracold atom optics; functional materials; and prime reliant coatings. New knowledge and understanding resulting from basic research related to these technology areas will lead to applications relevant to a broad range of future military systems. The multidisciplinary nature of these areas, and their multi-Service relevance, make them ideally suited for inclusion under the multidisciplinary element of the URI. In addition to the new multidisciplinary research efforts, multidisciplinary and PECASE programs begun in prior years continued, with new competitive awards for PECASE programs. ($139.574 million)

- Education. Under the National Defense Science and Engineering Graduate Fellowship program, 108 new graduate fellowships were competitively awarded for study leading to advanced degrees in science and engineering fields of importance to national defense. ($13.848 million)

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- Infrastructure. More than 220 new awards were made under the FY 2000 DURIP competition, enabling the purchase of research instrumentation needed to sustain universities' capabilities to perform cutting-edge defense research. Under the URI Support Program, efforts initiated in prior years continued in areas such as electronic and magnetic materials, image analysis, micromanufacturing, and neurodynamics. The FY 2000 competition under the DEPSCoR program resulted in 81 new awards. ($69.944 million)

(U) Selected technical accomplishments:

- Researchers at the State University of New York at Stony Brook, in partnership with Rensselaer Polytechnic Institute, Boston University, Iowa State University, Arizona State University, and Manhattan College, developed a comprehensive computer model to simulate and improve understanding of crystal growth processes. The model is unique in that it covers globally the entire system involved in crystal growth (e.g., the heat transfer from the various heaters, the dynamics of the liquid phase from which the crystal grows, the growing solid phase and its interface with the liquid phase). The increased understanding permits growth of crystals with fewer defects, leading to increased yields and usable crystals of larger diameters. One advance concerns indium phosphide (InP) crystals needed for high frequency satellite-to-ground and satellite-to-satellite links. For InP, the team used simulations, crystal growth experiments (in collaboration with the Air Force Research Laboratory, Sensors Directorate) and characterizations of resulting materials to understand how the density of crystal defects—twins and dislocations—are linked to material stress and thereby to growth conditions (e.g., temperature, temperature gradient, pressure, and rotation rate of the sample during growth). Using this knowledge, they controlled growth conditions to reduce twins and dislocations, producing usable crystals with twice the diameter (4", rather than 2") and 25% greater yields. Another advance is for silicon carbide (SiC) crystals used in solid-state devices for high-power microwave applications, particularly where higher operating temperatures are needed. By simulating the vapor growth of SiC and using the new understanding to improve control of the process, the researchers reduced the size of "micropipes," microscopic holes that make the crystal surface unusable for electronic devices, and reduced their density from over 1000 to as little as 2-3 per square centimeter. With this reduction in micropipe density, 75% more chips can be placed on a wafer of a given size. In a third area, the researchers developed the first model of the hydrothermal synthesis process that is used to grow high-quality quartz crystals for timing in the Global Positioning System and other space-based applications. Resulting improvements in that process can enable 30-40% higher growth rates for advanced nonlinear optical materials, such as bismuth silicate and zinc oxide that are used to process and store information.

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- Scientists and engineers at the University of California at Los Angeles and University of Southern California (USC) synthesized a new electro-optic polymer with an exceptionally high electro-optic (E-O) coefficient. The new material enabled USC researchers to demonstrate an E-O modulator for optical communications that has lower optical loss than lithium niobate and operates at high frequencies with significantly lower applied voltages. The high-E-O coefficient in the polymer stems from inclusion of highly polarizable molecules called chromophores. Based on their theoretical analysis, the scientists modified the chromophores' shape in a way that allowed the molecules to better align with each other, thereby yielding E-O coefficients comparable to those observed in an inorganic modulator material like lithium niobate. With the polymer, however, the light wave that is being modulated moves at a speed that more closely matches the speed of the applied, radio-frequency (RF) voltage that does the modulating, allowing the modulation to occur over a longer interaction region within the polymeric material than it would in the inorganic material. Consequently, the polymer needs less RF driving voltage at any given modulation frequency and can operate at higher frequencies before the gain of the link falls off or the noise level becomes too large. The researchers have demonstrated a modulator at about 100 gigaherz with good thermal stability to temperatures near 100 degrees Farenheit, drive voltage near one volt, and low insertion loss (less than 8 decibels from the input to output optical fiber). This advance is important to high-bandwidth data transmission for the digitized battlefield, network-centric warfare (e.g., using a secure, internet-based, common tactical picture), and many other military applications.

- A team of aerospace engineers and materials scientists at the Massachusetts Institute of Technology made a number of strides toward developing piezoelectric actuators capable of larger mechanical displacements, or strokes. Longer-stroke actuators are important for military applications such as twisting helicopter rotor blades or rotating their trailing edge flaps, to reduce harmful blade vibrations and blade-vortex interaction noise. The team grew for the first time single-crystal fibers of high-strain piezoelectric oxides (e.g., sodium bismuth titanate, or NBT), using an edge-defined film-fed growth method. The NBT's maximum strain is larger than the maximum strain for what is now the leading piezoelectric ceramic material, lead zirconate titanate (PZT). With the added advantage of the single crystal fibers, as opposed to polycrystalline PZT fibers, the researchers demonstrated actuators with eight times the stroke of conventional PZT actuators. Switching to crystalline oxides from PZT, which contains lead, also will reduce toxicity. Another accomplishment was the development of a micro-molding technique to form interconnected mats of polycrystalline fibers. This technique offers two advantages over current methods. It produces higher quality fibers, with fewer voids or other defects, to increase the length of the stroke obtainable with polycrystalline materials. More importantly, it produces interconnected mats of fibers—current methods generate single fibers of 130 micron diameter and building an actuator is a labor-intensive process that requires alignment of hundreds of fibers, one by one, into a sheet. This is an important step toward increasing production and reducing the cost of an actuator from about $1,000 currently, with the goal being to reduce it to $20-25. In parallel with these efforts, the team developed a mathematical model to gain an understanding of the transient behavior, under slow loading conditions, of active fiber composites and other highly insulating devices; this understanding is needed to help optimize piezoelectric actuators for defense applications.

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- Researchers at the University of Texas at Austin developed a new approach for detecting low concentrations of chemical and biological warfare agents. The approach identifies specific agents and does so quickly, allowing personnel to protect themselves or take medical countermeasures. The new system is a major advance over current methods for detecting low concentrations of biological agents because it is compatible with a portable device that troops could use in the field; current methods require bulkier laboratory equipment not always readily accessible to troops in combat situations. In their new approach, the researchers developed multiple types of sensors and achieved rapid production of them in quantity (hundreds of uniquely responsive detectors can be fabricated within a week). The sensors include: solutions that change color in the presence of specific disease-causing organisms; highly specific proteins that produce a measurable signal in response to toxins in the environment; nucleic acids that read the DNA of organisms and are able to detect unique genetic markers for anthrax bacilli and other biological agents; and antibody sensors that detect specific components of the spore coats of bacterial agents. The extremely sensitive sensors can detect concentrations of agents in the range of parts per million to parts per billion. The researchers attach the sensors to beads that they put into discretely separated wells that can be micromachined in large numbers in a silicon substrate. Because the sensors are in wells, rather than on a chip surface, the approach can use solution-phase reactions to detect agents. Troops would use the combined responses of different types of sensors in a single, portable microarray to recognize a wide range of known agents and to detect previously unknown threats.

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(U) **FY 2001 Plans:**

- Research. The Services are making 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 communication systems; networked and distributed systems; microchemical systems; biological and chemical sensing concepts; 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 are making 16 new awards focused on defense-relevant electronics, materials and biotechnology at the nanoscale, 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 the area of critical infrastructure protection. Following that competition, the Services are making 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. ($193.803
- 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. ($43.667 million)

- 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 are being completed. ($54.806 million)

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(U) FY2002 Plans:

- Research. The Services are conducting a competition for new multidisciplinary research efforts in nineteen high-priority basic research areas related to the following broad themes: energetics; multifunction materials; sensing; nanotechnology; control of adaptive and cooperative systems; and interoperable, adaptive, and scalable networks. Multidisciplinary and PECASE programs begun in prior years will continue, with new competitive awards under the PECASE program. ($149.756 million)

- Education. A FY 2002 competition will be conducted to award approximately 285 graduate fellowships under the National Defense Science and Engineering Graduate Fellowship Program. ($40.920 million)

- Infrastructure. A FY 2002 competition will be conducted for new awards under the DURIP program. ($49.698 million)

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

(U) B. Program Change Summary	FY2000	FY2001	FY2002	Total Cost
Previous President's Budget Submit	224.016	253.627	217.549	Continuing
Appropriated Value		295.077		Continuing
Adjustments to Appropriated Value				
a. Congressionally Directed Undistributed Reduction	-0.650	-2.135	0.000	
b. Rescission/Below-threshold Reprogramming, Inflation Adjustment	0.000	-0.656	0.000	
c. Other	0.000	0.000	22.825	
Current President's Budget	223.366	292.286	240.374	Continuing

Change Summary Explanation:

(U) **Funding:** FY 2000 and FY 2001 adjustments reflect Congressional undistributed reductions and a reprogramming action included in the FY2000 omnibus reprogramming request

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

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

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

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