Tools for the 21st Century

HPC DoD Modernization Program

annual report 2004

Department of Defense

High Performance Computing Modernization Program

2004 Annual Report

A Report by the Department of Defense
High Performance Computing Modernization Program Office

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SECTION 1

OVERVIEW

Overview

Introduction

The Department of Defense's High Performance Computing Modernization Program (HPCMP) provides the Department's scientists and engineers with an extraordinary computational environment to further national defense objectives. In less than ten years, the Program has produced an outstanding environment that routinely uses high performance computing resources to solve many of the Department's most challenging scientific and engineering problems. This, in turn, helps the United States ensure military advantage and war-fighting superiority on the 21st century battlefield.

The Program enables the Department's scientists and engineers to further national defense objectives through research, development, test, and engineering activities that directly support the science and technology (S&T) and test and evaluation (T&E) objectives of the Department, with a focus on the most complex, highest priority challenges. Examples of these activities include protecting bases of operation through the mitigation of toxic threats; modeling to support urgent requests for certification for new aircraft-store combinations before deploying to the conflicts in Afghanistan and Iraq; supporting U.S. supremacy in space operations; and conducting climate, weather, and ocean modeling that provides valuable information to countermine warfare operations, preparation for emergency operations, and humanitarian relief operations throughout the world. These examples highlight a small portion of the work being done in support of the Department's Transformational Objectives. DoD scientists and engineers, utilizing the resources provided by the HPCMP, are addressing multi-disciplinary, cross-service scientific and engineering challenges such as increasing the physics included in weather prediction models to improve accuracy, designing materials for specific properties such as personnel protection, and modeling complex flow fields around air systems to improve performance. Today's work will improve latency detection of targets based on their spectral or spatial/spectral signatures; enhance dynamic signal intelligence mission planning; enhance force protection against terrorist threats; and address critical needs such as the development of new high energy density materials for explosives and rocket propulsion.

HPCMP Mission

Deliver world-class commercial, high-end, high performance computational capability to the DoD's science and technology (S&T) and test and evaluation (T&E) communities, facilitating the rapid application of advanced technology into superior warfighting capabilities.

Congressional investment in and support of the HPCMP since fiscal year 1994 has caused cultural changes in the fundamental way science and engineering and test and evaluation (T&E) are pursued. In 1993, the Department had just over 180 gigaFLOPS (FLoating-point OPerations per Second) (GFs) of computational power to support the science and technology (S&T) community. As Figure 1 illustrates, the HPCMP has expanded those capabilities to over 95 teraFLOPS; this is an increase of a factor of over 500! This was done by applying sound management practices and good investment strategies. Similarly, we transitioned our communications network linking the laboratories from a government-owned, government-operated asset to a commercial environment providing a secure, high bandwidth capability. Our Program is a technology acquisition and service delivery program addressing the needs of Defense scientists and engineers for state-of-the-practice supercomputing environments. The HPCMP achieves the Program's mission and vision (as described on pages 4 and 5) by focusing on five specific goals. Each activity within the program supports one or more of these +goals, with progress tracked and successes delineated. These goals are:

1. Provide the best commercially available high-end HPC capability.
2. Provide high performance computing environments that enable critical DoD research, development, and test problems to be solved.
3. Educate and train DoD's scientists and engineers to effectively use advanced computational environments.

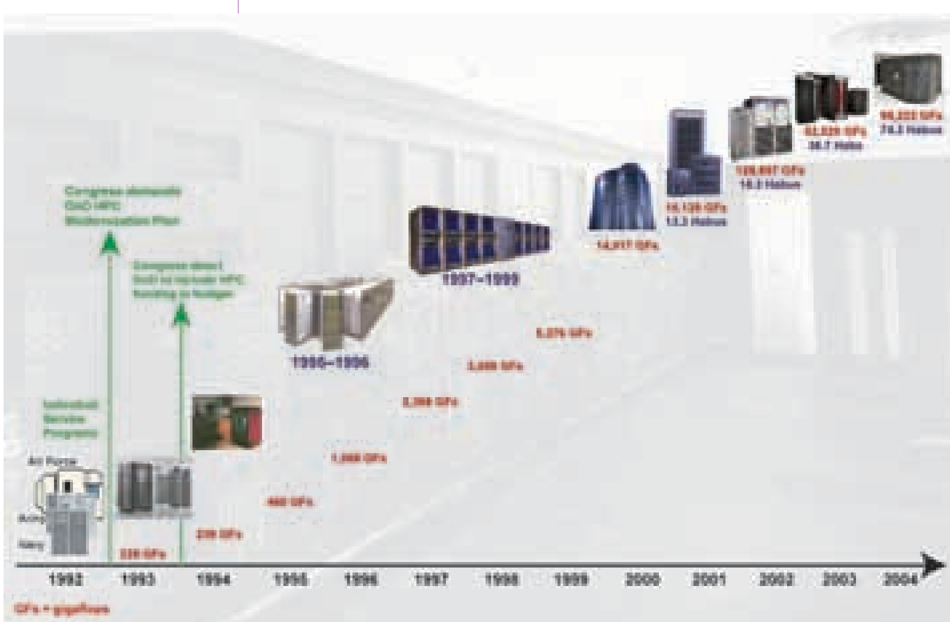


Figure 1. DoD S&T and T&E growth in computational capability

HPCMP Vision

A pervasive culture existing among DoD's scientists and engineers where they routinely use advanced computational environments to solve the most demanding problems.

4. Link users and computer sites via high-capacity networks, facilitating user access and distributed computing environments.
5. Promote collaborative relationships among the DoD HPC community, the National HPC community and Minority Serving Institutions (MSIs) in network, computer, and computational science.

The progress the HPCMP has made in meeting these goals is discussed in detail later in Section 2.

HPCMP Organization

The HPCMP is comprised of three major components: HPC Centers, Networking and Information Assurance, and Software Applications Support. These areas provide the base of the integrated program strategy (see Figure 2): to provide a technologically advanced computational environment to support the ongoing and emerging needs of the Department's laboratories and test centers. These components are interdependent, with distinct business practices and community relationships.

The HPC Centers component includes four major shared resource centers (MSRCs), four allocated distributed centers (ADCs), and 12 dedicated distributed centers (DDCs). These computer centers provide DoD scientists and engineers with the resources necessary to solve the most demanding computational problems. The Networking component includes the Defense Research and Engineering Network (DREN), which provides advanced capabilities to a greater user base at faster communication speeds than previously available on a wide basis and addresses the security requirements of the Program's environment. The Software Applications Support (SAS) component addresses the need for robust applications software and the expertise required to capitalize on the HPC resources provided by the Program.

The HPCMP Community

The HPCMP community consists of over 4,500 scientists, engineers, computer specialists, networking specialists, and security experts working throughout the United States. All three Defense Departments and several Defense Agencies

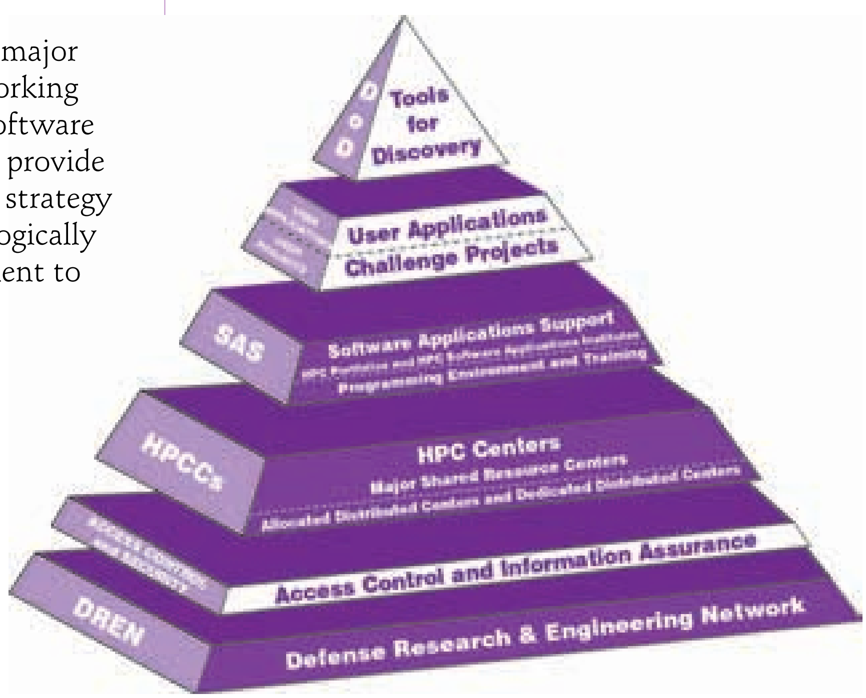


Figure 2. HPCMP Integrated Program Strategy

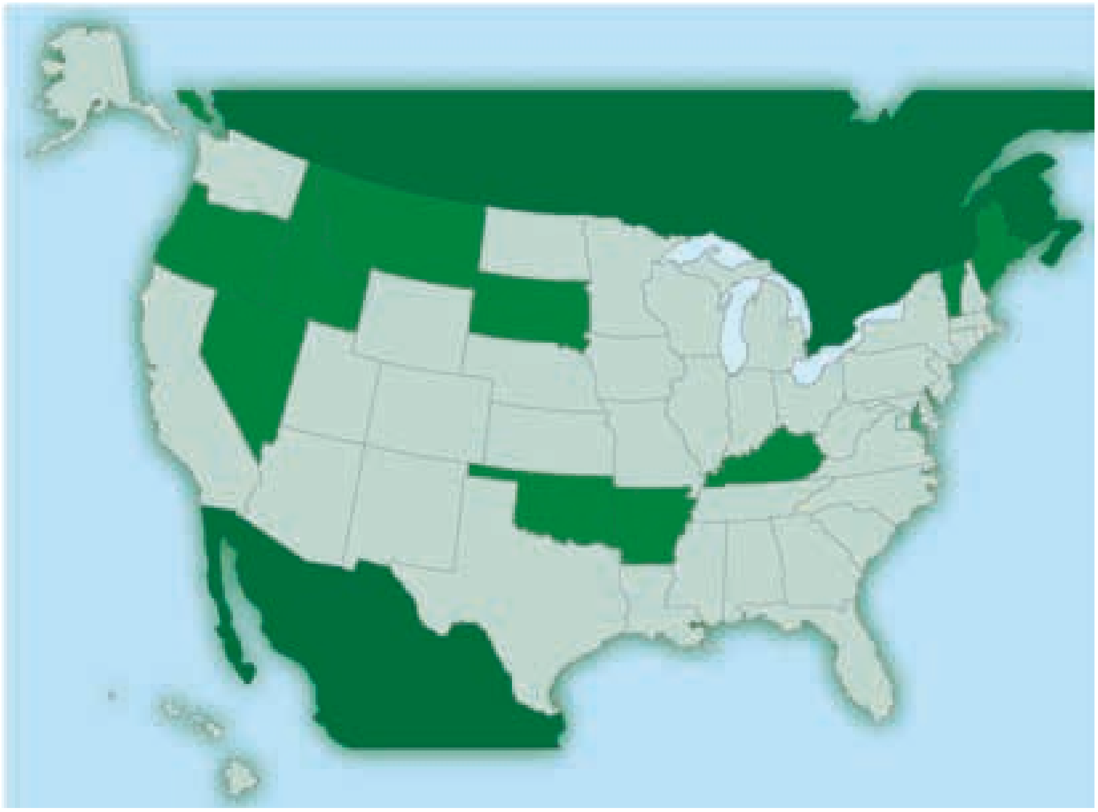


Figure 3. Users by State. The light green color represents states that have users utilizing HPCMP resources.

participate in the program. These HPC users execute over 550 projects, validated by the Military Services and Defense Agencies. Figure 3 shows the locations of the DoD personnel utilizing the HPCMP resources. The user base is diverse, drawing from the government workforce, academia, and industry. The demographics by type of workforce as well as by the DoD organizations is shown in Figure 4.

DoD Challenge Projects

The HPCMP recognizes the high priority work conducted within the DoD through the implementation of Challenge Projects. These projects represent the DoD's highest-priority, highest-impact computational work. The simulations and computations conducted in these projects represent 27% of the available hardware resources at the HPC Centers. The endeavors range from discovering new materials using quantum chemical simulations to studying the impact of new physics in the prediction of weather. There were 34 active DoD Challenge Projects in FY 2004—24 continuing projects and 10 new projects (see Table 1 on pages 8 and 9). The ten new projects were selected from 26 proposals submitted by the Services and Agencies in response to the HPCMP's annual call for Challenge Project proposals. Most of the Challenge Project Leaders presented the results of his/her work at the annual Users Group Conference that was held in Williamsburg, VA in June 2004. During FY 2004, papers related to the Challenge Project work were also presented at the American Geophysical Union meeting in San Francisco in December 2003.

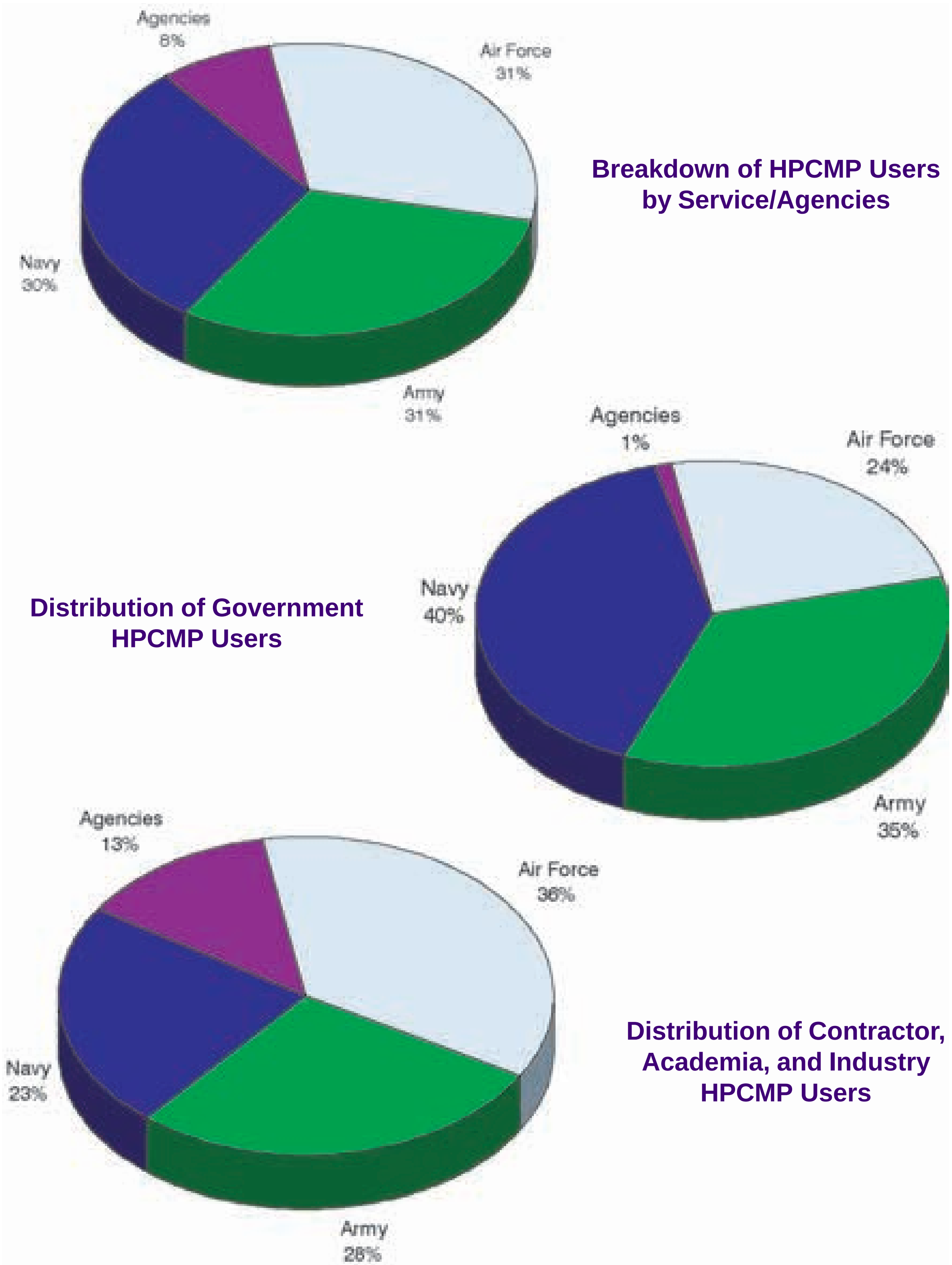


Figure 4. FY 2004 HPCMP User Demographics

Table 1. FY 2004 DoD Challenge Projects

Project Title	Project Leader/Organization
3-D CFD Modeling of the Chemical Oxygen-Iodine Laser II	Timothy Madden, Air Force Research Laboratory, Kirtland AFB, NM
Basin-scale Prediction with the Hybrid Coordinate Ocean Model	Eric Chassignet, University of Miami, Miami, FL
Computational Chemistry Model Leading to Mediation of Gun Tube Erosion	Cary Chabalowski, Army Research Laboratory, Aberdeen Proving Ground, MD
Computational Fluid Dynamics (CFD) in Support of Wind Tunnel Testing for Aircraft/Weapons Integration	William Sickles, Arnold Engineering Development Center, Arnold AFB, TN
Computational Simulations of Combustion Chamber Dynamics and Hypergolic Gel Propellant Chemistry for Selectable Thrust Engines in Next Generation Guided Missiles	Michael Nusca, Army Research Laboratory, Aberdeen Proving Ground, MD
Computational Support for Chemically Reactive Flows and Non-ideal Explosives	Joseph Crepeau, Applied Research Associates, Inc., Albuquerque, NM
Defense against Chemical Warfare Agents (CWAs) and Toxic Industrial Chemicals (TICs): Filtration, Prophylaxis and Therapeutics	Margaret Hurley, Army Research Laboratory, Aberdeen Proving Ground, MD
Directed High Power RF Energy: Foundation of Next Generation Air Force Weapons	Keith Cartwright, Air Force Research Laboratory, Kirtland AFB, NM
Distributed Pump Jet Propulsion (DPJP) for Submarines	Joseph Gorski, Naval Surface Warfare Center, Carderock Division, West Bethesda, MD, and Robert Kunz, Pennsylvania State University, University Park, PA
Dynamic Rotorcraft Simulations for Accurate Interactional Aerodynamics and Performance Prediction	Mark Potsdam U.S. Army Aviation and Missile Command, Moffett Field, CA
Evaluation and Retrofit for Blast Protection in Urban Terrain	James Baylot, Engineer Research and Development Center, Vicksburg, MS
First Principles Studies of Technologically Important Smart Materials	Andrew M. Rappe, University of Pennsylvania, Philadelphia, PA
High Accuracy DNS and LES of High Reynolds Number, Supersonic Base Flows and Passive Control of the Near Wake	Hermann Fasel, University of Arizona, Tucson, AZ
High Fidelity Analysis of UAVs Using Nonlinear Fluid/Structure Simulation	Reid Melville and Miguel Visbal, Air Force Research Laboratory, Wright-Patterson AFB, OH
High-Fidelity Simulation of Littoral Environments	Richard Allard, Naval Research Laboratory, Stennis Space Center, MS
Hybrid RANS-LES for High Fidelity Simulation of Circulation Control Schemes for Navy Applications	Eric Paterson, Robert Kunz, and Leonard Peltier, Pennsylvania State University, State College, PA
Hypersonic Scramjet Technology Enhancements for Long Range Interceptor Missile	Kevin Kennedy, U.S. Army Aviation and Missile Command, Redstone Arsenal, AL and Sanford Dash, CRAFT Tech, Dublin, PA
Large-Eddy Simulation of Tip-Clearance Flow in a stator-Rotor Combination	Parviz Moin, Stanford University, Stanford, CA
Modeling Complex Projectile-Target Interactions II	Kent Kimsey and David Kleponis, Army Research Laboratory, Aberdeen Proving Ground, MD
Multidisciplinary Applications of Detached-Eddy Simulation to Separated Flows at High Reynolds Numbers	Scott Morton, US Air Force Academy, Colorado Springs, CO

Table 1. FY 2004 DoD Challenge Projects—continued

Project Title	Project Leader/Organization
Multiscale Simulations of High Energy Density Materials	Jerry Boatz, Air Force Research Laboratory, Edwards AFB, CA
Multiscale Simulation of Nanotubes and Quantum Structures	Jerry Bernholc, North Carolina State University, Raleigh, NC
Numerical Modeling of Turbulent Wakes for Naval Applications	Joseph Werne, North West Research Associates, Boulder, CO
Scalable Multiscale Simulation of Material Behavior at the Nanoscale	Rajiv Kalia, University of Southern California, Los Angeles, CA
Seismic Signature Simulations for Tactical Ground Sensor Systems and Underground Facilities.	Mark Moran, Cold Regions Research and Engineering Laboratory, Hanover, NH
Signature Modeling for Future Combat Systems (FCS)	Raju Namburu, Army Research Laboratory, Aberdeen Proving Ground, MD
Simulation of Coherent Radar Backscatter from Dynamic Sea Surfaces	Jakov Toporkov, Naval Research Laboratory, Washington, DC
Stochastic Simulations of Flow-Structure Interactions	George Em Karniadadis, Brown University, Providence, RI
Three-Dimensional Modeling and Simulation of Bomb Effects for Obstacle Clearance	Alexandra Landsberg, Naval Surface Warfare Center, Indian Head, MD
Time-Accurate Aerodynamics Modeling of Synthetic Jets for Projectile Control.	Jubaraj Sahu, Army Research Laboratory, Aberdeen Proving Ground, MD
Time Accurate Unsteady Simulation of the Ship Stall Inception Process in the Compression System of a U.S. Army Helicopter Gas Turbine Engine	Michael Hathaway, Army Research Laboratory, Cleveland, OH
Tip-to-Tail Turbulent Scramjet Flowpath Simulation with MHD Energy Bypass	Datta Gaitonde, Air Force Research Laboratory, Air Vehicles Directorate, Wright-Patterson AFB, OH
Toward Predicting Scenarios of Environment Arctic Change (TOPSEARCH)	Wieslaw Maslowski, Naval Postgraduate School, Monterey, CA
Towards a High-Resolution Global Coupled Navy Prediction System	Julie McClean, Naval Postgraduate School, Monterey, CA

Highlights of Impact in FY 2004

The hardware, software, and networking infrastructure provided by this program to Defense scientists and engineers allows them to solve many critical problems faced by the Military Departments and Defense Agencies. In addition, it creates an avenue for them to look at enabling future activities through the extensive research and development programs. This results in a portfolio of both short-term investments with recognized short-term payoffs and longer-term activities. This balance allows for a stream of successes achieved through basic research, engineering development, test and evaluation, and operational systems.

The HPCMP efforts of the past eleven years have culminated in many activities providing support to Defense systems and to the nation as a whole. As with the efforts in the Department of Defense, these highlights encompass the multi-disciplinary nature of the work that we do. The following stories serve as a brief overview of the successes that occurred in FY 2004.

Joint Strike Fighter Digital Flight Control Program

Lockheed-Martin flight controls group, a contractor team in the Joint Strike Fighter program, used the DoD High Performance Computing Major Shared Resource Center at the Aeronautical Systems Center (ASC) Wright Patterson Air Force Base, Ohio, to meet a Critical Design Review on the Joint Strike Fighter. A major element of this review dealt with the validation of the Digital Flight Control Program. The Flight Control Program is critical to the successful operation of the aircraft.

This software is validated by integrating the digital flight control program with an airplane simulation in a software framework known as ATLAS. Over the span of a week, the Lockheed Martin flight controls group was able to complete all of the ATLAS Critical Design Review analysis using the ASC Major Shared Resource Center. Without this resource, the computer simulations would have required greater than 2 months of time on Lockheed Martin's in-house resources and the Joint Strike Fighter would not have been able to meet their deadline in completing this Critical Design Review.

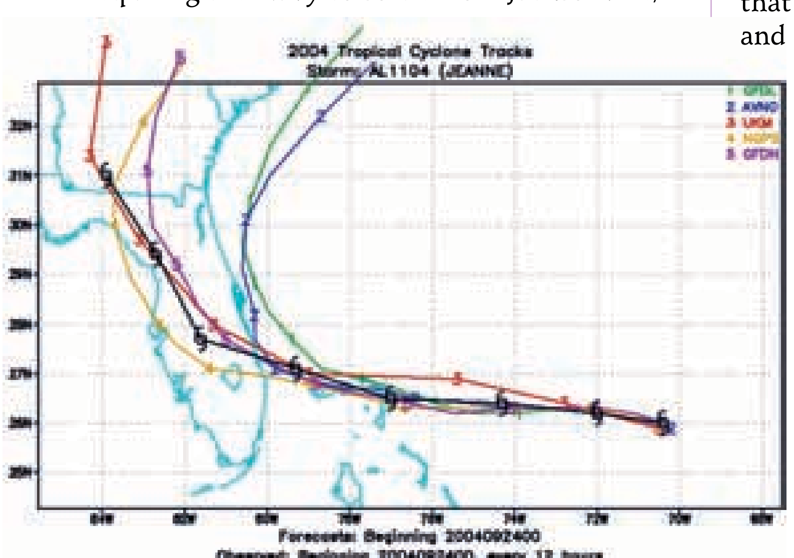
DoD Supports Hurricane Forecasting Using Supercomputers

With an above-normal year for the occurrence of hurricanes and the large numbers impacting the continental United States, accurate predictions of these hurricanes have minimized loss-of-life and destruction of property. Of the 6 major hurricanes in the 2004 season, 4 hit Florida: Charley, Frances, Ivan, and Jeanne. For several years, but particularly this season, the National Hurricane Center (NHC) forecasters have relied heavily on the computer models Navy Operational Global Atmospheric Prediction System (NOGAPS) and Geophysical Fluid Dynamics Laboratory – Navy (GFDN) as hurricane forecast aids. The information based on these models, provided by the Fleet Numerical Meteorology and Oceanography Center (FNMOC) in Monterey, CA using FNMOC and DoD HPCMP resources, was critical for planning the movement of assets at defense installations and issuing warnings to the civilian population. The inclusion of the Navy model led to improved consensus track forecasts. For Hurricanes Frances and Jeanne, the official forecast of the National Hurricane Center had predicted the hurricanes' landfall very close to the Jacksonville/Mayport area, requiring the Navy to sortie from Jacksonville/Mayport. With the resultant information from the Navy model was included, the track prediction was changed, and the Navy did not have to sortie from Mayport, saving ~$7M in evolution costs.

The improving effectiveness of hurricane prediction has been made possible by continued funding of numerical weather prediction research by the U.S. Navy and others. The acquisition of the computers on which much of this research was done has been made possible by the DoD HPCMP. In addition, the DoD HPCMP has funded past efforts in porting the earlier NOGAPS code, which ran on an early generation Cray C90 vector computer, to a Message Passing Interface (MPI) code that runs efficiently on a modern shared memory parallel supercomputer. This allowed the upgrades in the physics and spatial resolution of the model that enabled the accurate forecasts for Jeanne and other tropical cyclones this year.

NOGAPS was one of the first models to give a clear indication that Jeanne was going to strike Florida and cut inland across the state. An example of this is indicated by an excerpt from the official NHC forecast discussion on Jeanne posted at 1100 EDT on 23 Sep 2004, which reads:

"…The official track was nudged westward out of respect for the nogaps and gfdn models...which were first two models and the most consistent ones to indicate a westward motion toward florida. …" (Reference: Http://www.nhc.noaa.gov/archive/2004/dis/al112004.discus.040.shtml)



Hurricane Jeanne Forecast Tracks (courtesy of Fleet Numerical Meteorology Oceanography Center).

Caption: The forecast tracks utilized for Hurricane Jeanne beginning at 0000 GMT 24 Sep 2004 are shown in the figure. The observed path of Jeanne (black line) was well bracketed by the NOGAPS forecast track (gold line) and the GFDN forecast track (purple line). Other models utilized by the NHC were the NOAA/NCEP GFDL Hurricane Model (green line), the NOAA/NCEP GFS Model (blue line; labeled AVN0), and the UK Meteorological Office Global Model (red line).

JAVELIN Missile—Test and Evaluation

The Javelin Integrated Test and Simulation Network (JITSN) is a Hardware-in-the-loop (HWIL) facility that utilizes actual tactical hardware and software, allowing testers to create any physical environment; alter the terrain, target, and vegetation; and change engagement practices. The facility is utilized by the developer (Raytheon Missile Systems), researchers (Aviation and Missile Research, Development, and Engineering Center), and the testers (Redstone Technical Test Center), all tied together with the HPCMP Secret Defense Research and Engineering Network (S-DREN). The Distributed Center computers, provided by the HPCMP, are used to render the infrared (IR) scenes, control projection of the scenes to sensors, control the flight motion simulator, and synchronize the scenes with missile countermeasures. The collaboration and S-DREN connectivity permit timely evaluation of software modifications prior to fielding, loaded into the HPCs directly by the developer over the S-DREN. Voice, data, and video are shared in real time over the S-DREN giving all participants access to test events and simulations. The facility is capable of producing 50 firings per day, versus possibly 2–3 on the open-air range, supporting an accelerated development and test schedule. In addition, at a cost of $300,000 per missile, plus the cost of targets and the range, 50 open-air tests would be cost prohibitive. The facility has been used to support training in addition to development and testing. The HWIL facility experience has led to development of a multi-spectral (IR, ultraviolet (UV), millimeter wave, and semi-active laser) facility supported by Distributed Center hardware awarded to RTTC by the HPCMP.

The world's premier shoulder-fired anti-armor system, Javelin takes the fight to the enemy. Javelin automatically guides itself to the target after launch, allowing the gunner to take cover and avoid counterfire. Soldiers or Marines can reposition immediately after firing, or reload to engage another threat.

Section 2

Performance Results

Performance Results

FY 2004 Activities

The activities of fiscal year 2004 continued our forward progression in assisting the Department of Defense (DoD) science and technology (S&T) and test and evaluation (T&E) community in providing support to the warfighter, both near-term within FY 2004 and what will be of benefit in years to come.

This section is separated by the goals of the High Performance Computing Modernization Program (HPCMP) as we work toward making the vision a reality.

Goal 1: Provide the best commercially available high-end HPC capability

The HPCMP provides high performance computing capabilities to the DoD S&T and T&E communities via three types of computer centers:

- Major Shared Resource Centers (MSRCs)
- Allocated Distributed Centers (ADCs)
- Dedicated Distributed Centers (DDCs)

Major Shared Resource Centers

Major Shared Resource Centers are very large high performance computing (HPC) computational centers that provide leading-edge, high performance computational resources, data storage, data interpretation and HPC technical expertise to the defense community. These Centers are "purple" in that they serve all DoD Services and Agencies without regard to their location or supporting organization. They are located at four government installations listed and highlighted in Figure 1.

- US Army Research Laboratory (ARL), Aberdeen Proving Ground, MD
- Aeronautical Systems Center (ASC), Wright-Patterson AFB, Dayton, OH

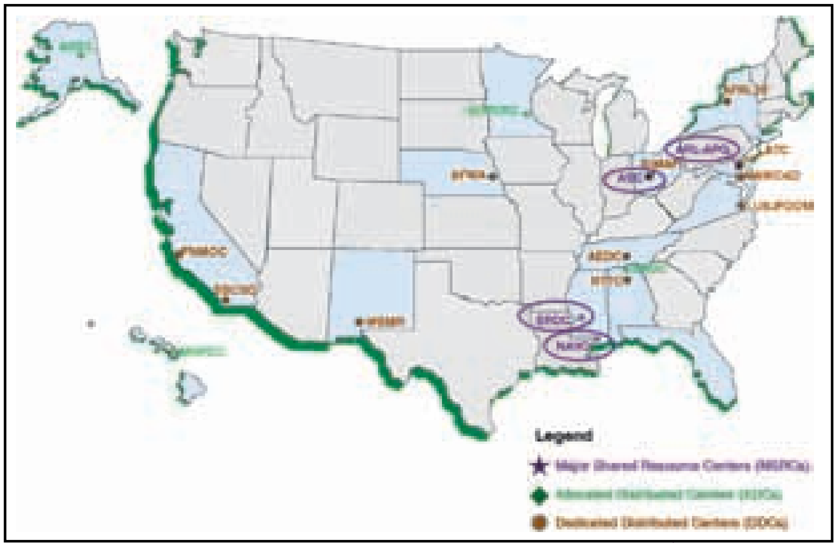


Figure 1. Location of Major Shared Resource Centers

- US Army Corps of Engineers (USACE) Engineer Research and Development Center (ERDC), Vicksburg, MS
- Naval Oceanographic Office (NAVO), Stennis Space Center, MS

At the beginning of FY 2004, the HPC systems at the four MSRCs had a total computational capability of 32.8 Teraflops (i.e., the capability to perform 32.8 trillion mathematical operations per second). During FY 2004, the HPCMP procured three very large and one smaller HPC systems for deployment at two of the MSRCs (NAVO and ARL). These four new systems have a computational capability of 44.8 Teraflops, which more than doubles the total capability from the previous fiscal year. At the end of FY 2004, the total capability of the HPC systems at the four MSRCs stands at 77.6 Teraflops. The bars in Figure 2 show the computational growth in Teraflops as well as HABUs at the four centers over the past 10 years. [See callout on page 17 for a definition of a HABU.]

Allocated Distributed Centers

To complement the computational capacity of the four MSRCs, the HPCMP also supports four "mid-sized" centers that provide additional computational resources to DoD researchers. These centers are identified as Allocated Distributed Centers (ADCs). From the DoD's perspective, ADCs function like smaller scale MSRCs but have a role of serving the DoD as well as other customers. The four centers are listed below and highlighted in Figure 3.

- Arctic Region Supercomputing Center (ARSC), Fairbanks, AL
- Maui High Performance Computing Center (MHPCC), Kihei, HI
- Army High Performance Computing Research Center (AHPCRC), Minneapolis, MN
- Army Space and Missile Defense Command (SMDC), Huntsville, AL

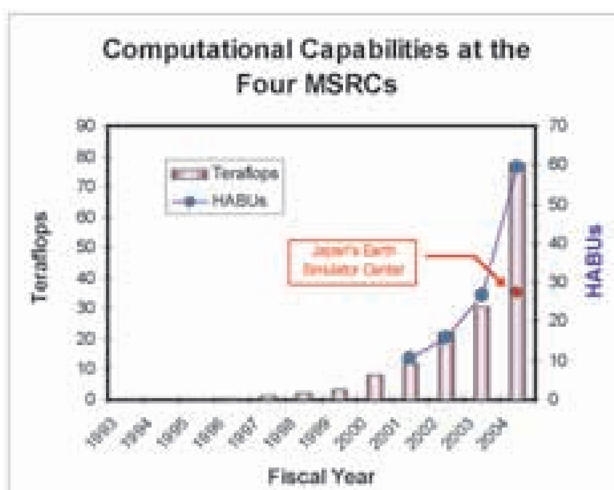


Figure 2. Growth in Capability of MSRC

Figure 3. Location of Allocated Distributed Centers

In FY 2004 the HPCMP arranged for the ARSC ADC to support open literature, DoD basic research. The academic community of users supporting the DoD, whose research is supported by the Offices of Research in the Defense Services, were otherwise challenged to acquire the proper access clearances required to use the systems located at the MSRCs. This operational model allows the ARSC Center to mix non-DoD university related work and DoD open literature work on the same systems; a win-win example of how the DoD leverages the use of ADCs.

The HPCMP measures computer system performance relative to the performance of DoD computational applications running on the systems. For the past four years, the HPCMP has been comparing the run times of applications that the DoD researchers use on existing and newly installed systems to obtain performance comparisons. By comparing the timing results of these applications on all the HPC systems, the HPCMP has been able to measure the real application's performance on any system, relative to the others. In 2002, a large IBM system located at the NAVO MSRC named HABU, was chosen as the baseline system for application timings. Hence, HPCMP performance measures are all in "HABU" equivalent units. For example, if a new system has a rating of 2 HABUs, then the researcher's application ran twice as fast on it as on the "HABU" system. The blue line in Figure 2 shows the growth in computational capability based on the HABU method of measuring system performance.

Collectively, the ADCs have a number of large HPC systems which provide a total of 18.1 Teraflops of computational capability to the HPCMP. Adding this computational power to the capability located at the MSRCs, the HPCMP total capability increases from 77.6 Teraflops to 95.7 Teraflops.

Dedicated Distributed Centers (DDCs)

Dedicated Distributed Centers are uniquely designed HPC capabilities that address specific DoD project needs that cannot be addressed using the shared resources available at the MSRCs and ADCs. Typically these small to medium-sized projects require HPC resources that have one or more of the following attributes:

- Require access to data or computational resources under time critical constraints that can not tolerate network latency or shared computing.
- Require special operational considerations that have security requirements or have unconventional operating considerations.

A typical DDC will have a lifecycle of three to four years. In FY 2004, five new DDCs were added to the already existing nine DDCs and two DDCs were transitioned from HPCMP oversight. The following DDCs, shown in Figure 4, are currently under HPCMP oversight:

- Aberdeen Test Center (ATC), Aberdeen Proving Ground, MD

Figure 4. Location of Dedicated Distributed Centers

- Air Force Research Laboratory, Information Directorate (AFRL/IF), Rome, NY
- Air Force Weather Agency (AFWA), Offutt AFB, NE
- Arnold Engineering Development Center (AEDC), Arnold AFB, TN
- Fleet Numerical Meteorology and Oceanography Center (FNMOC), Monterey, CA
- Joint Forces Command (J9), Suffolk, VA
- Naval Air Warfare Center Aircraft Division (NAWCAD), Patuxent River, MD
- Naval Research Laboratory (NRL-DC), Washington, DC
- Redstone Technical Test Center (RTTC), Huntsville, AL
- Simulations & Analysis Facility (SIMAF), Wright-Patterson AFB, OH
- Space and Naval Warfare Systems Center, San Diego (SSCSD), San Diego, CA
- White Sands Missile Range (WSMR), White Sands Missile Range, NM

An example of the type of projects supported by DDC resources include:

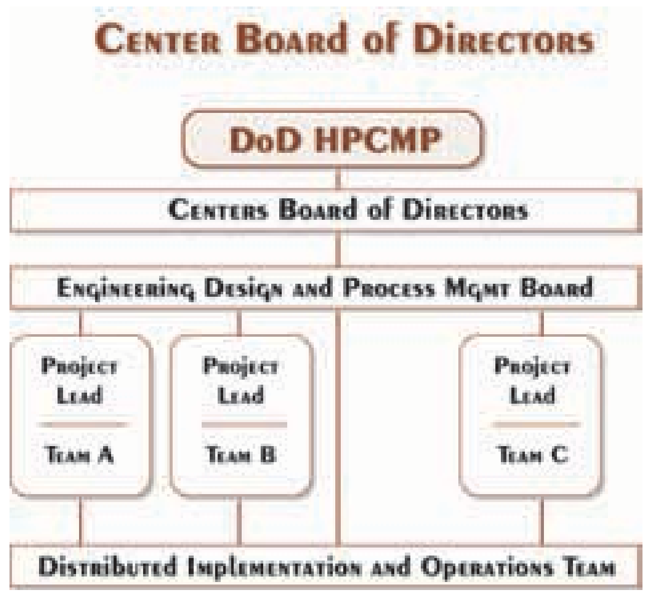
- Real-time analytic and decision support in test and evaluation of land combat systems
- Platform for conducting operational tests of weather research and forecast models
- Real-time global-scale computer-generated forces experimentation
- Real-time hardware-in-the-loop avionics and weapon systems simulations for test and evaluation
- Modeling and simulation of Command, Control, Communication, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) electronic systems under realistic tactical conditions
- Real-time test and evaluation of data imaging for aerial objects

Summary

The hardware and software acquisition budget for the MSRCs over the last five years has had, for all practical purposes, zero growth. However, in FY 2001, the HPCMP implemented a consolidated acquisition process whereby all HPCMP hardware and software is acquired via consolidated large contracts with competitively selected HPC vendors. The leveraging of volume purchasing power combined with technology advances commensurate with Moore's law (a prediction made by the president of Intel Corporation that the number of transistors contained on a silicon chip will double every 18 months) has provided the HPCMP with computational capabilities that exceed traditional growth curves.

Overarching Governing Infrastructure for Centers

The HPCMP is a geographically distributed community with a diversity of local skills and capabilities that must be captured in support of community ends. To achieve this transfer of best practices and innovations, an overarching centers' governing infrastructure was created. The center directors of the MSRCs, ARSC, and MHPCC are members of the Centers Board of Directors (CBoD) for the HPCMP Centers capability; the technical specialists that design, build, and to implement the solutions comprise the Engineering Design and Process Management Board (ED&PMB); and a group of individuals on the ground at each of the centers are positioned to sustain the capability. This latter group is identified as the Distributed Implementation and Operations Team (DIOT). This governing infrastructure was formulated in early FY 2004 and established a charter in March of 2004. The figure to the right shows the organization of the CBoD. The CBoD has met several times and has initiated three new investigations. The other two teams have begun to address the initiatives. Early indications are that the unified direction from the CBoD has helped to keep the ED&PMB and the DIOT on focus.



Goal 2: Provide high performance computing environments that enable critical DoD research, development and test problems to be solved

The DoD Software Applications Support component activities align with the goal above. This component consists of three major areas: HPC Portfolios, HPC Software Applications Institutes, and Programming Environment and Training (PET). The ultimate aim is to provide DoD scientists and engineers with the capability of modeling and simulating the physical world that can facilitate the design, development, test, and acquisition of superior weapons systems and allow our soldiers, sailors, and airmen to be better prepared through training, tactics, and support systems.

HPC Portfolios

The trend in research, development, test, and evaluation (RDT&E) clearly indicates that multi-disciplinary problems will further challenge DoD scientists and engineers and require HPC resources. This implies that many of tomorrow's applications will incorporate multiple computational disciplines, defined in this program by the computational technology areas. The portfolio effort within the DoD HPCMP has recognized these facts. Portfolios provide efficient, scalable, portable software codes, algorithms, tools, and models and simulations that run on a variety of HPC platforms and are needed by a large number of S&T and T&E scientists and engineers. Portfolio development teams span DoD Services and Agencies and include algorithm developers, applications specialists, computational scientists, computer scientists and engineers, and end users.

Developing software for scalable HPC systems remains technically challenging and labor intensive. The HPCMP helps the DoD take advantage of existing and future computing and communications capabilities by building software with an emphasis on reusability, scalability, portability, and maintainability. In addition, this initiative is producing a new generation of world-class scientists and engineers trained in scalable software techniques that will reduce the future costs of doing business and increase our future defense capabilities. HPC portfolios, shown in Figure 5, focus on specific themes that encompass multiple computational technology areas (CTAs) and cross the Services and Agencies boundaries.

The portfolios listed below addressed critical needs in S&T and T&E and were completed in FY 2004. The resultant software codes completed in these efforts provide DoD scientists and engineers with applications software that efficiently and effectively exploits the latest generation of scalable high performance computing systems. These applications affect the design, acquisition, and utilization of military technologies that will aid in the development of improved military capability for the 21st century.

Sensor/Scene Processing and Generation (SPG)

The Sensor/Scene Processing and Generation portfolio developed scalable HPC software that will assist research and development, and virtual testing of sensors including multi-function sensors, algorithms, and techniques in weapon models, hardware-in-the-loop, installed systems, and concept systems. Application areas and computational techniques include (1) single or multi-spectral target and background signature modeling and scene generation, (2) scene generation validation, verification, and accreditation (VV&A) software tools, (3) signal and image processing, (4) image cueing and automatic target recognition, (5) low-observables/counter low-observables, and (6) unified problem solving environment for sensor/scene processing and generation.

System-of-Systems Simulation (SOS)

The System-of-Systems Simulation portfolio built a set of tools designed to assist in the testing of integrated, autonomously operating weapons systems into dynamically controlled information networks or SOS. In recent years, the DoD has recognized that weapons systems operating autonomously provide a less than the optimal solution to our national security problems. Information processing nodes in the network will fuse information from other nodes to provide a relevant battle-space view to friendly participants. The testing of future System-of-Systems will require simulations more complex than any developed to date. This portfolio will assist in the tracking of interaction between hundreds of thousands of players, complex

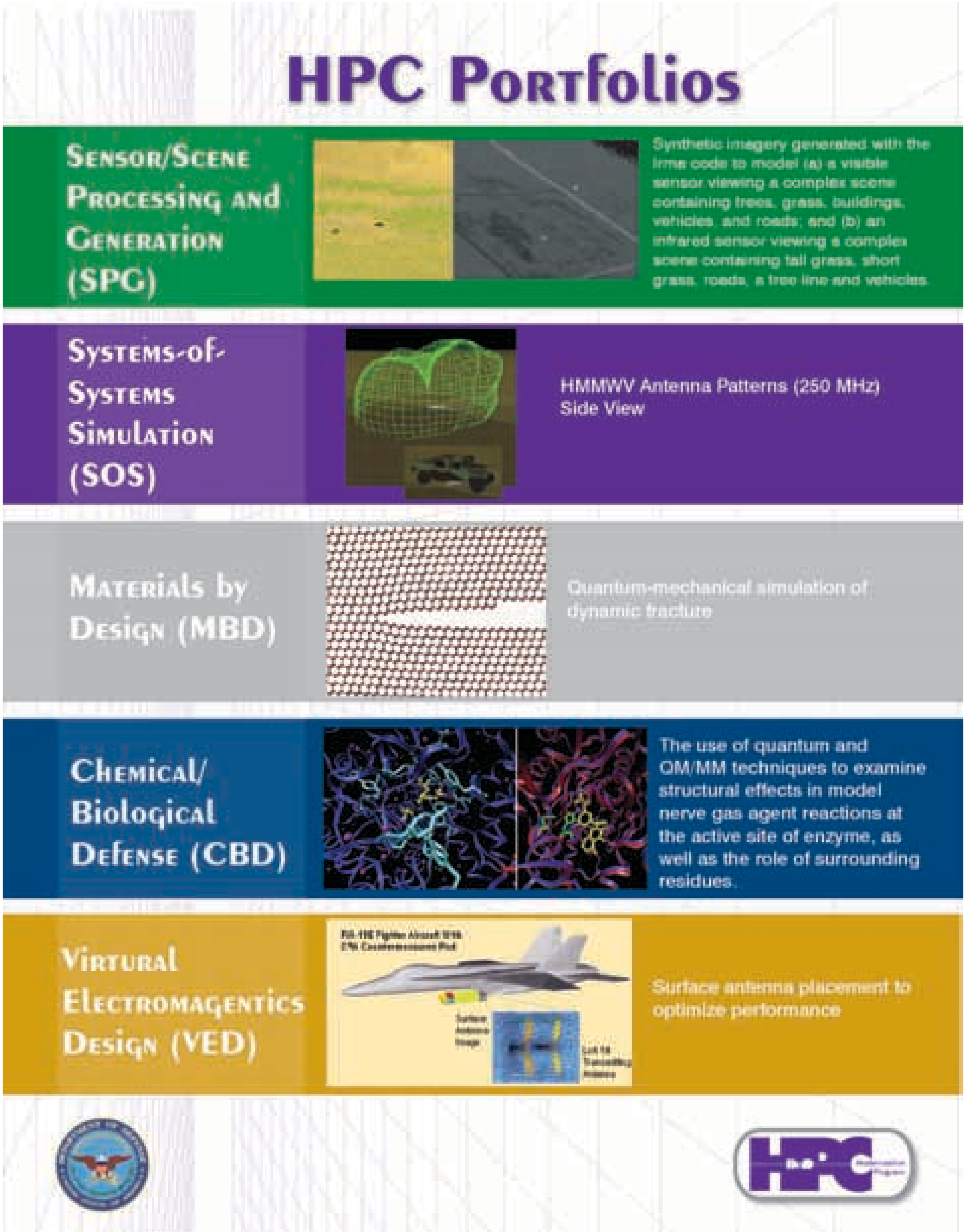


Figure 5. Examples of HPC Portolio researach

weapons systems, and environmental models while merging physics with information theory.

Materials by Design (MBD)

The first phase of the Materials by Design portfolio developed codes that address the design of a wide-range of materials, including metals, molecular and nanoscale materials, high energy density materials, optical materials, nanowire materials for spin quantum computing devices, polymer nanocomposites, and functional surfaces. Codes developed coupled structural mechanics approaches to achieve a microscopic-to-macroscopic algorithmic parallelization link. Some of these projects completed activities in FY 2004, half of this portfolio continues through FY 2006.

Chemical/Biological Defense (CBD)

The activities are ongoing, and address a nationally recognized need to better prepare in the event of attacks which incorporate biological agents or toxic chemicals. This portfolio was established to provide scalable software for military applications focused on chemical and biological threats and corresponding Defense Technology Objectives (DTO). This portfolio is a multi-disciplinary effort encompassing computational themes in the fields of chemistry and materials science, fluid dynamics, electronics, and nanoelectronics. The goal of the CBD portfolio is to provide high performance scalable software to support the soldier in the areas of chemical and biological agent detection, identification, transport, controls, and countermeasures. Activities in this portfolio are ongoing.

Virtual Electromagnetics Design (VED)

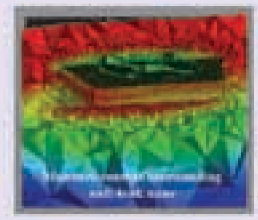
The overall goal of the VED portfolio is to provide to the DoD the ability to virtually design wide-band, multi-functional antenna and rough surface scattering solutions for a wide range of DoD activities including communication, acquisition, target identification, surveillance, and electronic attack. The specific goal is to develop a tightly integrated enabling set of tools for rapid analysis and design of large antenna aperatures and arrays in air, sea, and ground environments. The tools will be further integrated with DoD Laboratories HPC codes to enable the tri-services to solve previously unattainable DoD challenge problems.

HPC Software Institutes

Significant effort in FY 2004 was spent in creating, soliciting, and selecting the HPC Software Applications Institutes (see callout on page 24). The Institutes will address Service/Agency high priority, high value technology or materiel RDT&E mission priorities and augment traditional processes with computational insight by utilizing legacy or newly-developed computational techniques. Additional information about the institutes selected can be found on the the next page.

HPC Software Applications Institutes

Institute for Maneuverability and Terrain Physics Simulation (IMTPS)



The institute will focus on simulating near-surface environmental processes to support: detection of landmines, improvised explosive devices, and unexploded ordnance; the use of unattended ground sensor networks; analysis of maneuver and traffic-ability; and remote sensing of denied areas.

Biotechnology HPC Software Applications Institute for Force Health Protection (BHSAI)

The institute will build HPC experience and expertise within the DoD to deliver the best medical and non-medical biotechnology solutions to protect and treat our warfighters.

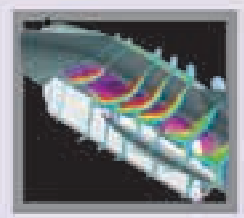
Battlespace Environments Institute (BEI)

This institute will migrate existing DoD climate/weather/ocean modeling and simulation, environmental quality modeling and simulation and space weather applications to the Earth System Modeling Framework (ESMF) and assist in transitioning non-DoD ESMF applications to DoD.

HPC Software Applications Institute for Space Situation Awareness (SSA)

The institute will address two top priority capability shortfalls in the SSA community: space object characterization/change detection and knowledge fusion/knowledge repository. The institute will apply the power of HPC and advanced algorithms to identify the functionality, capability, mission, status, and health of space objects.

Institute for HPC Applications to Air Armament (IHAAA)



This institute will identify and integrate new technologies and will rebuild and restructure existing Service-generated software using formal software engineering procedures that will build acquisition community confidence. Greater accuracy and rapid production of HPC solutions will enable early detection of problem areas in new systems and provide quicker reaction to warfighter needs.

Evolution of Software Applications Support within the HPCMP

An evolutionary timeline is shown below which graphically depicts how the DoD software applications programs are transitioning from CTA focused activities to ones that will lead to tightly integrated, multidisciplinary codes that tackle some of the most comprehensive and complex problems facing the DoD warfighters today. Both paradigms have evolved from individual software projects for applications codes from the mid-nineties, where the efforts focused on enhancing DoD applications codes originating up to several decades earlier. These codes were enhanced to become more robust and execute efficiently on scalable hardware coming on line in the mid-to-late nineties. From the beginning of the software applications efforts since 1998 until today, the DoD completed over 100 projects involving many hundreds of codes; this was a great boon to the weapons development, testing, and warfighting communities. These efforts improved the speed, complexity, and accuracy of military simulations in - materials for combat platforms, space and earth weather prediction, littoral environments, weapons systems, and simulations for the battlefield. Codes released within the last few years predict the weather with forecasting and nowcasting; model radar-based sensing of surface and subsurface targets, including land mines, unexploded ordnance, and vehicles; model 3-D rectangular arrangements such as the pulsed plasma micro-thruster for microsatellite propulsion; model and simulate large-scale military communications and tactical signal intelligence platforms, weather forecasting model improvements; and simulate large scale, heterogeneous, communication networks.

Historical Context, the Evolution of Applications Software

Programming Environment and Training

The Programming Environment and Training (PET) activity is responsible for gathering and deploying the best ideas, algorithms, and software tools emerging from the national high performance-computing infrastructure into the DoD user community. The PET activities are conducted through two separate contracts; one to MOS University Consortium, led by Mississippi State University, and the second to High Performance Technologies, Incorporated (HPTi). The teams from both contracts involve academic leaders to serve as points of contact for each of the areas covered by PET and experienced personnel located at DoD sites to provide HPC and scientific assistance to HPCMP users. In addition, PET personnel lead short-term projects that focus on delivering capabilities for urgent focused needs.

The focus of PET is placed on the ten HPCMP computational technology areas (see Table 1) and the four following cross-cutting areas, with a broad HPCMP-wide management approach:

Table 1. Computational Technology Areas (CTAs)

Computational Technology Area	Acronym	Description
Computational Structural Mechanics	CSM	Covers the high resolution, multi-dimensional modeling of materials and structures subjected to a broad range of loading conditions such as quasi-static, dynamic, electro-magnetic, shock, penetration, and blast.
Computational Fluid Dynamics	CFD	Provides accurate numerical solution of the equations describing fluid and gas motion.
Computational Chemistry and Materials Science	CCM	Predicts basic properties of chemicals and materials and applies molecular understanding to the development of advanced materials.
Computational Electromagnetics and Acoustics	CEA	Provides high-resolution multidimensional solutions of electromagnetic and acoustic wave propogation and their interaction with surrounding media.
Climate/Weather/Ocean Modeling and Simulation	CWO	Involves accurate numerical simulation and forecast of the Earth' atmosphere and oceans on those space and time scales important for both scientific understanding and DoD operational use.
Signal/Image Processing	SIP	Extracts and analyzes key information from various sensor outputs in real time; sensor types include sonar, radar, visible and infrared images, signal intelligence, and navigation assets.
Forces Modeling and Simulation/C4I	FMS	Focuses on force level modeling and simulation for training, analysis, and acquisition and the integration of high-speed command, control, communications, computers and intelligence (C4I) systems to manage the battlespace.
Environmental Quality Modeling and Simulation	EQM	Involves the high-resolution modeling of hydrodynamics, geophysics, and multi-constituent fate/transport through the coupled atmospheric/land surface/subsurface environment, and their interconnections with numerous biological species and anthropogenic activities.
Computational Electronics and Nanoelectronics	CEN	Analyzes, optimizes, and visualizes the performance of complex electronic and electromagnetic devices, circuits, and systems including the study of the effects of signal propagation as well as predictive and numeric designs, modeling and simulation of complex electronic devices, integrated circuits, and small components.
Integrated Modeling and Test Environments	IMT	Addresses the application of integrated modeling and simulation tools and techniques with live tests and hardware-in-the-loop simulations for the testing and evaluation of DoD weapon components, subsystems, and systems in virtual and composite virtual-real environments.

- **Computational Environments** – This area is dedicated to improve the usability of the computational environments at the program's shared resource centers, from the high performance computer down to the desktop.
- **Enabling Technologies** – This area is focused upon advancing the state of tools, algorithms, and standards for generalized pre- and post-processing analysis on enormous datasets.
- **Collaborative/Distance Learning Technologies** – This area discovers, tests, and deploys technologies to provide distance learning opportunities and promote collaborations between distant partners.
- **Education, Outreach, and Training Coordination** – This area furnishes efficient and productive instructional content to the user community as well as sponsors educational programs for undergraduate and graduate students to work with DoD personnel.

This contract year, technical and program management has emphasized and encouraged our entire team of functional experts, on-site personnel, Principal Investigators, and business administrators to focus on the key goals of the PET program; technology transfer, HPC code enhancement, and DoD user impact. The outcome of this focused effort has been promising, resulting in a diverse portfolio of successes that highlight work with key customers such as, the Naval Research Laboratory in Washington, DC, the Air Force Research Laboratory in Rome, NY, and the Natick Soldier System Center in Natick, MA. Meaningful user impact also implies technologies transferred and codes enhanced for maximum impact on HPC platforms. The computational chemistry and materials science functional area made significant contributions to technology transfer by providing tools to DoD users that enable more accurate modeling of materials as well as providing tools to researchers that enable modeling of materials for advanced body armor for the first time. In our computational electrogmagnetics and acoustics functional area we had significant cross-contract success cooperating with the forces modeling and simulation and signal/ image processing functional areas to assist in calculations for the Predator program.

PET Highlight—Unmanned Air Vehicles

The Unmanned Aerial Vehicle (UAV) has quickly become a cutting-edge Air Force technology with a variety of current and future applications. Improved UAV tactical performance in the area of radar signatures could ultimately expand the range and use of such vehicles. Precise and timely modeling and testing in the RF area is of vital importance to both predicting performance and improving the manufacture of UAVs. DoD HPC realized vastly improved precision calculations through innovative methodologies assembled through a collaborative effort between HPTi and MOS PET on-sites. To assist in improving design of UAVs, calculations of high resolution Radar Cross Section (RCS) require computational resources that exceeded SIMAF computing capabilities. Using such existing configurations can take 12 months or more. PET on-sites were chartered with assisting SIMAF to significantly reduce these cycle times, while maintaining accuracy and efficacy of output. From an original SIMAF estimate of 12-plus months for accurate computation, performance time with equivalent data accuracy was reduced to two months.

Goal 3: Educate and train DoD's scientists and engineers to effectively use advanced computational environments

Programming Environment and Training

The PET initiative enables the DoD high performance computing user community to make the best use of the computing capacity the HPCMP provides and to extend the range of DoD technical problems solved on HPC systems. PET is enhancing the total capability and productivity of the program's user community through training, collaboration, tool development, software development support, technology tracking, technology transfer, and outreach to users. PET is responsible for gathering and deploying the best ideas, algorithms, and software tools emerging from the national high performance computing infrastructure into the DoD user community.

The PET contracts offered 70 training events this past year, covering subjects ranging from Introductory MATLAB to Advanced Simulink. These classes were held at the locations highlighted in Figure 6 on the following page.

PET courses captured on video and transferred on compact disc are available for ordering on the PET Online Knowledge Center by DoD personnel and contractors. Nearly 250 CDs were ordered by users in the past year. The classes and number of CDs ordered are listed on the table above. Some of those courses can also be downloaded onto the users' desktops and viewed at their leisure (see https://okc.erdc.hpc.mil).

Table 2. Courses ordered on CDs

Course Name	Number of CDs
Introductory MATLAB	32
MultiLevel Parallel Programming	29
Advanced MATLAB	27
Advanced MPI	27
JAVA/VTK	26
Introductory MPI	23
Intermediate Unix	23
SGI Optimization	12
Donor Interpolative Receptor Transaction Library	9
MATLAB MPI	9
CFD Validation, Verification and Certification	8
Simulink, DSP and Real-time Workshop	7
Columbus Quantum Chemistry Workshop	5
Analysis of Large Data Sets	4
Integrated Simulation Environment	2
ASC CDLT DAY	1
Total	**244**

The value of these CDs is evidenced by the following user comment:

> *I was very impressed with the quality of the PET courses that are offered on CD for those that were not able to attend a particular course. A couple of weeks ago, I went to the PET website and was able to select a couple of PET courses that I was not able to attend and request them on CD. Now I am able to go through the class at my own pace, and I was astonished by the quality of the course material; being able to watch a video of the class and look at the slides that were presented (on the same Real player window) was awesome. I think this is a great resource and hope that the course offerings on this format get expanded in the future.*

Juan C Cruz
Missile, Launcher and Payload Integration Department, Analysis and Technology Branch

Figure 6. PET courses locations

Goal 4: Link users and computer sites via high-capacity networks, facilitating user access and distributed computing environments

Defense Research and Engineering Network

The Defense Research & Engineering Network (DREN) was created in order to link high performance computational users and supercomputers, no matter where the person or resource is or what Armed Forces they are associated with (see Figure 7 on page 30). Since then, DREN has acted as an enabler in many ways for the Research, Development, Test and Evaluation(RDT&E) community, the Missile Defense Agency (MDA), DoD Modeling & Simulation Office, Defense Threat Reduction Agency (DTRA), and others.

DREN is an enabler for major shared resource center efforts to perform secure, large-scale, remote, mass-storage for HPC disaster recovery. Although it's always been highly desirable to do in-band (live on-line) mass storage transfers, it has always been in the too-hard-to-do category. The challenge of transferring terabits of data daily between multiple centers was out-of-reach. This year, a number of advances have made these types of data exchanges a reality. Access to the DREN backbone was expanded at each of the DoD major shared resource centers to OC-48 (approximately 2.4 Gigabits per second). These centers are the first within the Department of Defense to have massive wide-area network (WAN) access capabilities. Anticipating rapidly rising bandwidth demands, DREN revamped its backbone nationwide using jumbo frame IP technology over a new protocol architecture (multi protocol label switching) which in turn, has enabled high-end tuning of computational resources over thousands of miles for massive data transfers.

DREN is centrally funded for science and engineering users of DoD high performance computational resources. Other congressionally authorized groups (MDA, modeling & simulation, operational test and evaluation groups) not part of HPC line-item funding must offset service delivery point and security costs to access the DREN.

It is in the best interest of the DoD to continuously expand the pool of quality scientists and engineers working on high priority DoD problems. Potential new users often discover the availability of HPC resources through initial exposure to DREN. Joint Forces Command in Suffolk, Virginia followed this pattern and this eventually expanded into a joint, distributed, systems-of-systems virtual communications concept for future real-time communications and network simulations.

An advantage of DREN is that it makes high capacity bandwidth available to all computational resources wherever they may be. This approach makes it much easier to ensure optimal use of high performance computing assets and reduces the effective cost of these scarce resources.

Historically, we associated access to scarce and expensive resources with close proximity to major centers of civilization. Today, we have much more flexibility in placement of new computational resources. That flexibility allows growth of new skill and job opportunities to rural (Midwest, Southwest) or remote (Alaska, Hawaii) labor markets that otherwise would be overlooked. High bandwidth WAN access allows the HPCMP to get resources very close to specialized real-time systems while expanding the pool of potential users working on DoD problems and keeps those resources extremely busy.

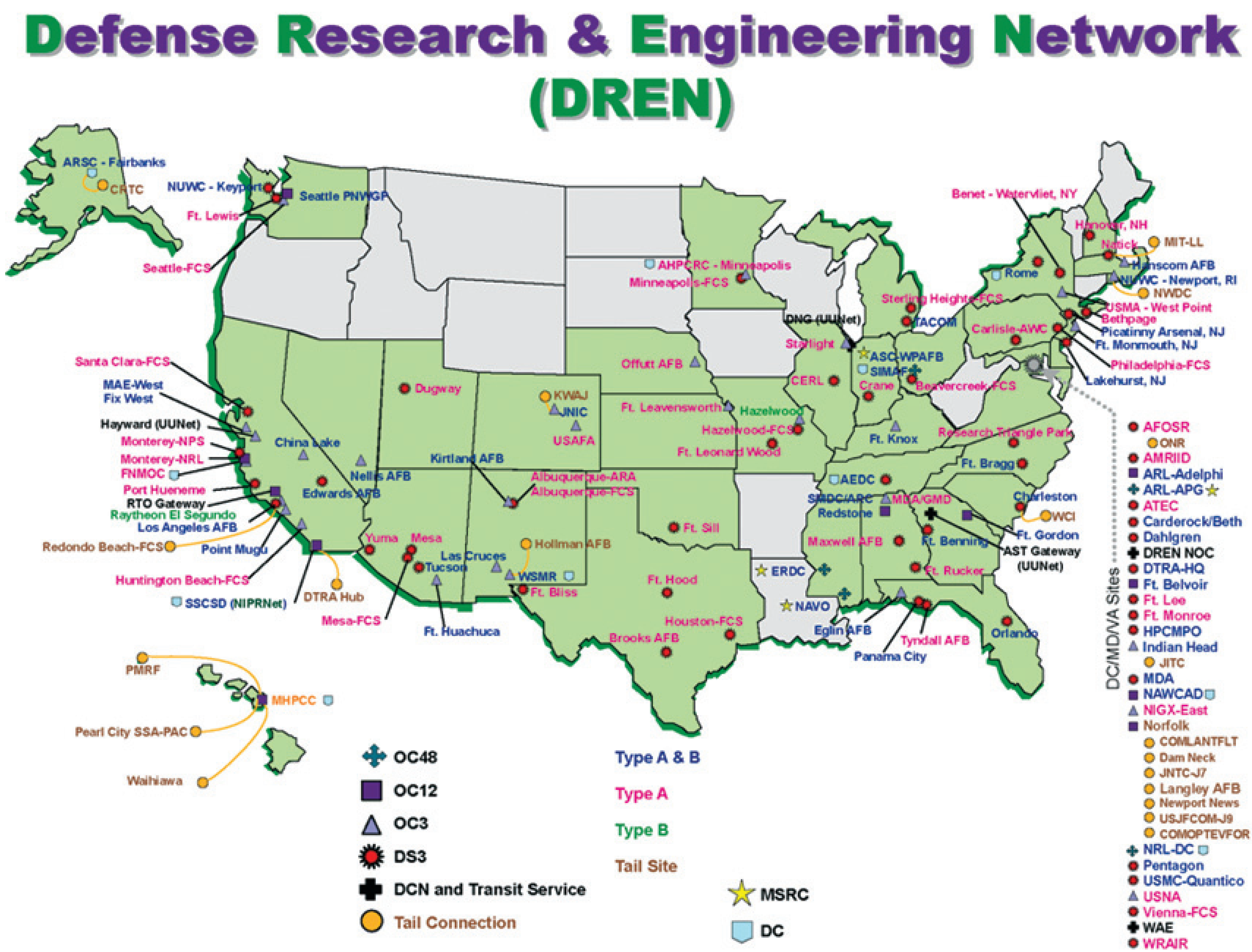


Figure 7. DREN Connections, High Performance Computing Shared Resource Centers, and Other Network Access Points

Goal 5: Promote collaborative relationships among the DoD HPC community, the National HPC community and Minority Serving Institutions (MSIs) in network, computer, and computational science

Defense Research & Engineering Network

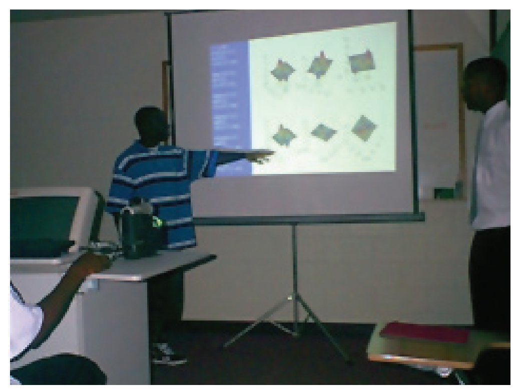
As one of the three major areas of DoD's high performance computing modernization program, DREN draws from the nations' high performance computing community most familiar with Defense supercomputing for technical advisory and security group members. DREN personnel also participate in the more generalized DoD networking and security communities through regular interactions with the Global Information Grid, direct participation on the DoD control boards and technical advisory councils, and participation as a Tier 2 DoD CERT (Computer Emergency Response Team for hostile acts of intrusion and compromise).

DREN contributes to overall federal agency networking and security through the Joint Engineering Team (JET) which coordinates Federal agency networking activities, operations, and plans represented by DoD DREN, DOE, NASA, NSF, NGI, and Image Intensifying (I2). The JET reports to the Large Scale Networking (LSN) Coordinating Group of the White House's Office of Science and Technology Policy Interagency Working Group (IWG).

DREN peers (exchanges network traffic) at well-known international exchange points such as Starlight in Chicago, Los Angeles (Rialto), and the Pacific Northwest Gigapop in Seattle, and actively participates in international science exchanges such as the Australian Meteorological and Oceanographic Society and Asian Pacific Advanced Networks projects.

Programming Environment and Training

The Education, Outreach, and Training Coordination functional area within PET is responsible for creating education opportunities targeted to undergraduate and graduate education, with emphases on minority serving institutions by sponsoring summer intern programs and summer institutes. This, in effect, will help create a workforce pipeline for the Department of Defense and the nation.



The Summer Intern program takes place in June, July, and August. The Summer 2004 Intern program was successful, and the student presentations can be found on the

PET Online Knowledge Center (https://okc.erdc.hpc.mil). From these presentations we get the clear message that not only does the summer intern program impact the workforce pipeline, but the projects that these students work on directly impacts DoD research. A total of 26 summer interns were placed at four locations: ARL–Aberdeen, MD, ERDC–Vicksburg, MS, ASC–WPAFB, OH, and NAVO–Stennis Space Center, MS.

One of our primary efforts in attracting and preparing students at MSIs for the intern program is the Summer Institute program. It is a two-week program held at an MSI that introduces the students to HPC and gives them some introductory instruction. In Summer 2004, PET sponsored four summer institutes at Jackson State University, Florida International University, University of Hawaii and Central State University. They collaborated with PET personnel from several functional areas to present the students with a well-rounded experience.

The Computational Science Workshop for Underrepresented Groups was held again in January 2004. This annual event, jointly supported by PET and other sources, brings together students and faculty from MSIs for a weeklong course on building a parallel computer and on methods for solving problems in computational science. The 2004 workshop, attended by 10 faculty and 20 students from MSIs, was held on the campus of the University of Southern California.

Participants at the
2004 Computational Science Workshop for Underrepresented Groups

SECTION 3

FINANCIAL STATEMENTS

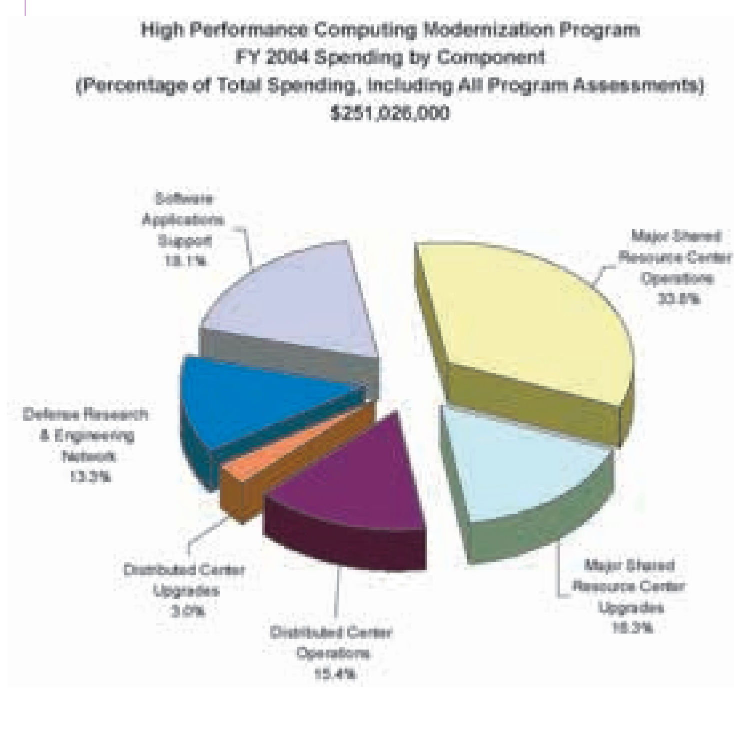
FY 2004 Budget Resources

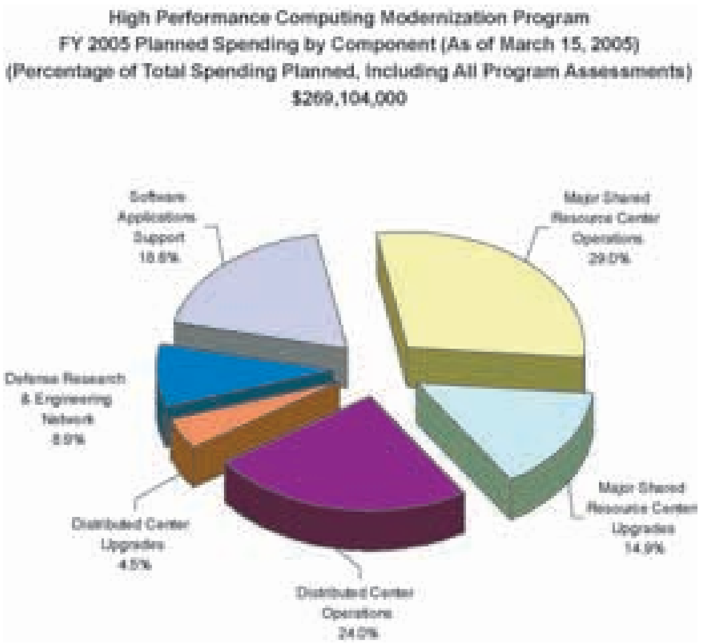
Financial Analysis

The HPCMP funds are used for (1) capitalization, sustainment, and operations at the MSRCs; (2) annual capitalization for selected DCs; (3) wide area network services for the DoD HPC community; (4) development of key HPC software; and (5) expert HPC services from leading academic institutions.

We use multiple contracting officers assigned in support of different efforts. We use contracting officers at the General Services Administration in support of HPC equipment and services purchases and use contracting officers at various DoD installations in support of service contracts. This structure is necessary because the program requires multiple contracts and contract types with an ongoing need to ensure that state-of-the-art technical capabilities are made available to DoD scientists and engineers in a timely manner.

Contracts are a combination of firm fixed price, cost and/or indefinite delivery/indefinite quantity. All procurement awards are made for commercially available systems.





Acquisitions are accomplished competitively to the fullest extent possible and encourage the inclusion of small, disadvantaged businesses and MSIs.

We evaluate the effectiveness of each program component by measuring actual cost and schedule performance versus planned cost and schedule performance and through the measurement of actual outcomes versus planned outcomes. The MSRC contractors submit several reports regularly including a monthly and quarterly cost performance report and quarterly contract funds status report. Each contract specifies, as a deliverable, a work breakdown structure to facilitate the on-going review of smaller task components. Cost/schedule status reports are one of the primary tools used for oversight management of the MSRCs.

The balance sheet on the next page shows the cumulative value of the program.

Obligations and Costs

Our Financial Manager conducts semi-annual reviews with each major component manager and major field activity to review actual cost performance against budgeted cost goals in a tailored work breakdown structure format with special attention on variance analysis. Significant variances are reported to our Program Director and corrective actions taken. We receive approximately $250,000,000 each year in funding appropriated for the DoD. Cash flow during 2004 is illustrated by the Cash Flow Statement on page 40.

While the program has leveraged major cost performance improvements in computer technology since 1994, validated requirements have always exceeded the computing capability available to address those requirements. This occurs: 1) because the use of science-based models and simulations to answer research questions and solve engineering problems has grown dramatically; and 2) because fully funding the HPC requirement is unaffordable given the entire scope of activities the DoD budget must address. While fiscal resources do not fully meet the computational requirements of the science and technology and test and evaluation communities, the returns provided are substantial and are allocated to the highest priority projects. These shortfalls can be seen in the FY 2004 Income Statement shown on page 41.

Financial Trends

Except for minimal inflation adjustments, HPC budgets are essentially flat. We are addressing urgent new requirements by

High Performance Computing Modernization Program
Balance Sheet
As of March 15, 2005

Assets and Equity		
Hardware	$905,218,999	
Less: Depreciation		
Fiscal Year 1994–2001:	$733,998,768	
Fiscal Year 2002:	$53,793,571	
Fiscal Year 2003:	$20,712,857	
Fiscal Year 2004:	$6,933,429	
Fiscal Year 2005:	$0	
		$89,780,374
Software (1)	$135,234,877	
Less: Depreciation		
Fiscal Year 1994–1999:	$87,844,346	
Fiscal Year 2000:	$17,116,596	
Fiscal Year 2001:	$12,185,610	
Fiscal Year 2002:	$10,176,631	
Fiscal Year 2003:	$5,614,413	
Fiscal Year 2004:	$1,578,842	
Fiscal Year 2005:	$0	$718,439
Manpower Contracts (2 & 3)		
Software Development		
Exercised Contract Value	$24,601,718	
Less: Value Consumed	$22,209,445	
Remaining Exercised Value		$2,392,273
Maintenance Contracts (2 & 3)		
Hardware Maintenance		
Fiscal Year 2005:	$23,396,500	
Software Maintenance		
Fiscal Year 2005:	$4,368,433	
Less: Value Consumed		
Hardware Maintenance		
Fiscal Year 2005	$14,657,137	
Software Maintenance		
Fiscal Year 2005:	$2,960,883	$10,146,913
Intellectual/Operations		
Government Labor		
Fiscal Year 2005:	$17,989,708	
Contract Labor		
Fiscal Year 2005:	$91,103,478	
Less: Value Consumed		
Government Labor		
Fiscal Year 2005:	$12,573,763	
Contract Labor		
Fiscal Year 2005:	$60,997,058	$35,522,365
Total Assets	**$138,560,364**	

Liabilities		
Uncompleted Software Development	$2,392,273	
Maintenance Contract Liabilities		
Hardware		
Fiscal Year 2005:	$8,739,363	
Software		
Fiscal Year 2005:	$1,407,550	
Intellectual/Facilities Expense		
Government Labor		
Fiscal Year 2005:	$5,415,945	
Contract Labor		
Fiscal Year 2005:	$30,106,420	
Total Liabilities	**$48,061,551**	
Program Equity		**$90,498,813**
Total Liability and Program Equity		**$138,560,364**

(1) Research, Development and Engineering Funding used to develop inventory software.

(2) Office of Management and Budget Circular A-11, Section 300 - Planning, Budgeting, Acquisition, and Management of Capital Assets (Paragraph 300.4), defines capital assets as land, structures, equipment, intellectual property (e.g., software), and information technology (including IT service contracts) that are used by the Federal government and have an estimated useful life of two years or more. Therefore, manpower is treated as a capital asset.

(3) Small consumable items such as computer tapes and supplies are considered as expense items and not carried as inventory items.

High Performance Computing Modernization Program
Cash Flow Statement
October 1, 2003 — September 30, 2004

	Fiscal Year 2004
Revenue	
Research, Development and Engineering Funding	
President's Budget	$185,282,000
Congressional Funding	$20,200,000
Department of Defense Reprogramming - In	$0
(Less Department of Defense Reprogramming - Out)*	($2,990,000)
Net Research, Development and Engineering Funding	**$202,492,000**
Procurement Funding	
President's Budget	$48,927,000
Congressional Funding	$0
Department of Defense Reprogramming - In	$0
(Less Department of Defense Reprogramming - Out)	($393,000)
Net Procurement Funding	**$48,534,000**
Net Revenue	**$251,026,000**
Investments	
Major Shared Resource Center Upgrades	$40,974,468
Distributed Center Upgrades	$7,559,533
Software Development	$16,099,849
Expense	
Major Shared Resource Center Operations	$84,937,254
Distributed Center Operations	$38,769,625
Defense Research & Engineering Network	$33,334,957
Software Initiatives	$29,350,314
Net Expense	**$251,026,000**
Balance (As of September 30, 2004)	**$0**

High Performance Computing Modernization Program
Income Statement
October 1, 2003 — September 30, 2004

	Fiscal Year 2004
Income	
Research, Development and Engineering Funding	
Major Shared Resource Center Operations	$84,937,254
Distributed Center Operations	$38,769,625
Defense Research & Engineering Network	$33,334,957
Software Initiatives	$45,450,162
Procurement Funding	
Major Shared Resource Center Upgrades	**$40,974,468**
Distributed Center Upgrades	$7,559,534
Defense Research & Engineering Network	$0
Software Initiatives	$0
Total Income	**$251,026,001**
Expense[1]	
Research, Development and Engineering Funding	
Major Shared Resource Center Operations	$84,937,254
Distributed Center Operations	$38,769,625
Defense Research & Engineering Network	$33,334,957
Software Initiatives[2]	$29,350,313
Depreciation of Capital Assets	
Hardware (Depreciated based upon a 48-month life-cycle)[3]	$71,642,000
Software (Depreciated based upon a 60-month life-cycle)[4]	$19,575,285
Total Expense[5]	**$277,609,435**
Balance (As of September 30, 2004)	**-$26,583,434**

Note 1: Expenses include travel; supplies; government and contractor salaries and training; maintenance of hardware and software; studies and analysis; annual operations investments; and communications, utilities, facilities lease, and facilities maintenance.

Note 2: Software initiatives are separated into two distinct categories—expenses associated with research and development, management, education/training and expert services; and capital assets resulting from developed software.

Note 3: Depreciation for HPC hardware is calculated using a 48-month straight-line depreciation method. Current HPC technology development results in predictable obsolescence. Generally after 48-months of use, HPC systems are retired with little or no residual value. Fiscal year 2004 depreciation includes the 12-month value calculated for all systems in the inventory between October 1, 2003 through September 30, 2004.

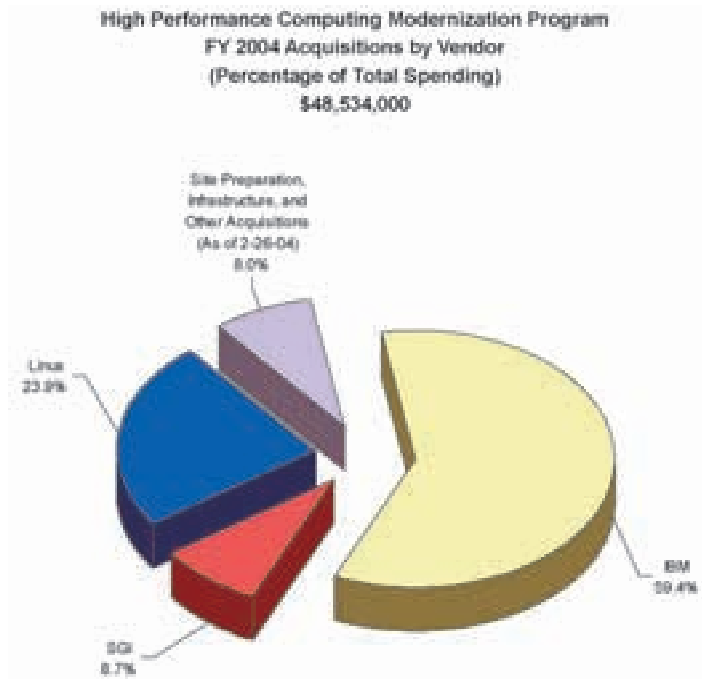
Note 4: Depreciation for HPC software is calculated using a 60-month straight-line depreciation method. A period of 60-months is used because it is the typical life cycle of HPC software before significant modifications are required. Fiscal year 2004 depreciation includes the 12-month value calculated for all software in the inventory between October 1, 2003 through September 30, 2004.

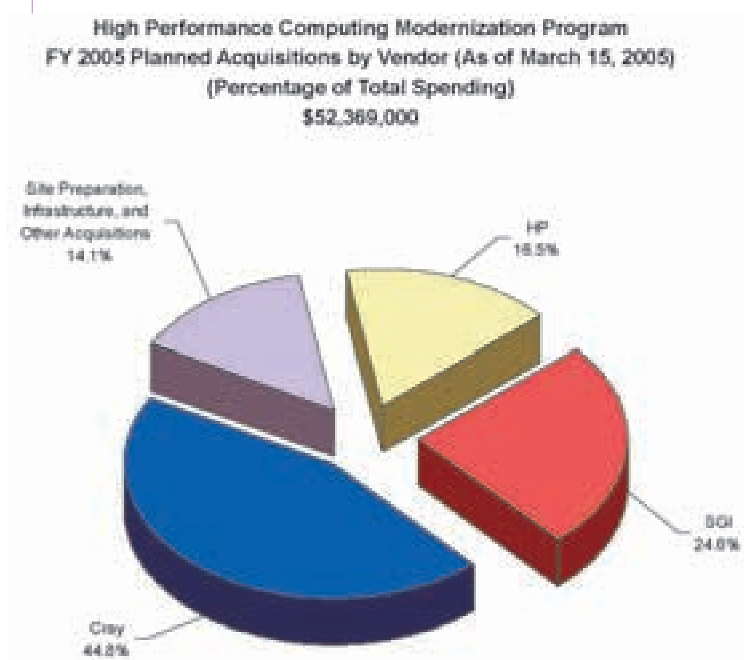
Note 5: Annual program investments in system hardware have not been made at levels sufficient to maintain stable equipment inventories. For several years depreciated values have not been offset by new assets.

adjusting priorities within the existing funding profile. For example, in FY 2004 a new effort to address a long-standing need for a disaster recovery infrastructure was implemented, and equipment and software were acquired and installed. We increased the overall capability of our HPC systems by about 80%, and add or upgraded systems at five DCs. Security of the DREN network was increased by encrypting all internal traffic. In addition, we are converting the network to the new IPv6 standard. Development of shared scalable applications supporting software will continue. The DoD HPC user community will continue to be supported by the PET efforts. Our Software Protection Initiative will continue to mature. The charts on the previous page break out program-wide and planned spending during 2005.

The Income Statement on page 39 shows that we currently have a continuing deficit in that the dollars we spend are not keeping up with the rapidly growing needs of the scientific community. We require multiple contracts and contract types. The charts shown to the right, display spending by vendor in FY 2004 and planned spending by vendor in FY 2005.

We deploy, sustain, and upgrade commercially available high performance computing environments and networking services in support of DoD laboratories and test facilities. We have substantially improved the Department's computational capabilities with the objective of providing the DoD the technology to ensure dominance on the battlefield by the early fielding of the most advanced computing capability available.





ACRONYMS

Acronyms

3-D	three-dimensional
ADCs	Allocated Distributed Centers
AEDC	Arnold Engineering Development Center
AFB	Air Force Base
AFRL/IF	Air Force Research Laboratory, Information Directorate
AFWA	Air Force Weather Agency
AHPCRC	Army High Performance Computing Research Center
ARL	Army Research Laboratory
ARSC	Arctic Region Supercomputing Center
ASC	Aeronautical Systems Center
ATC	Aberdeen Test Center
BEI	Battlespace Environments Institute
BHSAI	Biotechnology HPC Software Applications Institute for Force Health Protection
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance
CBD	Chemical/Biological Defense
CBoD	Center Board of Directors
CCM	computational chemistry and materials science
CDs	compact disks
CEA	computation electromagnetics and acoustics
CEN	computational electronics and nanoelectronics
CERT	Computer Emergency Response Team
CFD	computational fluid dynamics
CSM	computational structural mechanics
CTAs	Computational Technology Areas
CWO	climate/weather/ocean modeling and simulation
DCs	Distributed Centers

DDCs	Dedicated Distributed Centers
DIOT	Distributed Implementation and Operations Team
DoD	Department of Defense
DOE	Department of Energy
DREN	Defense Research and Engineering Network
DTO	Defense Technology Objectives
DTRA	Defense Threat Reduction Agency
ED&PMB	Engineering Design and Process Management Board
ERDC	Engineer Research and Development Center (USACE)
EQM	environmental quality modeling and simulation
FLOPS	FLoating-point OPerations per Second
FMS	forces modeling and simulation
FNMOC	Fleet Numerical Meterology Oceanography Center
FY	fiscal year
GFDL/N	Geophysical Fluid Dynamics Laboratory/Navy
GFLOPs/GFs	gigaflops
GFS	Global Forecast System
GMT	Greenwich Mean Time
HPC	high performance computing or high performance computer
HPCMP	High Performance Computing Modernization Program
HPTi	High Performance Technologies, Incorporated
HWIL	hardware-in-the-loop
IHAAA	Institute for HPC Applications to Air Armament
IMT	integrated modeling and test environments
IMTPS	Institute for Maneuverability and Terrain Physics Simulation
IR	infrared
IWG	Interagency Working Group
J9	Joint Forces Command
JET	Joint Engineering Team
JITSN	Javelin Integrated Test and Simulation Network
LSN	Large Scale Networking
MBD	Materials by Design
MDA	Missile Defense Agency

MHPCC	Maui High Performance Computing Center
MPI	Message Passing Interface
MSIs	Minority Serving Institutions
MSRCs	Major Shared Resource Centers
NASA	National Aeronautics and Space Administration
NAVO	Naval Oceanographic Office
NCEP	National Center for Environmental Predictions
NAWCAD	Naval Air Warfare Center Aircraft Division
NGI	Next Generation Internet
NHC	National Hurricane Center
NOAA	National Oceanic and Atmospheric Administration
NOGAPS	Naval Operational Global Atmospheric Prediction System
NRL-DC	Naval Research Laboratory, Washington, DC
NSF	National Science Foundation
OKC	On-line Knowledge Center
PET	Programming Environment and Training
RCS	Radar Cross Section
RDT&E	research, development, test, and evaluation
RTTC	Redstone Technical Test Center
S-DREN	Secret Defense Research and Engineering Network
S&T	science and technology
SAS	Software Applications Support
SIMAF	Simulations & Analysis Facility
SIP	signal/image processing
SMDC	Army Space and Missile Defense Command
SOS	System-of-Systems Simulation
SPG	Sensor/Scene Processing and Generation
SSA	HPC Software Applications Institute for Space Situation Awareness
SSCSD	Space and Naval Warfare Systems Center, San Diego
T&E	test and evaluation
TFLOPs	teraFLOPS
UAVs	Unmanned Air Vehicles
UK	United Kingdom

U.S.	United States
USACE	US Army Corps of Engineers
UV	ultraviolet
VED	Virtual Electromagentics Design
VV&A	validation, verification, and accreditation
WAN	wide area network
WSMR	White Sands Missile Range

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