2008 Annual Report

Department of Defense High Performance Computing Modernization Program

Solving the Hard Problems

Acknowledgments

The High Performance Computing Modernization Program Office (HPCMPO) is indebted to many people who provided the knowledge, time, and talent to create the 2008 Annual Report. Special thanks are due to Sheryl Caramanzana, Lisa Powell, Leah Glick, and our summer intern, Heather Peterson, for the layout, design, and editing work. Thanks also go to the people within the program office who lent their expertise and shared contributions to this publication. And, most importantly, the HPCMPO would like to acknowledge all HPC users who solve hard problems to benefit the lives of our airmen, soldiers, and sailors. Your research and dedication has helped Americans here and abroad in both large and small ways. All of you contributed to HPCMP's mission and the contents within this annual report. You have our heartfelt thanks.

Deborah Schwartz
Oversight and Outreach Program Manager

For more information about the DoD High Performance Computing Modernization Program and the DoD High Performance Computing Modernization Program Office visit our website at http://www.hpcmo.hpc.mil

HPC DoD Modernization Program
SOLVING THE HARD PROBLEMS

Department of Defense
High Performance Computing Modernization Program

2008 Annual Report

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

April 2009

Director's Message

This year, the High Performance Computing Modernization Program (HPCMP) made great strides in improving critical defense capabilities through some of the world's most powerful supercomputers. In 2008, the Program supported leading edge technology located at four Major Shared Resource Centers (MSRCs) and four Allocated Distributed Centers (ADCs). The Defense Research and Engineering Network (DREN) emerged as an important contributor to combat power and protection with the effective implementation of IPv6. A funded program in 2008, Computational Research and Engineering Acquisition Tools and Environments (CREATE) began a long-term effort to enhance the productivity of the Department of Defense (DoD acquisition engineering workforce by deploying air vehicle, ship, and antenna design tools. Here, at the Program, we are excited that the HPCMP continues to excel, providing the supercomputer technology and know-how the DoD scientists and engineers use every day to preserve our nation's resources and develop new technologies to keep America strong.

Dedicated to and inspired by the technical community it supports, the HPCMP promotes collaborative relationships among scientists and engineers and mentors and students. The HPCMP shifts the paradigm of science and technology, so that HPC-enabled simulation is now equal to developmental live experimentation. To prepare Americans for these innovations, the HPCMP conducts outreach programs on a national scale. The Program offers Joint Educational Opportunities for Minorities (JEOM) Internships for those in the science, technology and mathematics majors; University workshops, and National Defense Science and Engineering (NDSEG) Fellowships for graduate students; and the Users Group Conference (UGC), where those already involved or interested in the Program can come together to discuss new research and projects.

In 2008, the HPCMP continued to calculate the HPCMP's Return On Investment (ROI) for the DoD in the area of air vehicles, which rely on the Programs' computing resources. Every dollar the HPCMP invested returned at least seven dollars of value for the taxpayer.

As the Program ends another successful year, we continue to improve supercomputing capabilities, which support the design and test of innovative materials and weapon systems to save lives and help our nation's Warfighters. The need for science and engineering continues to accelerate and we intend to develop the best solutions for our nation's defense. Developing the technology we need is an ongoing effort—we'll never be finished, but the nation can rest assured that we have state-of-the-art technology and a world-class S&T and T&E community on our side.

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Program Overview

Introduction

When new critical technologies are needed, where do Department of Defense (DoD) scientists and engineers turn? They turn to the High Performance Computing Modernization Program (HPCMP) where solving the hard problems is routine.

Technological superiority wins wars. History teaches us that victory finds those who properly prepare. In order to mitigate present and future defense challenges, the HPCMP provides capabilities for the DoD to empower a military second to none.

Our military gains strength through technology. The DoD HPCMP team, under the leadership of Mr. Cray Henry, made major contributions to the Warfighter, science and technology (S&T), and the nation. The HPCMP provides the supercomputer technology and know-how the Department's scientists and engineers use every day to preserve our nation's resources and develop new technologies to keep America strong. The HPCMP developed a methodology to calculate the HPCMP's Return On Investment (ROI) for the DoD in areas, such as armor/anti-armor design and development and climate, weather, and ocean (CWO) modeling, which rely on the Programs' computing resources. For these applications, an $821 million investment yielded returns in billions of dollars! Every dollar the HPCMP invested saved several dollars for the taxpayer.

HPCMP Mission

Accelerate development and transition of advanced defense technologies into superior warfighting capabilities by exploiting and strengthening US leadership in supercomputing, communications, and computational modeling.

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.

High performance computing (HPC) tools solve complicated and time-consuming problems. Researchers expand their toolkit to solve modern military and security problems using HPC hardware and software applications. Through HPC solutions, projects gain knowledge to protect our military through new weapons systems for overseas deployments in Afghanistan and Iraq and assist long-term weather predictions to plan humanitarian and military operations throughout the world.

Dedicated to and inspired by the technical community it supports, the HPCMP promotes collaborative relationships among scientists and engineers and mentors and students. The HPCMP shifts the paradigm of science and technology with HPC advancements in simulation now equal to developmental live experimentation. To prepare Americans for these innovations, the HPCMP conducts outreach programs on a national scale.

Collectively, HPCMP training and career development offers opportunities for young people to work with seasoned and well-respected scientists and engineers, located at DoD laboratories and test centers across the country. With guidance and exposure to HPC resources, these young Americans can become skilled professionals in the federal workforce.

The HPCMP's mentorship and collaboration foster the DoD HPC community to advance technology and improve the capabilities and effectiveness of the Warfighter and the DoD.

The HPCMP Goals

Commitment to support the Warfighter and protect our nation drives the HPCMP mission. To accomplish this mission, the HPCMP focuses on five goals:

- Acquire, deploy, operate, and maintain best-value supercomputers
- Promote collaborative relationships among the DoD computational science community, the national computational science community, and minority serving institutions
- Continuously educate the research, development, test, and evaluation workforce with the knowledge to employ computational modeling effectively and efficiently
- Acquire, develop, deploy, and support software applications and computational work environments that enable critical DoD research, development, and test challenges to be analyzed and solved
- Acquire, deploy, operate, and maintain a communications network that enables effective access to supercomputers and distributed S&T/T&E computing environments

Every component in the HPCMP organization supports one or more goals. The HPCMP tracks and reports its progress on a quarterly and annual basis. At an annual joint meeting consisting of the Configuration Steering Board (CSB)/ Overarching Integrated Product Team (OIPT)/High Performance Computing Advisory Panel (HPCAP) members, the HPCMP reports successes and sets new goals and priorities for the upcoming year.

The HPCMP Organization

Components within the HPCMP organization remain interdependent and maintain distinct business practices and community relationships. Because of these components, customers gain state-of-the-art tools and high performance computing capabilities. High-speed networks reach thousands of customers in academies, the Services, Agencies, and other institutions. HPC Centers, across the country, experience rapid growth in computational capabilities using innovative HPC products.

The HPCMP organizational framework promotes success and solves HPC issues:

- HPC Centers
- Networking
- Software Applications Support (SAS)
- Resource Management
- Outreach
- Oversight

HPC Centers Provide supercomputers	**Networking** Provide networks and advanced communication capabilities	**SAS** Provide state-of-the art software tools to enable users to make the best use of HPC hardware resources
Resource Management Gather, analyze, store, and report requirements, allocation and usage information on DoD computational projects and HPC systems performance to support DoD/Services/Agencies allocations, program planning, acquisition, and operational processes	**Outreach** Promote HPCMP and foster the exchange of ideas among HPC scientific and computational communities within the DoD and at the National level	**Oversight** Ensure the HPCMP complies with US and DoD requirements

The HPCMP Community

In the beginning of FY 2008, the HPCMP community consisted of 2,254 individual users: scientists, engineers, and security experts on approximately 284 sites throughout the United States. These innovators within the Air Force, Army, Navy, and several defense agencies executed 382 projects. In early FY 2009, the HPCMP anticipates significant growth in the HPCMP community: 4,152 users to execute 529 projects at 125 sites.

The HPCMP responds to the computational needs of its users and ensures the appropriate distribution of assets across the DoD S&T and test and evaluation (T&E) communities based upon documented requirements and Service priorities. Users gain access to high performance computing centers; for example, Army Research Laboratory (ARL), Engineer Research and Development Center (ERDC), Naval Oceanographic Office (NAVO), Air Force Research Laboratory (AFRL), Maui High Performance Computing Center (MHPCC), Arctic Region Supercomputing Center (ARSC), and other HPC Centers support several projects, but not all users work in the military. Some users from DoD-sponsored project teams come from Services, universities, and affiliated agencies.

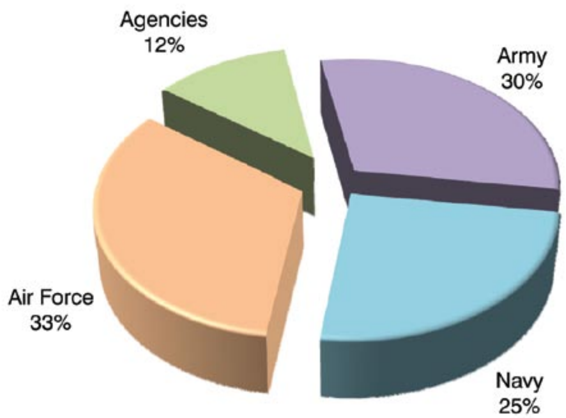
HPCMP Users in the Services and Agencies

HPCMP's dynamic and diverse community values HPCMP resources and the increase in users is proof of the Program's increasing impact.

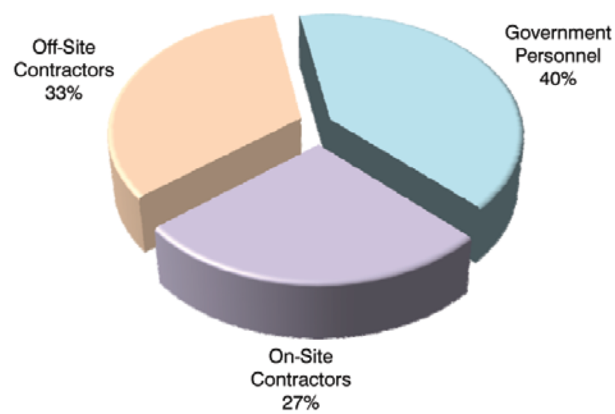
Army Participation	Navy Participation	Air Force Participation	Agencies Participation
ARL & ERDC	NAVO	AFRL & MHPCC	DARPA, DTRA, JFCOM, MDA, PA&E, and ARSC
1,343 Users	942 Users	1,330 Users	537 Users
24 Organizations	16 Organizations	25 Organizations	4 Organizations
108 Projects	197 Projects	199 Projects	25 Projects
50 DREN sites	40 DREN sites	21 DREN sites	84 DREN sites
15 Challenge Projects	13 Challenge Projects	11 Challenge Projects	2 Challenge Projects
2 DHPIs	2 DHPIs	3 DHPIs	2 DHPIs
5 Institutes	1 Institute	3 Institutes	

FY 2008 HPC Statistics – Who are HPC Users?

After receiving allocations from the Program, project research and development involve Services, Agencies, and universities. Services and Agencies decide the amount of resources to allocate for each project. The two pie charts below show user categories and distribution by Services, Agencies, contractors, and government personnel.



HPC Users by Service/Agency



DoD HPC Users by Government or Contractor

Computational Technology Areas (CTAs)

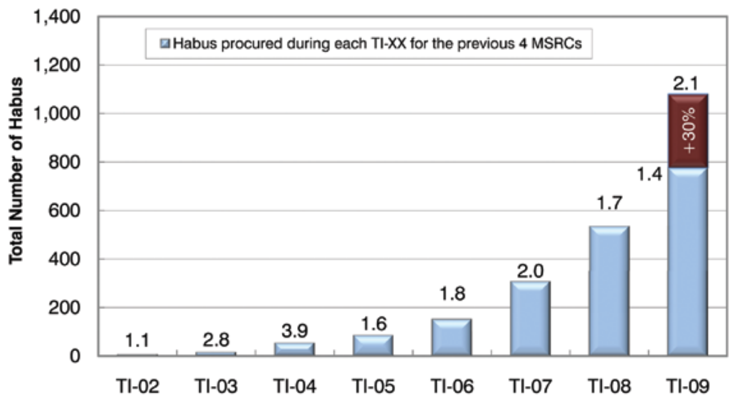
The HPCMP community focuses on hundreds of projects throughout the country, categorized into areas called Computational Technology Areas (CTAs). The following table provides FY 2008 CTAs and the number of users.

Computational Technology Area	Description	Users
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.	423
Computational Fluid Dynamics (CFD)	Provides accurate numerical solution of the equations describing fluid and gas motion.	1,537
Computational Chemistry, Biology, and Materials Science (CCM)	Predicts properties and simulates the behavior of chemicals and materials for DoD applications. Methods ranging from quantum mechanical, atomistic, and mesoscale modeling, to multiscale theories that address challenges of length- and time-scale integration, are being developed and applied. Of recent emerging interest in the CCM CTA are methodologies that cover bioinformatics tools, computational biology, and related areas, such as cellular modeling.	501
Computational Electromagnetics and Acoustics (CEA)	Provides high-resolution multidimensional solutions of electromagnetic and acoustic wave propagation, and their interaction with surrounding media.	322
Climate/Weather/Ocean Modeling and Simulation (CWO)	Involves accurate numerical simulation and forecast of the Earth's atmosphere and oceans on those space and time scales important for both scientific understanding and DoD operational use.	259
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.	393
Forces Modeling and Simulation (FMS)	Focuses on the research and development of HPC-based physical, logical, and behavioral models and simulations of battlespace phenomena in the correlation of forces.	78
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.	169
Electronics, Networking, and Systems/C4I (ENS)	Focuses on the use of computational science in support of analysis, design, modeling, and simulation of electronics from the most basic fundamental, first principles physical level to its use for communications, sensing, and information systems engineering; activity ranges from the analysis and design of nano-devices to modeling systems-of-systems.	164
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.	147
OTHER	Various	159

Computational Capability at the Major Shared Resource Centers (MSRCs)

Since 2002, the HPCMP steadily increased its computational capability through the acquisition of new systems at its MSRCs and Allocated Distributed Centers (ADCs). This steady increase of cutting-edge technology provides the systems to support groundbreaking work in chemistry, physics, and mathematics. Through the Technology Insertion (TI) process, the HPCMP makes an annual investment into the acquisition of new high performance computing systems for distribution to HPC Centers.

In FY 2008, the HPCMP received approximately $50 million in total funding to build and improve infrastructure, provide resources to competitive projects, and acquire large HPC systems for the HPC Centers. The figure (right) shows the increase of computational performance due to the availability of HPC assets from TI-02 to TI-09 (estimated) in total number of Habus. The number above each bar shows a factor increase from the previous year. For a thorough definition of the Habu measurement, see page 7.



HPC Installations (TI-01 Through 09) Added HPC Capability Trend

Resource Management

Resource Management determines the requirements of HPC users and reports customer community special interest activities, such as requirements site visits and Challenge allocation processes. The Resource Management team gathers, analyzes, stores, and reports requirements, allocations, and usage information on DoD computational projects and HPC systems performance to support DoD/Services/Agencies allocation, program planning, acquisition, and operational decisions. Resource Management consists of five major activities that accomplish these goals, described in this section.

Mission: To ensure HPCMP computational resources are appropriately distributed across the DoD S&T and T&E communities based upon documented requirements and Service priorities.

Requirements Document & Analysis

*DoD Challenge Projects**
29 continuing projects
10 new projects

Metrics Management

*Dedicated HPC Project Investments (DHPIs)**
5 continuing projects
1 new project

*Capability Applications Projects (CAPs)**
6 Phase I projects
1 Phase II project

*The definition of these projects are found on page 9 (Challenge), page 13 (DHPI), and page 14 (CAPs).

Requirements Analysis

To serve the HPC community, the HPCMP conducts surveys to capture customer requirements and continuously improve processes. HPCMP projects provide their input in the Portal to the Information Environment (pIE), an online requirements questionnaire. In FY 2008, the HPCMPO analyzed this data and made key decisions, such as resource acquisitions and allocations, training courses, and software licensing. Every year, the HPCMPO publishes a requirements analysis report to discuss survey analysis, which is available upon request.

During FY 2008, the HPCMP Requirements Team made site visits to the following locations:

- US Air Force Research Laboratory, Human Effectiveness Directorate (AFRL/RH), Brooks AFB, TX
- US Air Force Research Laboratory, Materials and Manufacturing Directorate (AFRL/RX), Tyndall AFB, FL
- US Air Force Research Laboratory, Munitions Directorate (AFRL/RW), Eglin AFB, FL
- US Army Armament Research, Development and Engineering Center, (ARDEC), Picatinny Arsenal, NJ
- US Army Aviation and Missile Research Development and Engineering Center (AMRDEC), Redstone Arsenal, AL
- US Army Communications-Electronics Command (CECOM), Ft. Monmouth, NJ
- US Army Medical Research and Materiel Command (USAMRMC), Ft. Detrick, MD
- US Army Night Vision Laboratory (NVL), Ft. Belvoir, VA
- Dugway Proving Ground (DPG), UT
- Naval Surface Warfare Center (NSWCC), Carderock, MD
- Naval Surface Warfare Center (NSWCD), Dahlgren, VA
- Naval Surface Warfare Center (NSWCP), Panama City, FL
- Naval Undersea Warfare Center (NUWC), Newport, RI
- Navy Warfare Development Command (NWDC), Newport, RI
- Redstone Technical Test Center (RTTC), Redstone Arsenal, AL
- Soldier Biological Chemical Command Research Development Engineering Center (SMCCOM), Natrick, MA
- Space and Missile Defense Command (SMDC), Huntsville, AL

Habu—a Measure of Computational Performance

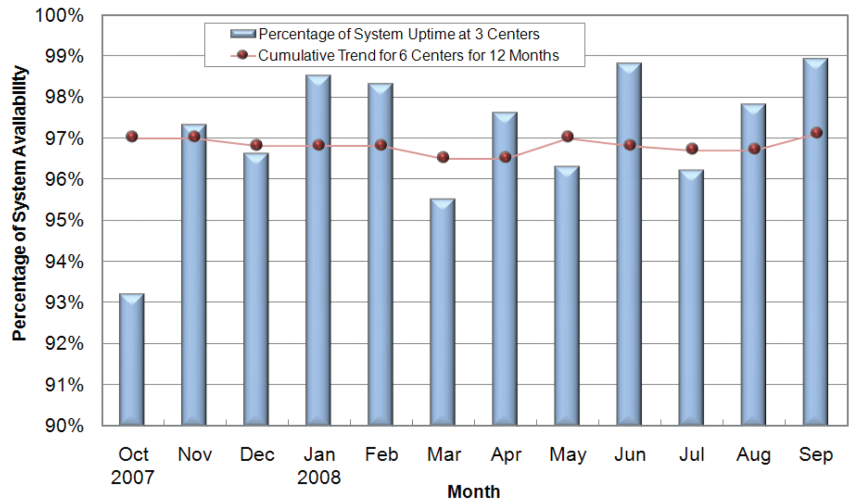
The HPCMP rates computer systems in terms of the speed at which DoD computational applications run on the systems. For the past six years, the HPCMP has run a suite of applications on existing and new systems to obtain performance comparisons. By comparing the timing results for these applications, the HPCMP is able to compare the performance of any system relative to the others. In 2002, a 1,024-processor IBM system located at the Naval Oceanographic Office MSRC named Habu, was designated the baseline system. Hence, performance measures are all in “Habu” equivalent units. For example, if a new system is rated at two Habus, that system is roughly two times more capable than a system rated at one Habu. That is, the new system executes the suite of applications at roughly twice the performance of the old. Of course, any individual application may run faster or slower.

Performance Metrics

Two types of system performance metrics assist the HPCMP to assess HPC system performance: number of processor hours utilized on each HPC system by each user organization (usage) and average expansion factor (normalized turnaround time) for each HPC system.

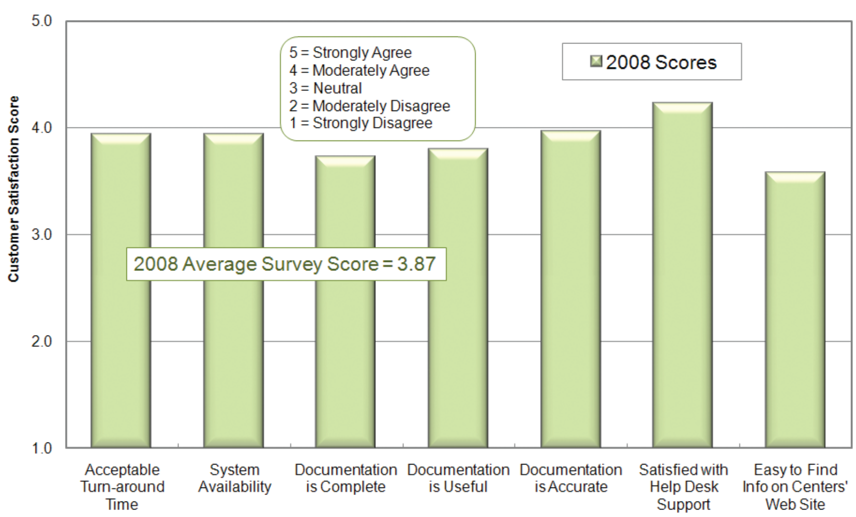
Together, these metrics provide an indication of how much computational work each system performs by each user organization and timeliness. The overall operational goal is to balance the delivery of maximum total number of processor hours, while maintaining an acceptable turnaround time for users.

Serving S&T and T&E communities, the HPCMP ensures optimum system performance of technology across the country. The HPCMP tracks the percentage of system availability and maintains a 96–97 percent cumulative trend across its six Centers, ensuring customers benefit from seamless HPC performance (see figure below).



HPCMP Systems Uptime at the Six Centers from October 2007 to September 2008

Optimum system performance contributes to customer satisfaction. In the most recent survey, HPCMP customers provided favorable scores and expressed positive feedback regarding HPC resources, as shown in the following chart.

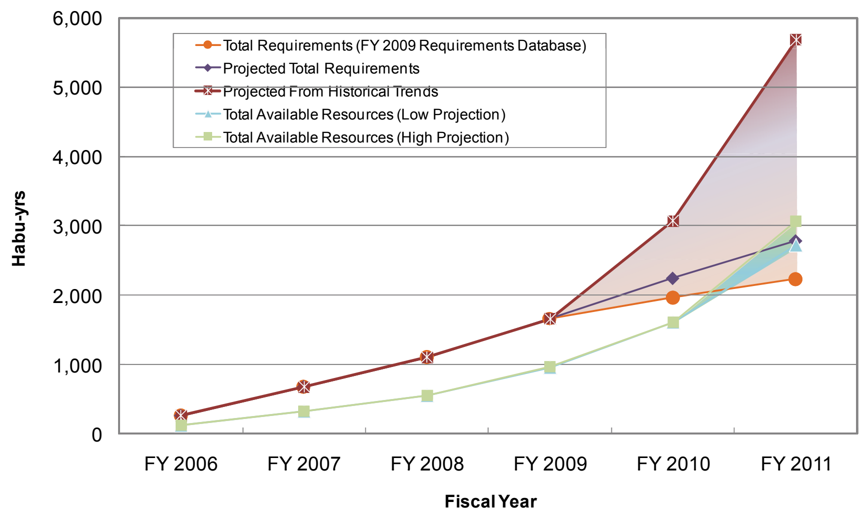


HPC Centers Metrics

HPCMP Computational Requirements

HPCMP investments and operational decisions rely on validated requirements. The HPCMP gathers, analyzes, and validates user community requirements to include systems hardware, software, network, and training. Furthermore, the Program takes the time to check information through in-person interviews and quality assurance checks. Senior S&T and T&E executives in each Service and Agency pay attention to requirement details to set usage priorities. In FY 2008, overall requirements increased from previous years and are projected to increase at a steady, consistent rate.

For FY 2008, after requirements analysis, the HPCMP implemented an allocation policy to meet customer needs. The HPCMP allocates 100 percent of all of its resources to HPC Centers. In turn, the HPC Centers allocate these resources to Services/Agencies, 70–75 percent; Challenge Projects, 25–30 percent; and other high-priority projects, 1 percent.



Total Computational Requirements of the HPCMP Community

DoD S&T and T&E communities that meet analysis requirements receive a spectrum of computational platforms at the unclassified and classified levels to support a wide range of DoD applications. A reliable high-speed network connects users to powerful resources and platforms with computational power, central memory, and data storage. HPC balances technology with aggressive training programs to educate HPC users and broaden their knowledgebase. Progress, education, and innovation optimize the HPC impact on DoD's ability to support the Warfighter.

DoD Challenge Projects

The HPCMP allocated approximately 30 percent of its HPC resources in FY 2008 to competitively selected DoD Challenge Projects. A rigorous technical and mission relevance evaluation determines the selection of these computationally intensive, high-priority projects. Senior scientists and engineers within defense S&T and T&E organizations, universities, and industry research partners head these high-priority projects. Services and Agencies allocate the remaining resources through Service and Agency unique processes. The HPCMP provides large blocks of premium computer time at a high-priority and expert technical assistance to Challenge Projects.

Challenge Project efforts produce and support key enabling technologies, capabilities, and demonstrations expressed by the Defense Technology Objectives (DTOs). These enabling DTOs, in turn, support Joint Vision 2020 and the 13 Joint Warfighting Capability Objectives (JWCOs) promulgated by the Joint Requirements Oversight Council of the Joints Chiefs of Staff.

This section provides a list of 10 new Challenge Projects and completed Challenge Projects for FY 2008. Refer to the Appendix for Challenge Projects that continued into FY 2009. The new Challenge Projects for FY 2008 are:

New FY 2008 Challenge Projects
Atmospheric Turbulence Forecasts for Air Force and Missile Defense Applications Project Leader: Joseph Werne, Northwest Research Associates, Colorado Research Associates Division, Boulder, CO Sponsor: Air Force Airborne Laser System Program Office
High-Fidelity Multidisciplinary Simulation of Biologically Inspired Micro Air Vehicles (MAV) Project Leader: Raymond Gordnier, Air Force Research Laboratory, Air Vehicles Directorate (AFRL/RB), Wright-Patterson AFB, OH Sponsor: Air Force
High-Resolution Parallel Coastal Ocean Modeling for Collaboration on Office of Naval Research (ONR) and DoD Field Experiments Project Leader: Oliver B. Fringer, Stanford University, Stanford, CA Sponsor: Office of Naval Research
Hypervelocity Stage-Separation for Interceptor Missile Project Leaders: Kevin Kennedy, US Army Aviation & Missile Research, Development & Engineering Command (AMRDEC), Development & Engineering Center and Sanford M. Dash, CRAFT Tech, Pipersville, PA. Sponsor: Army
Multiscale Simulations of High Performance Capacitors and Nanoelectronic Devices Project Leader: Jerry Bernholc, North Carolina State University, Raleigh, NC Sponsor: Office of Naval Research
Numerical Exploration of the Stable Atmospheric Boundary Layer (SABL) and Its Effect on Forecasting Battlefield Weather, Sensor Propagation and Diffusion and Dispersion of Smoke and Other Agents Project Leader: Patrick A. Haines, US Army Research Laboratory (ARL), White Sands Missile Range, NM Sponsor: Army
Reliable Prediction and Analysis of 3-D Separation Using Computational Fluid Dynamics (CFD) Project Leader: Hermann Fasel, University of Arizona, Tucson, AZ Sponsor: Office of Naval Research
Smart Weapon Flight Control System Design Using Coupled Time-Accurate CFD/Rigid Body Dynamic (RBD)/Future Combat Systems (FCS) Simulations Project Leader: Jubaraj Sahu, US Army Research Laboratory (ARL), Aberdeen Proving Ground, MD Sponsor: Army
Virtual Prototyping of Directed Energy Weapons Project Leader: Keith Cartwright, US Air Force Research Laboratory, Directed Energy Directorate (AFRL/RD), Kirtland AFB, NM Sponsor: Air Force
Vulnerability of Structures to Weapons Effects Project Leader: James T. Baylot, USACE Engineer Research and Development Center (ERDC), Vicksburg, MS Sponsor: Army

In FY 2008, the Challenge Project Proposal Review Board evaluated FY 2009 Challenge Project proposals. The Challenge Project Proposal Review Board reviewed 27 proposals from the Services, Defense Threat Reduction Agency (DTRA) and the Defense Advanced Research Projects Agency (DARPA), and scored proposals based on technical merit, computational merit, and potential for significant progress. The Deputy Undersecretary of Defense (Science and Technology) [DUSD(S&T)] approved 41 DoD Challenge Projects for FY 2009; 17 new, 23 continuing, and 1 extension.

The following table provides a list of the 16 Challenge Projects completed in FY 2008.

Completed FY 2008 Challenge Projects

Advanced Chemical Oxygen-Iodine Laser Technology Development Using 3-D Navier-Stokes Simulation

Project Leader: Timothy J. Madden, US Air Force Research Laboratory, Directed Energy Directorate (AFRL/RD), Kirtland AFB, NM

Sponsor: Air Force

The project's chemical laser results predicted the bulk gas flow velocity components associated with vortex rotation and developed a model for laser-induced fluorescence as a tool to directly compare simulation data with experiment flow imaging diagnostics. The DoD can benefit from the optimization of chemical lasers.

Characterization and Prediction of Stratospheric Optical Turbulence for DoD Directed Energy Platforms

Project Leader: Frank H. Ruggiero, US Air Force Research Laboratory, Space Vehicles Directorate (AFRL/RV), Hanscom AFB, MA

Sponsor: Air Force

The project initiated Direct Numerical Simulations (DNS) and Large Eddy Simulations (LES) of gravity wave simulations for wave characteristics and Reynolds numbers. This project will directly support ongoing efforts to increase the lethality of the Airborne Laser (ABL) through improved optical turbulence prediction. Results from this project will be ported to the ABL's Atmospheric Decision Aid (ADA). Several other weapon, reconnaissance, and communication systems and acquisition programs in development will be impacted by optical and/or mechanical turbulence and benefit from this work.

Computational Studies of Naval SONAR and Non-Volatile Random Access Memory (NVRAM) Devices

Project Leader: Andrew M. Rappe, University of Pennsylvania, Philadelphia, PA

Sponsor: Office of Naval Research

The project's density functional theory (DFT) calculations revealed local structure origins of relaxor behavior, which sets the operating range of SONAR devices. The US Navy can reap considerable military advantage with sensitive SONAR-detecting materials.

Coupled Aircraft/Ship Performance Prediction for Dynamic Interface

Project Leader: Susan Polsky, Naval Air Systems Command (NAVAIR), Patuxent River, MD

Sponsor: Navy

The project examined all classes of aircraft (fixed-wing, rotary-wing, and short-takeoff/vertical-landing [STOVL]). Processes and data, gathered from this project, can enhance manned flight simulators for dynamic interface test and evaluation applications.

Coupled Computational Flow Dynamics (CFD)/Computational Structural Mechanics (CSM) Modeling of Structure Response to Blast Loading

Project Leader: Joseph D. Baum, Science Applications International Corporation (SAIC), McLean, VA

Sponsor: Defense Threat Reduction Agency

The project's simulations model the complex physical processes to define weapon-target interaction and improve DoD's ability to protect major US Government centers, major transportation links (suspension bridges, tunnels, etc.), national monuments and infrastructure centers from large (truck-size) terrorist attacks.

Design of Energetic Ionic Liquids

Project Leader: Jerry Boatz, Space and Missile Propulsion Division (AFRL/RZSP), Edwards AFB, CA

Sponsor: Air Force

The project investigated the interactions of energetic high-nitrogen compounds with ultrafine or nanophase aluminum particles. The DoD can use results for potential applications in rocket and missile propulsion.

Design of Materials for Laser Protection Applications

Project Leader: Ruth Pachter, US Air Force Research Laboratory, Materials & Manufacturing Directorate (AFRL/RX), Wright-Patterson AFB, OH

Sponsor: Air Force

The project focused on theoretical predictions of critical properties to design materials that protect from optical threats, exhibiting multi-photon absorption processes. Proposed computational challenge studies enable fundamental insight and prediction for optical limiting materials developments that meet specific requirements. The project significantly impacts an existing laser protection program in the Air Force.

Completed FY 2008 Challenge Projects

First-Principle Predictions of Crystal Structure of Energetic Materials

Project Leader: Krzysztof Szalewicz, University of Delaware, Newark, DE

Sponsor: Army Research Office

The project's ability to use a computational method, symmetry-adapted perturbation theory based on the density-functional description of monomers (SATP[DFT]), to predict crystal structure provided accurate results. The DoD can use the SATP(DFT) method to predict properties of energetic materials and crystals of other compounds, including notional materials.

Global Ocean Prediction with HYbrid Coordinate Ocean Model (HYCOM)

Project Leader: Alan J. Wallcraft, US Naval Research Laboratory (NRL-SSC), Stennis Space Center, MS

Sponsor: Navy

Project results show that 7 km mid-latitude resolution is the minimum for predication of the "ocean weather". The ultimate goal is to double this resolution for development, evaluation, and investigation of ocean dynamics. HYCOM is planned as the next generation operational global ocean nowcast/forecast system at Navy Oceanographic Office (NAVOCEANO) and will transition from R&D to NAVOCEANO.

High Fidelity Electromagnetic Target Signatures for Combat Identification (CID)

Project Leader: Mary Ann Gualtieri, US Air Force Research Laboratory, Sensors Directorate (AFRL/RY), Wright-Patterson AFB, OH

Sponsor: Air Force

Combat identification is vital in the development of the US Department of Defense (DoD) advanced weapon systems. This Challenge Project focused on researching key technical issues for generating high fidelity electromagnetic target signatures for CID. This effort will advance the DoD's capability to generate, produce, and support high fidelity target signatures databases.

High Resolution Simulation of Full Aircraft Control at Flight Reynolds Numbers

Project Leader: Scott A. Morton, US Air Force SEEK EAGLE Office (46 SK/SKI), Eglin AFB, FL

Sponsor: Air Force

The project's computational methods determine static and dynamic stability and control characteristics of fighter and transport aircraft with various store configurations. Services can benefit from early discovery of complex aerodynamic phenomena and these computational methods.

Multidisciplinary Computational Terminal Ballistics for Weapons Systems

Project Leaders: Kent D. Kimsey and David S. Kleponis, US Army Research Laboratory (ARL), Aberdeen Proving Ground, MD

Sponsor: Army

The lethality component focuses on improving and developing lightweight and efficient lethal mechanisms for advanced kinetic energy (KE) ammunition, multi-function warheads, and munitions with scalable lethality. The survivability component focuses on innovative protection mechanisms, survivability concepts, materials, and structures applied to the development of mass- and space-efficient protection systems for troops, equipment and vehicles against a spectrum of threats. Characterization of improvised explosive devices (IED) and the development of potential armor solutions to defend against these threats will also be investigated.

Multi-Scale Predictability of High-Impact Weather in the Battlespace Environment

Project Leader: James D. Doyle, US Naval Research Laboratory (NRL-MRY), Monterey, CA

Sponsor: Navy

The project's initial results transitioned to operations in March 2008. This work will result in critical upgrades to the current forecasting capability of the DoD by providing reliable probabilities of the occurrence of high-impact weather events.

Prediction Capability for High-Speed Surface Ships

Project Leader: Joseph Gorski, US Naval Surface Warfare Center, Carderock Division (NSWCCD), West Bethesda, MD

Sponsor: Navy

The project's results demonstrate the ability of software to numerically predict vehicle hydrodynamics. The US Navy can reap benefits from a computational approach for the future design and analysis of ships.

Completed FY 2008 Challenge Projects
Solidification of Complex High Temperature Structural Alloys Project Leader: Christopher Woodward, US Air Force Research Laboratory, Materials and Manufacturing Directorate (AFRL/RX), Wright-Patterson AFB, OH Sponsor: Air Force Simulations were performed for elemental, binary and ternary alloys of Ni with Al, W, Ta, and Re to compute equations. Results establish the limits of the accuracy of current density models used in commercial casting software and offer a new path for systematically improving them.
Statistical Fatigue and Residual Strength Analysis of New and Aging Aircraft Structure Project Leader: Scott Fawaz, US Air Force Academy, (USAFA), Colorado Springs, CO Sponsor: Air Force The project focused on the development of advanced computational methods for reliable fatigue and residual strength analysis of bolted-riveted-bonded metallic structures, such as full fuselage, wing, and empennage sections. Access to analysis results can reduce inspection requirements; prevent premature retirement of old aircraft; and increase aircraft safety for the US Air Force.

Dedicated HPC Project Investments (DHPIs)

Each year, the HPCMP conducts extensive review of the department's most important, high priority, computationally intensive projects to determine which ones require unique, dedicated HPC resources in order to meet pertinent objectives and milestones.

Dedicated High Performance Computing Project Investments (DHPIs) are modest-sized HPC systems awarded to technically sound, mission critical projects that cannot be performed using batch HPC resources due to special operational requirements (e.g., classification level, real-time response, hardware-in-the-loop, embedded implementations, use of emerging technologies).

In FY 2008, three existing projects that began in FY 2006, reached completion. See Appendix A to view a list of the Continuing FY 2008 DHPIs.

Completed FY 2008 DHPIs
Interactive Algorithm Development for WMD Defense, MIT Lincoln Labs, Lexington, MA This project focused on the detection and decryption of communications to discriminate targets and intercept missiles.
Operational, Probabilistic, Numerical Weather Prediction at High Resolution, Dugway Proving Ground, UT This project supported range weather prediction that provided a probabilistic dispersion of bio-hazards.
Virtual Electronic Battlefield – FY 2006, US Army Communications-Electronics Research, Development and Engineering Center, Ft. Monmouth, NJ This project demonstrated a real-time integration of physical and simulated network entities in support of Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) system-of-systems investigations on network centric warfare.

The HPCMP cancelled one project due to poor progress, which focused on NRL/NSWMSC's examination of contamination prediction, "Application of HPC to Support Operational Use of CT-Analyst". One of the two delivered systems was never used; therefore, the HPCMP repurposed the unused system, and recast the other system under a new project, "Automated Generation of Nomografs for Urban Chemical Dispersion Scenarios".

Although DHPI proposals were renewed, only one was awarded in 2008:

New FY 2008 DHPI
Program-restricted Hydrocode Calculations of Active, Reactive, and Combined Armor Packages Project Leader: Robert L. Doney, III, Army Research Laboratory Weapons and Materials Research Directorate (ARL/WMRD) Sponsor: Army

This DHPI uses a 2,016 core Cray XT5 to test armor configurations salient to current and future conflict. The HPCMP also funded an out-of-cycle early access architecture to US Air Force Research Laboratory, Information Directorate, Rome, NY (AFRL/RI) to assess the capability of cell processor clusters.

Capability Applications Projects (CAPs)

Starting in FY 2005, the HPCMP provided newly acquired systems to Capability Applications Projects (CAPs), to test key DoD application codes on a substantial portion of entire HPC systems and to solve large problems quickly by using a fraction of the newest, most capable systems. CAPs goals are:

- To quantify the degree to which important application codes scale to thousands of processors
- To enable new science and technology by applying these codes in dedicated high-end, capability environments

The HPCMP focuses on true capability use for a short time before placing the systems into allocated operational use. System use is implemented in two phases:

- Exploratory phase designed to test scalability and efficiency of application codes to significant fractions of systems (5–15 projects on each system)
- Production phase designed to accomplish significant capability work with efficient, scalable codes (1–3 projects on each system)

In FY 2008, the following CAPs ran on the final TI-07 acquisition, the ERDC Cray XT4, which arrived in FY 2008:

Completed CAPs on the TI-07 Acquisition
Advanced Virginia-Class Submarine Hydrodynamic Studies, Other Navy
Atomistic Simulations of Shock-Induced Chemistry, Detonation, and Sensitivity of Energetic Materials, ARO
Characterization and Prediction of Stratospheric Optical Turbulence, AFRL
*HYCOM Global Ocean with Tides, NRL
*Quantum Algorithms for MHD and Turbulent Flows, AFOSR
Self-Consistent Modeling of Nonequilibrium Properties of Josephson Junctions, ONR

*Phase I and Phase II CAPs

In addition, the HPCMP evaluated 10 CAP proposals and awarded six CAPs in FY 2008. These CAPs ran on the Navy Cray XT5, IBM P6, and ARSC Cray XT5 systems acquired for TI-08. CAPs used 4 percent of total HPC usage in FY 2008.

Awarded CAPs on the TI-08 Acquisition
Anion Exchange Mechanism and the Effect of Strain on Anion Composition in Semiconductor Superlattices Project Leader: Thomas F. Kuech, University of Wisconsin, Madison, WI Sponsor: ARO
Benchmarking the Optical Lattice Emulator Project Leader: James Freericks, Georgetown University, Washington, DC Sponsor: DARPA
Eddy Resolving Modeling of the Pan-Arctic Ocean and Sea Ice (ERM-AOSI) Project Leader: Wieslaw Maslowski, Naval Postgraduate School (NPS), Monterey, CA Sponsor: Navy
Large Scale URANS/DES Ship Hydrodynamics Calculations with CFD Ship-Iowa Project Leader: Fred Stern, University of Iowa, Iowa City, IA Sponsor: ONR
Mesoscopic Detailed Balance Algorithms for MHD and Quantum Turbulence Project Leader: George Vahala, The College of William and Mary, Williamsburg, VA Sponsor: AFOSR
Statistical Fatigue and Residual Strength Analysis of New and Aging Aircraft Structure Project Leader: Scott Fawaz, US Air Force Academy (USAFA), Colorado Springs, CO Sponsor: Air Force

By the end of 2008, all TI-07 and TI-08 CAPs ended, including "Quantum Algorithms for MHD and Turbulent Flows". In this memory-intensive research project, Dr. George Vahala pushed the boundaries of quantum research at the AFRL MSRC. Dr. Vahala's project is highlighted in the following success story on page 16, as it describes his contributions to enhance the capabilities of the DoD to patrol the US border.

Highlights of Impact in FY 2008

The HPCMPO met program challenges in FY 2008 to encourage future growth in the development of tools and new supercomputing capabilities and exceeding customer satisfaction. The following lists describe the FY 2008 accomplishments and the HPCMPO's objectives for FY 2009 to sustain success:

FY 2008 Accomplishments

- Provided supercomputing services to the DoD RDT&E community
- Awarded, without protest, a new $344M technical services contract for supercomputer center support
- Awarded, without protest, contracts for $50M worth of new supercomputers
- Developed and released the solicitation package for expert services
- Established the "virtual" CREATE Program Office
- Delivered 500M processor hours to the user community

FY 2009 Objectives

- Provide premier services to the DoD computational science and engineering communities
- Refresh the supercomputers at the largest supercomputing centers
- Upgrade the information storage infrastructure across all major supercomputing centers
- Award a new customer productivity enhancement contract
- Renew the Program's CNDSP certification
- Develop and release the solicitation package for DREN services

Massive Quantum Research Project Pushes Boundaries

This High Performance Computing Modernization Program (HPCMP) Capability Applications Project (CAP), "Quantum Algorithms for MHD and Turbulent Flows," was run at the AFRL MSRC by Dr. George Vahala, Professor of Physics, College of William & Mary, Williamsburg, Virginia in support of the Hanscom AFB. AFRL MSRC System Utilization: SGI Altix 4700 (HAWK) with 2,251,713 total hours

By Gary Sivak and Dinah Luneke from Wright Cycles, Spring 2008

Border Patrol Scenario

Guards leisurely glance at computer screens to check on results from the continuous scanning for underground disturbances along the U.S.–Mexico border. In this future scenario, thanks to the field applications of Jeffrey Yepez (AFRL) and Dr. George Vahala's work, guards may more easily be able to detect underground movements in order to prevent illegal aliens from slipping into the country. These and other future applications are pushing the boundaries of quantum research as Dr. Vahala and his colleagues work to enhance and expand the capabilities of the DoD in order to serve the warfighter.

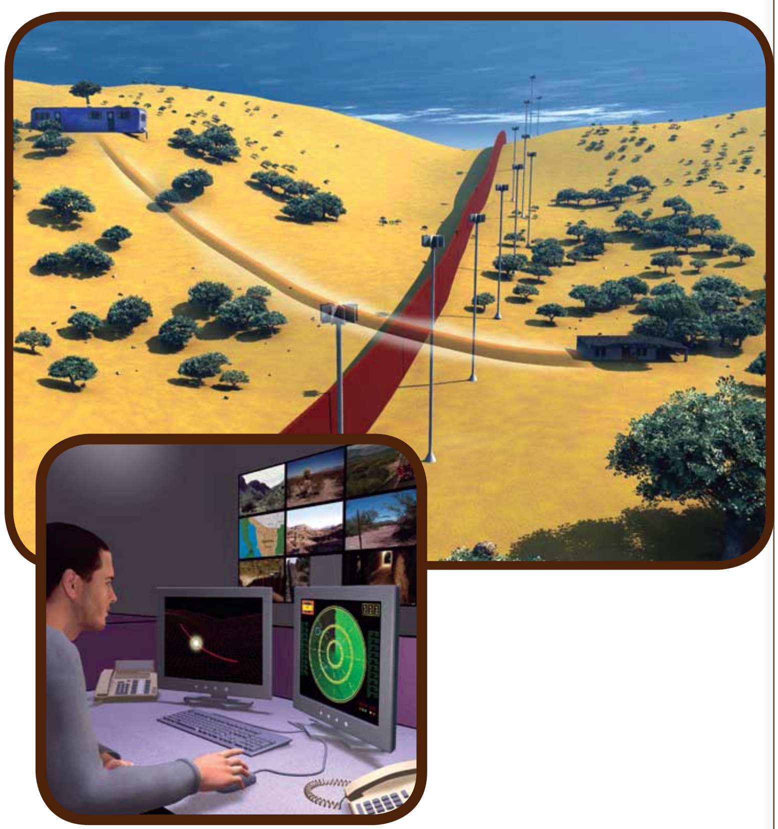
HPCMP "Tips Its CAP" for Massive DoD Projects

Memory can mean several things to people for a variety of reasons. Attaining adequate computer memory for DoD research projects elevates this concept to a whole new level for the research user community. In its quest to help DoD researchers fulfill their mission, the HPCMP provides resources for large scale computer runs for its CAP program, which includes goals to:

1. Quantify the degree to which important application codes scale to thousands of processors, including the identification of potential bottlenecks for scaling these codes
2. Enable new science and technology for the DoD by applying these codes in dedicated, high-end, capability environments.

During the time period between acceptance testing and production release, the HPCMP makes select HPC systems available for CAPs. Designated users may test their application codes on a substantial portion of the entire system and solve large, meaningful problems in a relatively short time.

Dr. Vahala was granted a CAP for the TI-07 HAWK system at the AFRL MSRC to run his memory-intensive research project. A massive amount of research was accomplished through this 9,000 processor study. Dr. Vahala's job represents the largest single job to run on the HAWK, lasting almost 25 hours and using 224,663 processor hours.



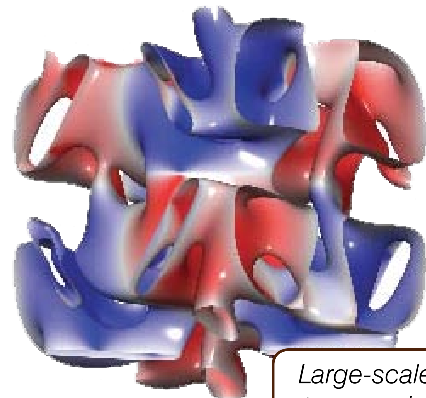
From CFD to Kinetic Velocity Space

Two distinct projects were part of this theoretical research CAP. The first was a classical project – Magnetohydrodynamics (MHD), similar to the turbulence found on Jupiter and in plasmas, and the second used the quantum lattice approach to quantum turbulence. This massive computer run consisted of homegrown codes that were mesoscopic detail balanced representations. For instance, if fluid or MHD turbulence is observed, the flow is collision-dominated and makes valid the direct Computational Fluid Dynamics (CFD) solution of the continuum equations (like the CFD solution of the Navier Stokes Equation for fluid turbulence). According to Dr. Vahala, the inherent problem with using CFD codes for such large-scale computer analyses is their scalability with the number of processors. Typically, as more and more processors are added to solve the flow, while working in a CFD code, the simulation run time will merge together. In essence, when doubling the number of processors, one would anticipate that as the numbers go up, the wall clock time—the time one has to wait for the simulation results —should decrease. Instead, with standard CFD codes, after one or two thousand processors, that will cease. The more processors added can actually take longer because the communication between them could result in a road jam.

"The codes that we are running, instead of working in standard X-T space—space/time, go into kinetic space," Dr. Vahala said. "That means more memory, unfortunately. On the other hand, the problem is now in a higher dimensional space and one can get a simpler solution trajectory, which can be solved more simply. Not only that, but you can then parallelize so, in fact, you do not see any saturation with cores. That's why we ran with all the 9,000 cores that were available."

The dimensions used involve space/kinetic/velocity/ time, which translates to a factor of "6+1." This simply means, "Six in velocity-space, and one in time." The advantage of the lattice discretization method is that dimensionality in this kinetic velocity space can be reduced. It is difficult to store a six-dimensional array on a computer as the methods are extremely memory bound.

At the time of this writing, Dr. Vahala and his team are "banging at the data analysis" with more than 10 terabytes (TB) of data from a single run.

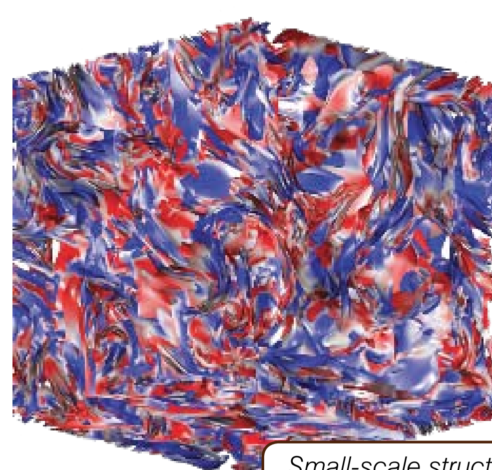


Large-scale structures at very early times

Pushing the Law of Physics' Boundaries

As this work progresses, Dr. Vahala will continue to seek CAP status at centers throughout the DoD. Besides running at the AFRL MSRC, Dr. Vahala has also run HPC projects at NAVO and ERDC.

"The Air Force chap we're working with is viewing his technique, of these quantum lattice gas methods, as being able to understand the law of basic physics: quantum chromodynamics, quantum electrodynamics, even to unification with quantum gravity," Dr. Vahala remarked. "He has extremely high goals for this method using basic quantum bit (qubit) information where you can obtain the Dirac Equation and others that could result in a unified theory spanning all the fields of study in physics."



Small-scale structures in the turbulent MHD regime

MHD equations were modeled during the intensive CAP. These are the basic starting equations for the study of turbulence where conducting fluid or plasma interacts with a magnetic field. Plasma fusion, solar, magnetosphere, astrophysics—all begin with MHD serving as a fundamental equation. While periodic boundary conditions were utilized in these CAP runs, the lattice method readily adapts itself to handling arbitrary boundary geometries (e.g., those generated by Mathcad®) without losing any of its excellent parallelization. One can readily include more detailed structures like yaw grids and other elements.

Benefiting the Warfighter and the World

Although it is still a little early to predict all the outcomes of this MHD work, there are definitely planning and logistics benefits expected from the quantum research. An area, such as the field of cryptography, works by understanding how information can be passed along that cannot be deciphered without possessing the encryption key. Cryptography studies work like Morse Code. The only way to interpret the message is to understand the code. In similar fashion, messages sent using quantum encryptions can only be correctly interpreted if one possesses the special key to decipher the message. This study of quantum cryptography can help make informed decisions for potentially intercepted data. The information would be coded in such a way as to be considered unbreakable, and interception or eavesdropping would be detectable as the interference can be tested.

The Beat Goes On

The results of this study have generated a tremendous amount of interest in the scientific community. In analysis, the extremely small fluctuations (10–14) involve a study of interference patterns. This is similar to comparing the difference between two musical tones. Normally, one cannot tell the difference in the beats by simply listening, but if one were to compare them side by side, the differences between the two tones would be much more noticeable.

"There is simply no end in sight for this research as the work is quite continuous," Dr. Vahala said. "If you did not have HPC access, you could not get anywhere, and it's even stronger than that. Without HPC, this work just could not be accomplished. Typically, each processor has only two gigabytes (GB) of memory. So to perform large-scale simulations, one really needs to be able to use the 9000 cores optimally. Our codes do that. This type of research project cannot be performed even with dozens of researchers working side-by-side in a laboratory on PCs. Our research requires the enormous computer capability of such a massive system as the HAWK."

Potential future applications of this work include such areas as: improved weather predictions using advanced ocean modeling; smaller, lighter, and more efficient engines; unbreakable encryption of sensitive information; and the development of next-generation materials for submarines and other military vehicles.

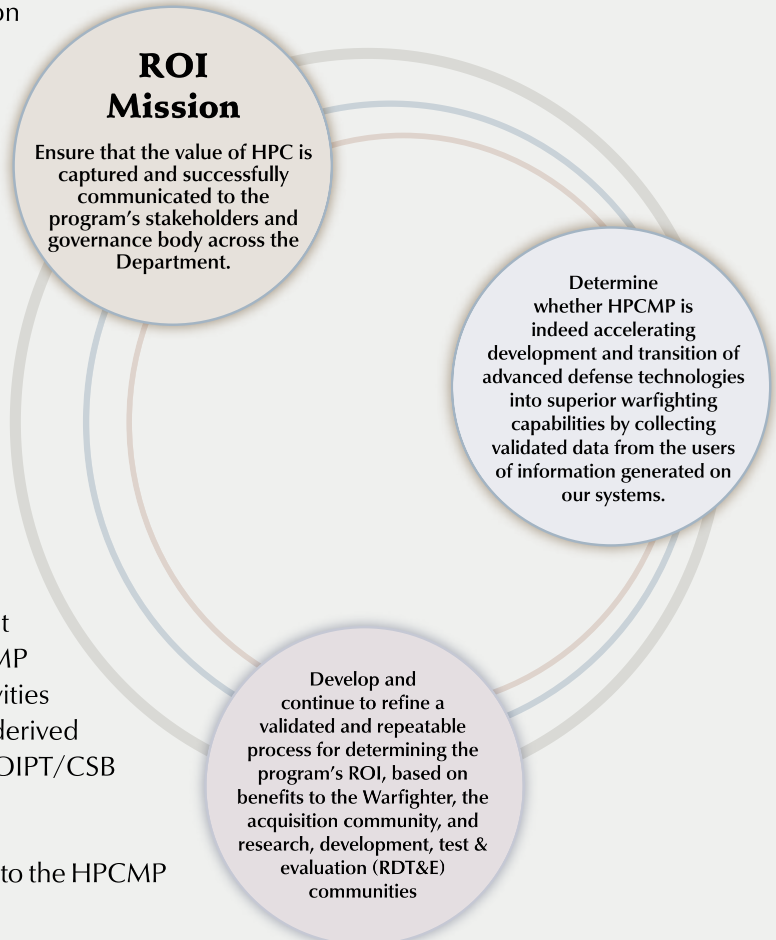
For more information, please contact CCAC at www.ccac.hpc.mil or 1-877-222-2039.

Return On Investment (ROI)

HPCMP resources are a fundamental enabling technology for developing future capabilities and responding to immediate combat threats. Over the past three years, ROI studies captured vital statistics and qualitative and quantitative information to confirm HPCMP resources and projects provide high value for the Warfighter.

ROI History

During its 14-year history, the HPCMP demonstrated its value through the development of Program success stories. During 2002-2003, the HPCMP performed a User Impact study to determine HPCMP's impact on several high priority projects, which was used to satisfy Clinger-Cohen requirements, and included an ROI analysis. Recognizing the importance of rigorously demonstrating the quantitative value of the Program to the nation's defense decision makers, the HPCMP Director established a pilot project to determine ROI for a subset of HPCMP projects.



As a result, ROI analysis delivered valuable information to HPCMP decision makers. The HPCMP OIPT/CSB recommended the extension of ROI analysis to include formal presentations at the annual meeting. In recent years, comprehensive presentations at the annual OIPT meeting provided relevant qualitative and quantitative benefits of HPCMP projects. Annual presentations cover ROI activities and the quantitative and qualitative benefits derived from the studied projects, since the previous OIPT/CSB meeting.

In FY 2008, ROI studies continue to deliver value to the HPCMP and assist the DoD S&T and T&E communities.

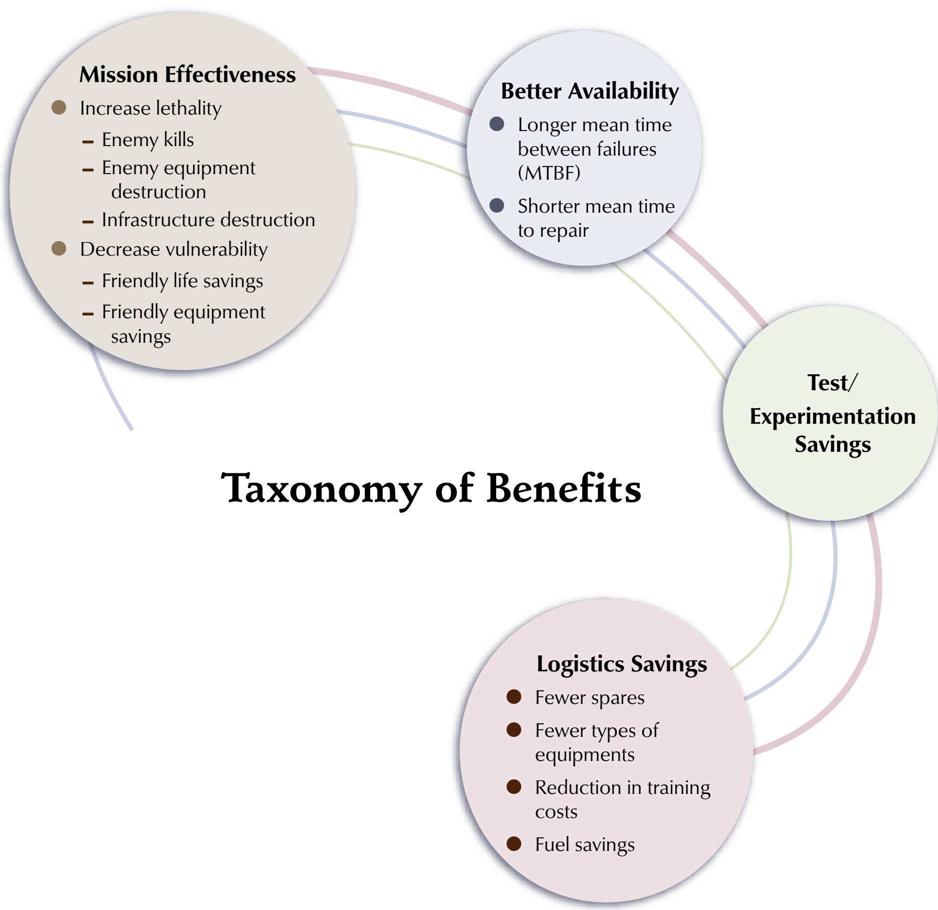
ROI Team

The ROI team is comprised of members from the HPCMPO, the Joint Interoperability Test Command (JITC), and the National Defense University (NDU). The NDU validated the ROI methodology; made recommendations to improve future ROI analyses; and validated results for individual analysis.

The HPCMP determined each project investment cost by allocating a proportion of the HPCMP total budget to each project based on the project's percentage of total HPCMP resource utilization. (For example, if a project used 25 percent of HPCMP resources, the HPCMP determined that the project's investment cost equaled 25 percent of the total budget.)

The HPCMP ROI team, HPCMPO staff, and JITC, conducted voice, teleconference, and face-to-face interviews with users and program management personnel supporting various projects using validated interview questions. After data was collected and analyzed, the ROI team scheduled and conducted interviews to document quantifiable benefits. In addition to documenting quantifiable benefits to the Warfighter, the ROI team collected qualitative data and anecdotal "success stories."

The following lists benefits to the Warfighter ascertained through ROI studies:



In FY 2008, the ROI team evaluated the use of HPCMP resources in concept development, design, testing, and operational support of Air Vehicles.

The following diagram illustrates ROI studies on air vehicle development and support disciplines. The numbers in each discipline represent individual projects (Number of ROI-studied projects/Number of studied projects yielding quantitative results).

Air Vehicle Development & Support Disciplines
Air Vehicles
(95/21)

Flying Qualities & Performance (37/6)

- Manned (25/5)
  - Fixed Wing (9/3)
  - Rotary Wing (16/2)
- Unmanned (5/0)
  - Micro Air Vehicles (3/0)
  - Unmanned Air System (2/0)
- Hypersonic (7/1)

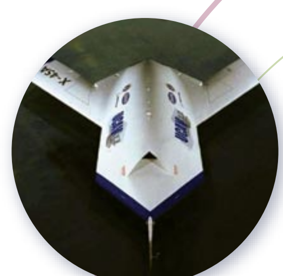
Fatigue (3/1)

Test Facilities (16/2)

Compatibility (39/12)

- Aircraft Stores (29/10)
  - Captive Carry (14/4)
  - Separation (15/6)
- Aircraft-ship (10/2)

This section discusses five projects from the ROI studies: Unmanned Air Vehicles (UAVs) and EP-3E Turret and Radome from the Flying Qualities and Performance category; Aircraft/Ship Compatibility and LITENING Pod from the Compatibility category; Fatigue Life Prediction from the Fatigue category; and the Joint Strike Fighter (JSF) Sled Test from the Test Facilities category.



Flying Qualities & Performance

Unmanned Air Vehicles (UAV)

In the late 1990s, the DoD revived the concept of using UAVs, also known as Unmanned Air Systems, for performing actual combat in the form of various designs generally designated as unmanned combat air vehicles (UCAVs). Since then, UCAVs played an increasingly important role in the planning and execution of military operations. Whether they are large or small, remotely controlled or fully autonomous, the computational requirements for high fidelity design and airflow modeling require high performance computing resources to avoid costly tests and experimentation. This section discusses UAV ROI studies and the HPCMP impact in two examples: Unmanned Combat Air Systems (UCAS) Program and Micro Air Vehicles (MAV) Projects.

Unmanned Combat Air Systems (UCAS) Program

Aeronautical engineering teams from NAVAIR-Patuxent River (NAVAIR-PAX), Arnold AFB, and Wright-Patterson AFB performed research projects on advanced UAV designs. The NAVAIR-PAX team improved performance of the Naval UCAS Program (later recognized as the Joint Unmanned Combat Air Systems [J-UCAS]) ; Arnold AFB engineers used CFD models of the UCAS to design improvements to the craft during weapon separation; and the Wright-Patterson AFB team used advanced CFD models created on HPCMP resources to analyze lift, drag, and pitch characteristics of various UCAS potential designs.

The Air Force's and Navy's common efforts to produce an affordable, lethal, low observable air vehicle, capable of dynamic distributed control caused the Services to merge their efforts, forming the J-UCAS Program. Through the use of HPCMP resources and a CFD model, the team analyzed UCAS' proposed configuration for aircraft carrier suitability. The CFD model enabled the team to optimize the configuration for carrier use during the conceptual design phase, saving time and resources. HPCMP analysis of conceptual UCAS design showed significant reduction in drag and turbulence by increasing the wing twist. Engineers credited the high granularity CFD models as the only way to generate this data, since flight tests and wind tunnel data were unavailable. From their analysis, the team helped guide decision makers to adjust programmatic direction and build a knowledge base that started at the beginning of the program; one that will have continued usefulness in the development of future unmanned air systems.

In addition, a CFD model was developed to optimize the J-UCAS flowfield during weapon separation. The use of this model allowed constructing a test plan to provide the optimum combination of computer simulation, ground testing, and flight testing. Results from this model removed the need to move flight testing to a larger wind tunnel or to design and build a smaller model for the test chamber. The elimination of additional tests saved the Joint program hundreds of thousands of dollars.

Quantitative benefits for the J-UCAS use of HPCMP resources were based on cost avoidance of not moving to a larger wind tunnel. Although considerable benefits are expected from the other work, it is too early in the development cycle to quantify these benefits. The following estimated cost benefits reflect how HPCMP resources positively impacted J-UCAS research and development:

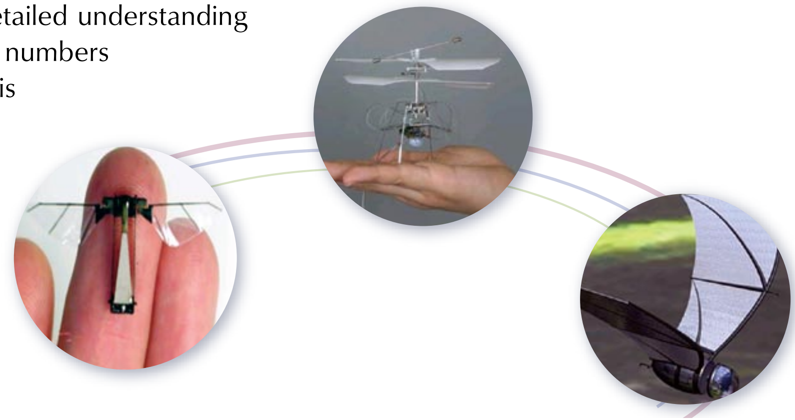
J-UCAS Cost Avoidance and Savings

	Lower bound	Upper bound
Cost Avoidance	$200,000	$800,000
	Based on cost of not moving to a larger testing wind tunnel	Based on not designing & constructing a smaller testing model

Micro Air Vehicle (MAV) Projects

Two ongoing projects at Wright-Patterson AFB used HPCMP resources to compute flow field coefficients (e.g., pitching and rolling moment coefficients) to develop a MAV. All teams required a high degree of fidelity in their models to satisfactorily compute these challenging unsteady flow fields. This type of computational capability can only be developed with the support of high performance computing.

The development of MAVs is still in its infancy. Advanced concepts, such as flexible or flapping wings, autonomy of action, and morphing aircraft, require high fidelity modeling of fluid and structure, including nonlinear effects.



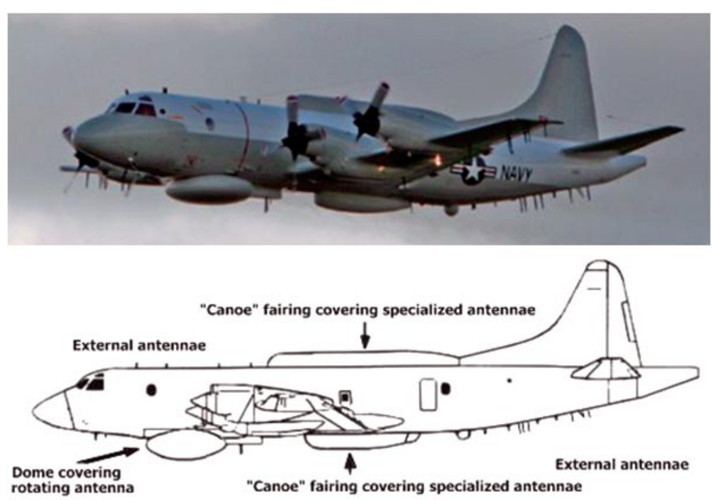
More susceptible to wind currents, MAVs are designed around non-linear responses; their designs require a detailed understanding of unsteady aerodynamics at low Reynolds numbers (ratio of inertial to viscous forces) and this data is incorporated into their designs. The low Reynolds number flight regime, highly flexible structure, and size and power restrictions, make physical model design and testing difficult. Extreme flight conditions demand the use of both nonlinear aerodynamics and structural solvers. Investigation of dynamic maneuvers and aero servo-elastic problems require the coupling of nonlinear aerodynamics and structural solvers with a flight mechanics model. Hence, development of these vehicles cannot be accomplished without high performance computing enabled simulation.

The Wright-Patterson AFB team is currently investigating multiple classes of MAVs, including fixed wing (e.g., conventional, morphing, perching), rotary wing, and flapping wing models. Because Micro UAVs are very early in their development cycle, no quantitative benefits are available. However, Micro UAVs require HPCMP resources for development, so this area is expected to yield large quantitative benefits in the future.

EP-3E Program

In 2008, the EP-3 Program Office was tasked with the integration of a new electronic countermeasures system consisting of a lower forward turret and an upper forward radome. The EP-3 Program required system integration and flight clearance to occur as quickly as possible, for direct deployment in active theaters of operations. Since the "quick response" requirement and unavailability of a suitable subscale model precluded the use of wind tunnel testing, flight engineers decided CFD analysis was the only feasible alternative.

Researchers divided CFD analysis into two phases. The first phase focused on the lower forward turret and the second phase studied the effects of adding the upper forward radome. No new wind tunnel testing was required for this flight clearance.



Details of Modifications from P-3A Patrol Aircraft to EP-3E

Through NAVAIR's use of HPC resources to perform CFD modeling and analysis, only one flying qualities flight test was required, saving three or more additional flight tests. The Computational Research and Engineering Acquisition Tools and Environments (CREATE) Shadow-Operations (Shadow-Ops) team reduced the required time for the Navy EP-3 reconnaissance aircraft's Flying Qualities Flight Clearance from one year to three months and greatly accelerated the deployment of this critical warfighting asset. The elimination of subsequent tests, construction costs, and flying quality reports allowed the acquisition program to meet an ambitious schedule for deployment to the forward theater. Modeling and simulation using HPC resources saved the program $1M–$1.4M. These compressions sped EP-3E fielding and yielded obvious positive impacts for the DoD and Warfighter.

The Shadow-Ops team used the EP-3E CFD database in lieu of test flights for installation, validation, and verification to minimize the number of test flights. Because of the HPCMP's involvement, the acquisition program saved time, resources, and money. The following list provides project benefits:

- Lower forward turret installation
  - Final flight clearance required one flight test only
  - Shadow-Ops team saved 2-3 flights in Phase I
- Upper forward radome
  - No flights required
  - 3-4 flights in Phase II eliminated
  - No new wind tunnel testing required

In addition, the EP-3E community provided generous feedback on the benefits of using HPCMP resources:

> "The computational support supplied by the Shadow Ops team provided the required computational data to NAVAIR Flight Dynamics Branch to help issue a safe-for-flight clearance, from a flying qualities perspective, without the need for a costly, time consuming wind tunnel test" (LCDR Ryan Batchelor, EP-3E Special Mission Class Desk).
>
> The data and subsequent flying qualities analysis was "sufficient to limit the flight test program to only one flight. This further reduced flight test time by several weeks, saving the program tens of thousands of dollars and allowing the EP-3E Program to deploy this capability in the forward theater in support of the Global War on Terror (GWOT)" (Ms. Ryan Fitzgerald, Flight Dynamics Engineer).

Without the use of HPC-enabled modeling and simulation, between five and seven flights would be required to obtain flight clearance after the addition of the turret and radome. The following calculations provide benefits for using HPCMP resources:

Lower Bound Cost Avoidance for Certification of the EP-3E

Item	Number of Test Flights Avoided	Cost of One Test Flight	Total Costs
Turret	2	$200,000	$400,000
Radome	3	$200,000	$600,000
		Total Lower Bound Cost Avoidance	**$1,000,000**

Upper Bound Cost Avoidance for Certification of the EP-3E

Item	Number of Test Flights Avoided	Cost of One Test Flight	Total Costs
Turret	3	$200,000	$600,000
Radome	4	$200,000	$800,000
		Total Upper Bound Cost Avoidance	**$1,400,000**

Compatibility

Aircraft-Ship Compatibility

Landing an air vehicle on a moving ship is one of the most challenging tasks faced by our Warfighters. Designing ships and airplanes to accomplish this task safely is one of the most challenging areas for the acquisition community. The conduct of experiments and tests to determine aircraft-ship compatibility is very difficult, so researchers obtain critical information through high fidelity simulation. HPCMP resources have been used extensively to determine flow fields over various ships for wind over deck angles and interaction with aircraft as it lands on ship.

Studies determined airwake for the following classes of ships: Amphibious Assault Ship – Tarawa Class (LHA), Amphibious Assault Ship – Wasp Class (LHD), Aircraft Carrier (CV), Guided Missile Destroyer (DDG), Multi-Mission Surface Combatant Destroyer (DDX), and Littoral Combat Ship (LCS).

Using CFD models, HPCMP resources have been used to determine aircraft compatibility with different types of ships; the characterization of airwakes to calculate safe landing limits, design of ship topside; and development of training simulators. Specific analysis focused on solving the following problems:

- Effects of catapulted F-14 wake on H-60 operations
- Effect of JSF exhaust on ship and personnel
- Limits on approach and landing of V-22 on ship

HPCMP resources enabled the Aircraft and Ship acquisition programs to save an estimated \$81.5M–\$170.5M.

The aircraft and ship communities provided generous feedback on the benefits of using HPCMP resources:

> "CFD-generated airwake data provides a substantial return on investment, as it is being used as the primary design guidance tool for USN surface ship topside design...the tool has influenced and confirmed design for LHAs, DDGs, CVN 21, and CVN 28" (Ansis Kalnajs, Warrant Holder – Topside Design, Navy Ships, NAVSEA).
>
> "[HPCMP resources] influenced topside design on LHA 6 and 7 [and we] could not have gotten the results any other way; possibly wind tunnel, but not sure it would have given correct results. The alternative would be a ship built with bad island structure; significant cost and delay...huge risk mitigation tool" (Rich Celine, Aviation Systems Engineer, LJHA, NAVAIR).
>
> "[We] changed island design on CVN-21 as a result of testing in MFS [Manned Flight Simulator] with ship airwake models" (Steve Naylor, NAVAIR).

Navy development of cost-effective ship designs to meet performance requirements on schedule and within budget is feasible with HPCMP solutions.

The following table shows the total benefit derived from characterization of the ship airwake on the Amphibious Assault Ship – Tarawa Class (LHA), Amphibious Assault Ship – Wasp Class (LHD), Aircraft Carrier (CV), Guided Missile Destroyer (DDG), Multi-Mission Surface Combatant Destroyer (DDX), and Littoral Combat Ship (LCS). The lower bound reflects the cost of obtaining minimum information using physical experimentation. The upper bound reflects cost to obtain a useful set of information to characterize the ship airwake, which is still not as accurate as CFD modeling.

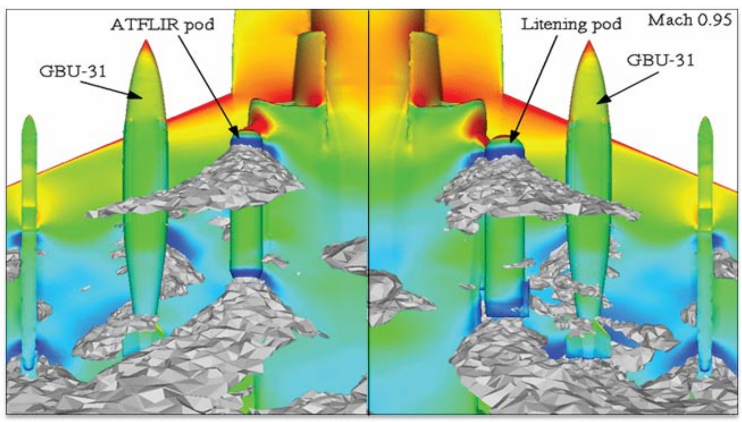
Navy Ships Cost Avoidance and Savings

Project	Lower Bound	Upper Bound
Navy ships	$80,000,000	$160,000,000

Litening Pod

LITENING is an advanced airborne infrared targeting and navigation pod that makes further improvements upon the Advanced Targeting Forward Looking Infrared (ATFLIR), the world's first Generation III Targeting Forward Looking Infrared (FLIR). LITENING is designed to improve both day and night attack capabilities and it presents pilots with real-time, FLIR and Charge Coupled Device (CCD) images. It is fully operational 24 hours a day, including in adverse weather conditions. LITENING II can acquire targets at altitudes of up to 40,000 feet, versus the 25,000 feet typical of previous pods.

The LITENING pod received multiple benefits from the use of HPCMP resources. HPCMP resources revealed the cause of undesirable bomb separation from aircraft equipped with the FLIR and ATFLIR. This analysis showed that the blunt aft end for both ATFLIR and the LITENING pod caused a large shock, which propagates from the aft end to the adjacent bomb tail. However, for the LITENING pod, which is longer and further back on the aircraft, this shock misses the tail and causes less of an effect.



Shock Wave Pattern for ATFLIR and LITENING Pod

Prior to the LITENING pod effort, the Navy had two choices to clear new aircraft/store configurations: wind tunnel test or the buildup approach (also known as hit or miss method). Both methods had serious limitations. Wind tunnel testing required at least six months of lead-time and a minimum of $500K. The buildup approach consisted of increasing the release airspeed during flight testing until the store came uncomfortably close to hitting the aircraft/adjacent stores. Because of the LITENING pod effort, the Navy now has a cost-effective and capable tool that can provide a safe flight test process to permit flight clearance recommendations in a timely fashion.

Without high performance computing-assisted modeling, the LITENING pod equipped aircraft would have required operational flight envelope restrictions, similar to the TFLIR/ATFLIR equipped aircraft, at the potential cost of reduced mission effectiveness in conflicts. The modeling of the TFLIR and ATFLIR pods resulted in significant financial benefit when the findings were used to develop the LITENING pod within a two-year schedule, allowing a more rapid deployment of advanced technologies to the Warfighter. HPC modeling enabled resources to focus on areas of high program risk and provide key information for certification. HPC modeling is now routinely part of the store compatibility certification tool box.

HPC modeling helped shorten development time by reducing the number of required test configurations; reducing the number of flight tests required for certification; and identifying and eliminating defects before system build. Using data generated from the TFLIR/ATFLIR programs, the LITENING pod program compressed the development schedule by two years and saved $4M. By avoiding the necessity of flight tests, the DoD saved an additional $2M.

LITENING Cost Avoidance and Savings	
Flight test costs avoidance	$2,060,000
Savings due To LITENING schedule compression	$4,000,000
Total Lower Bound Savings	**$6,060,000**

Fatigue

The US Military, particularly the Air Force and Navy, has serious problems with aging aircraft. Air Force aircraft are, on average, more than 28 years old—an unprecedented age caused by the lack of aircraft procurement during the 1990s and higher operational demands. The Services attempt to stay in front of problems from aging aircraft, but admit the need for further risk mitigation.

Military aircraft will continue to age dramatically. Even if existing acquisition contracts are executed as planned and the Air Force and Navy receive requested fighter aircraft, they will still have to field an unprecedented number of older fighters, in order to meet all of the Service's obligations. Furthermore, the "operational tempo" for aircraft operations is increasing, not decreasing over time.

The Services devote significant resources to study the issue and pursue innovative solutions to head off potential aircraft aging problems. To meet increased operational requirements, the Air Force and Navy take multi-faceted approaches to manage the problem.

Fatigue Life Prediction

Using HPCMP resources, researchers focus on the development of advanced computational methods for reliable fatigue and residual strength analysis of bolted-riveted-bonded metallic structures. Finite Element Methods (FEM) are used to model large sections of aircraft at a very fine level of granularity and to calculate stress intensity factors. These stress intensity factors are input into the Air Force's crack growth program (AFGROW), to help predict fatigue life. Because of the necessity for a fine grained analysis over a large structure, this work could not be performed without high performance computing resources.

The AFGROW with the FEM option is currently used to support only one Air Force aircraft. Use of the AFGROW method at Hill AFB for the A-10 program allowed an extension of inspection intervals by 15 percent. This reduction in inspection frequency saves the Air Force $30M annually.

Reduced Inspection Savings

Item	Benefit Calculation	Lower Bound Savings
Cost of 7.5 fewer inspections per year	7.5 inspections × $4,000,000/inspection	$30,000,000
	Total Lower Bound Savings	**$30,000,000**

Test Facilities

Joint Strike Fighter (JSF) Tests

The F-35, currently under development, is a supersonic, multi-role stealth fighter designed to replace a number of aging fighter and strike aircraft. One of the most important systems for the JSF, as is true for any high performance aircraft, is the ejection system. Typically, an ejection system consists of rocket powered ejection seat, which includes a parachute. This system is linked with a canopy jettisoning system and/or a canopy fracturing capability as part of the ejection seat. Since the ejection and canopy jettisoning system cannot be tested in flight, testing is accomplished using high speed sleds which duplicate ejection conditions, as closely as possible. HPCMP resources were used to augment JSF canopy and ejection seat testing and ensure that the testing would provide useful results.

In the original test design, a high speed camera assembly, mounted to the front of test sled, recorded JSF canopy images as the sled moved down the track. In order to increase the likelihood of successful tests, researchers developed computational models to determine the effects of the camera on the test. The analysis showed that the placement of the camera on the front of the test sled would have invalidated the results of the test. In the second part of this analysis, canopy fracturing at a representative sled speed was modeled using an aerodynamic model combined with a glass fracturing model. This analysis showed that the canopy design did not give a clean breakaway, so researchers modified the canopy design.

In addition to the improvement to canopy modeling, the CFD research led to a design change in the pilot seat. The advanced concept for the seat used HPCMP resources to compute six-degrees-of-freedom trajectories, aiding rescuers in pinpointing the probable location of ejection seats in crash investigations. The CFD research proved that previous testing and designs did not produce accurate aeronautical forces. Flawed design could, potentially, cost the DoD millions of dollars.

The following table provides cost benefits due to HPCMP resources. HPCMP resources enabled cost avoidance in several areas: JSF test sled, CFD canopy rupture tests, seat design improvements, and fore-body design.

JSF Canopy Testing & Seat Redesign Cost Avoidance and Savings

Project	Lower Bound	Upper Bound
JSF Program office estimate	$50,000,000	$100,000,000

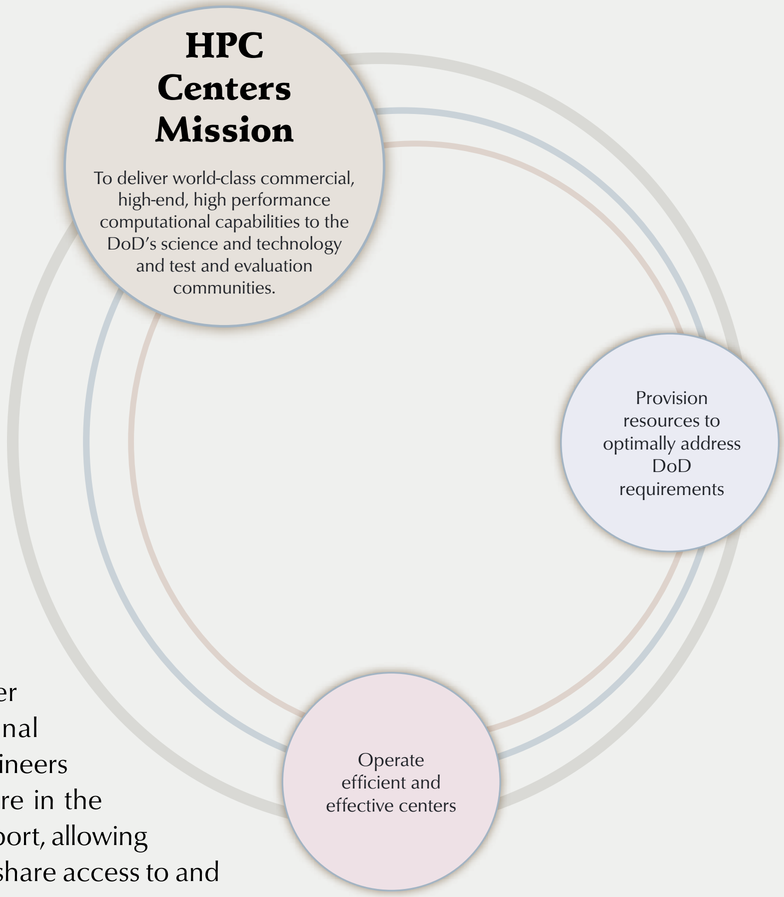
The HPCMP's ROI studies developed and implemented a validated and repeatable process for determining the value of the Program to the DoD based on benefits to the Warfighter and the RDT&E and acquisition communities. This progress across all Program activities optimizes the impact of HPC on the DoD S&T and T&E programs' support of the warfighting mission now and in the coming years.

HPC Centers

HPC Centers provide support to solve demanding computational problems and develop innovative products for the Warfighter. Pioneering DoD scientists and engineers throughout the United States use the Major Shared Resource Centers (MSRCs) and Allocated Distributed Centers (ADCs) to access leading edge technology and expertise across a range of HPC services:

- Supercomputers
- High-Speed Networks
- Mass Storage
- Data Exploration
- Customer Assistance
- Infrastructure and Operations Management

In FY 2008, MSRCs and ADCs provided resources and made improvements to continue user support.



Major Shared Resource Centers (MSRCs)

The MSRCs are large HPC Centers that deliver leading-edge, high performance computational resources and expertise to DoD scientists and engineers within the DoD Services and Agencies, anywhere in the USA. The MSRCs provide DoD with "purple" support, allowing the Air Force, Army, Navy, and DoD Agencies to share access to and use of HPC resources.

In FY 2008, four MSRCs supported the defense community:

- US Air Force Research Laboratory (AFRL) MSRC, Wright-Patterson AFB, Dayton, OH
- US Army Corps of Engineers (USACE), Engineer Research and Development Center (ERDC) MSRC, Vicksburg, MS

- US Army Research Laboratory (ARL) MSRC, Aberdeen Proving Ground, MD
- Naval Oceanographic Office (NAVO) MSRC, Stennis Space Center, MS

Through its annual Technology Insertion (TI) process, the HPCMP delivers and updates supercomputing capability at its HPC centers (See Technology Insertion section). Often, these new HPC systems stress power, cooling, weight, and space available at the HPC Centers. In conjunction with the host organization, the HPCMP supports the costs of facility enhancements to meet customer needs.

In FY 2008, the HPCMP upgraded and refurbished MSRCs, in a continuing effort to provide state-of-the-art equipment and technology. The following list provides details for major upgrades and improved facilities to accommodate HPC resources:

- AFRL MSRC installed a power-distribution switch to receive incoming power from two sources and began the planning process for a new building.
- ARL MSRC converted its facility to maintain the new HPC system for classified use.
- ERDC MSRC gained a new building to house the power distribution and power back-up assets.
- NAVO MSRC refurbished its entire computer floor to facilitate one of their new HPC systems and acquired new computer floor space in another building for a new system and existing systems.

Collectively, the MSRCs have 16 large HPC systems, of which, a few of the larger are two 8,000+ core Cray Inc; XT systems, a 9,216 core SGI system; and a 5,312 core IBM system. In FY 2008, the MSRCs operated systems totaling 402 teraFLOPS (one teraflop equals 1 trillion Floating point Operations Per Second) of computational capability.

Allocated Distributed Centers (ADCs)

The ADCs are partner HPC Centers that supplement the computational capacity of the MSRCs. Although they offer less HPC variety or capacity than the MSRCs, they provide a significant additional total capability to HPCMP customers. In addition, each supports a specialized community from either the DoD or academia. ADCs include:

- Arctic Region Supercomputing Center (ARSC), Fairbanks, AK
- Army High Performance Computing Research Center (AHPCRC), Moffett Field, CA
- Army Space and Missile Defense Command (SMDC), Huntsville, AL
- Maui High Performance Computing Center (MHPCC), Air Force Maui Optical and Supercomputing Site (AMOS), Kihei, HI

Collectively, the ADCs have several large HPC systems, including a 2,320 core SUN system at ARSC and a 5,120 core DELL system at MHPCC. In FY 2008, the ADCs operated systems totaling 64 teraFLOPS of computational capability.

Customer Focus

Striving to meet the needs of customers, the HPC Centers use a combination of synchronized resource, workload, and enterprise system management services. An array of advanced HPC technologies, resources, and service support enables scientific productivity by HPCMP customers. This year, with the advent of a single support contract for the four MSRCs, the Consolidated Customer Assistance Center (CCAC) implemented a streamlined set of procedures to speed up trouble ticket resolution—95 percent of 700 tier 1 customer call tickets/month was resolved in less than

90 minutes per request! The Data Analysis and Assessment Centers (DAACs) provided the ezViz and Computational Support Environment (CSE) analysis tools to support a wide variety of unclassified and classified projects. HPCMP projects made over 600,000 self-serve requests via these tools during 2008.

In addition, DAAC personnel directly collaborated with users 160 times to provide data analysis services. Application Support Analysts work directly with users to enhance their productivity by optimizing applications for use on HPC systems. Through collaborative working relationships, analysts support users with advanced use of compilers, message passing libraries, and performance analysis tools. Both in-house government applications and commercial applications are supported. Behind the scenes, infrastructure and operations management activities include system and network administration, security management, facilities planning and enhancement, and 24X7 operational and performance monitoring. This support allows scientists and engineers to focus on the computational science instead of the infrastructure required to support their computing needs.

The HPCMP assists customers through collaboration, technology, and service support.

Consolidated Customer Assistance Center (CCAC)

As the first point of contact for HPC users that need customer service, CCAC is accessible through telephone, Web pages, and email.

Data Analysis and Assessment Centers (DAAC)

Providing specialized data analysis to customers, DAAC supports both unclassified and classified research projects.

Application/System Performance Analysis

Code Optimization and Code Porting are two of the areas where Centers' specialists directly support users to make their jobs run faster and more efficiently.

Infrastructure & Operations Management

Behind the scenes support for systems and network administration, security management, and infrastructure configuration management enables scientists and engineers to focus on the computational science instead of the infrastructure needed to compute.

Cross-Center Projects

Many projects require collaboration and cooperation between the HPC Centers. HPC Centers deliver a rich set of services, leveraging the unique expertise of each HPC Center to accomplish a common goal of improving DoD's computational capabilities.

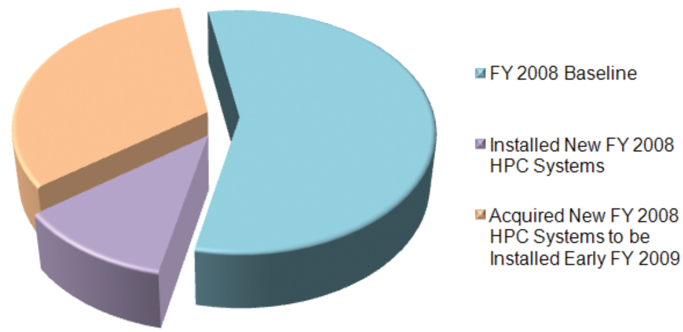
The following cross-center projects pursued in FY 2008 provide increased computational capability, enhanced data storage and migration, improved software management and distribution, and improved common operating environments and other tools beneficial to scientists and engineers.

Cross-center projects include:

- Technology Insertion (TI)
- Storage and Lifecycle Initiative
- Consolidated Software Initiative
- User Interface Toolkit (UIT)
- Baseline Configuration
- Next Generation Technical Services (NGTS) Contract
- Enterprise System Monitoring (ESM)

Technology Insertion (TI)

Each year, the Centers collaborate to determine the optimum set of HPC systems to acquire. The following pie chart illustrates the teraFLOPS (1 trillion **Fl**oating point **O**perations **P**er **S**econd) capacity increase due to new FY 2008 HPC system acquisitions. The increase in teraFLOPS corresponds to the ability to do more computational work or to apply more processing power to important problems, thus reducing the overall time to achieve a solution.



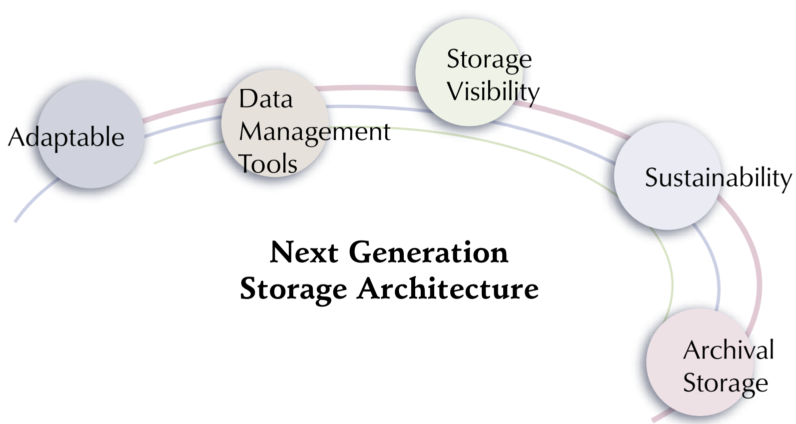
TeraFLOPS of New HPC Systems for FY 2008

At the beginning of FY 2008, the HPC systems at the four MSRCs and ADCs had a total computational capability of 437 teraFLOPS (the capability to perform 437 trillion mathematical operations per second). During FY 2008, the HPCMP procured large systems for deployment with a computational capability of 341 teraFLOPS, of which, 90 were installed in 2008 and 251 will be installed in early 2009. Therefore, the total capability of the HPC systems at the four MSRCs and ADCs increased from 437 to 527 teraFLOPS. Once the remaining systems are installed in early FY 2009, the total will reach 778 teraFLOPS.

Storage & Lifecycle Management Initiative

HPCMP customers perform research, design, and test activities at the HPC Centers that produce prodigious amounts of data to document and support analyses. HPC Centers provide a high-performance, high-capacity, and highly-reliable mass storage capability to retain these data files, as long as necessary. As the available supercomputing power to RDT&E users increases, users can perform larger and more complex analyses, providing better understanding and technology for the Warfighter of today and tomorrow. As the analyses increase in scope and size, so do associated data files. These files become harder to use and store.

At the forefront of technology, in early FY 2008, the HPC Centers initiated a plan to provide improved user productivity tools to enable management of the increasing amount of data storage forecast over the next 10 years. The plan's objective is to design and implement a HPCMP next generation data storage architecture critical to provide continued support for DoD R&D efforts. The plan focuses on management of RDT&E data files over their entire lifecycle. This plan will provide improved tools to allow customers to categorize their data for later access and use.



HPC Centers' next generation storage architecture leverages technology advances and product integration to address critical requirements for success in managing future data storage and data management requirements. The initiative supports automated data migration, user data management tools, and disaster recovery for HPC Centers' systems.

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Storage Lifecycle Management is the fundamental new capability that enables the next generation of HPCMP data storage. It integrates Information Lifecycle Management techniques with storage infrastructure and will enable HPCMP customers to assign metadata attributes to data files for file identification and management. This capability, designed during 2008, will be procured during 2009, with initial operating capability at the HPC Centers in late 2009.

The metadata attributes will be used for new, more powerful, user tools to find and manage data sets and provide information for the data archival and disaster recovery infrastructure that operates behind the scenes. Disaster recovery infrastructure preserves and protects the research data generated by HPCMP customers. The additional power provided by the metadata attributes will enable users to gain more access to and control data files, enabling significantly improved lifecycle management.

Consolidated Software Initiative

The capability to share commercial software licenses across HPC Centers and platforms resulted in significant cost savings for the Program and its user community. 2008 marks the evolution of this capability from addressing S-only commercial applications software to a more comprehensive software management process that addresses all HPC applications software and tools at the Centers. Now, HPC Centers have even greater flexibility to provide more user functionality, while realizing cost savings.

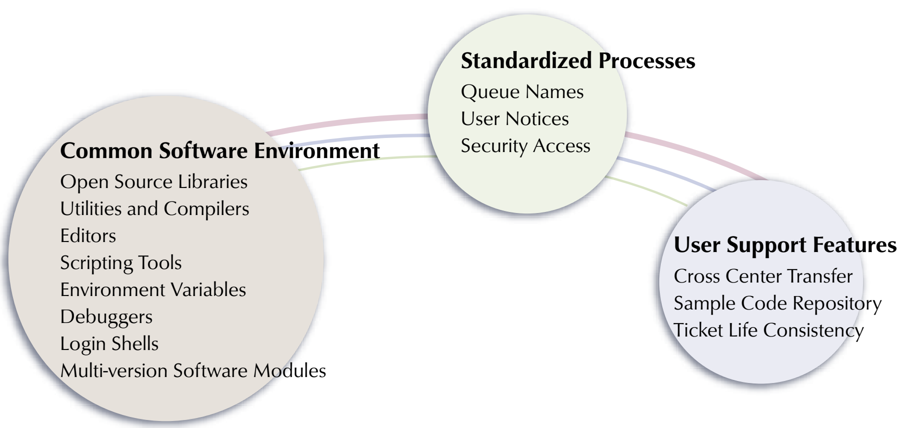
User Interface Toolkit (UIT)

The HPCMP provides the UIT as a resource for developers to build user-friendly desktop applications to access HPCMP resources. The UIT is an Application Program Interface (API) that provides for secure authentication to access HPCMP resources and commands through a single library. Applications that use UIT and its complete job stream management capability, allow novices and experts, alike, to manage workflows. The second major version of this set of tools, with streamlined interfaces and increased capabilities, was released in 2008. Numerous Web-based training sessions and four seminars are available to current and potential new users and developers.

Baseline Configuration

The Baseline Configuration initiative ensures that a common and user-friendly operating environment is available across the diverse supercomputer and support systems within the HPCMP. HPC users can seamlessly adapt to the environments at each HPC Center because of the common set of capabilities and functions for HPC systems. The HPC Centers concentrate on three aspects of operation: common software environment, standardized processes, and user support features.

This year, the team added four new policies to the 19 previously developed policies and made five major revisions to older policies to keep the baseline configuration



Baseline Configuration concentrates on three aspects of HPC Center operations: A common software environment, standardized processes, and user support features.

current with the needs of the user community. The common baseline across systems enabled some customers to use as many as eight different HPC systems during 2008 and to focus on their R&D mission instead of requiring them to revise software and support tools to make them compatible with different environments.

Next Generation Technical Services (NGTS) Contract

In a continuing effort to provide more efficient and effective services at the MSRCs, the Program restructured its support contracts at the four largest centers, creating a single contract activity in FY 2008, the NGTS contract. The HPC Centers collaborated with the General Services Administration (GSA) to restructure the technical services contract and consolidate four MSRC contracts into one enterprise approach focused on standardizing delivery and achieving common goals.

On March 19, 2008, Lockheed Martin was awarded the NGTS contract, a five-year, $344M contract to operate the MSRCs and support HPCMP assets, programs, and specialized HPC operations funded by services and laboratories. At no cost to the government, HPC Centers made a seamless 60-day transition to the NGTS contract. The NGTS contract supports 30-50 full-time employees per HPC Center and facilitates leveraging innovations and efficiencies across multiple HPC Centers. A single contractor and contract structure provides significant opportunities for increased collaboration and synergy among MSRCs to reduce costs and delivery times and to propagate best practices across the Program.

Enterprise System Monitoring (ESM)

In 2008, one of the NGTS contract initiatives focused on providing centralized monitoring of HPC systems, support systems, and network devices to improve system management and customer assistance. This year, the Program completed definition of scope and coordination with all potential stakeholders to enable initiation of detailed capabilities definitions and system design.

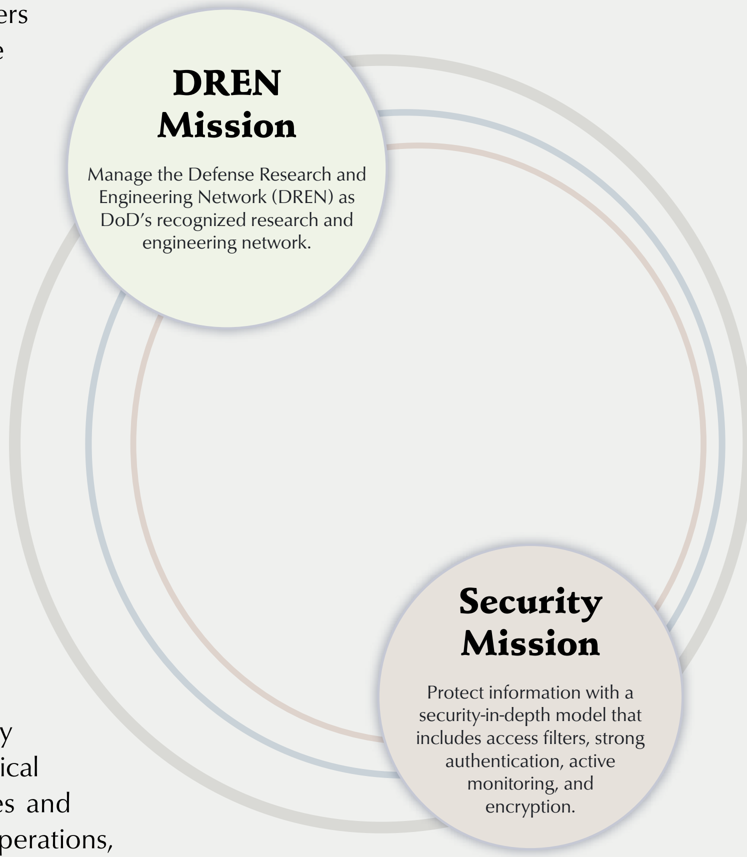
Networking

Defense Research and Engineering Network (DREN) and Security

No matter where you are in the country, HPC users have the ability to link to high performance computing resources through the Defense Research and Engineering Network (DREN). Nationwide, DREN connects HPCMP's geographically dispersed HPC networks. Military services and associates gain secure, robust access to supercomputers to collaborate with other high-end computing users in the defense community through the DREN. The Missile Defense Agency (MDA), DoD Modeling & Simulation Office, Joint Forces Command, and Defense Threat Reduction Agency all collaborate on HPC networks for R&D and T&E programs to benefit the Warfighter.

Today, we have flexibility to enable customers in remote regions of the country to access HPC resources. The DREN is an enabler that expands the pool of HPC researchers available to the DoD to solve the hard problems.

Increasing the pace of federal collaborations, the DREN contributes to overall federal agency networking and security through the Large Scale Network (LSN) and Joint Engineering Team (JET). As elements of the White House's Office of Science and Technology Policy Interagency Working Group, LSN and JET extend US technological leadership in leading-edge network technologies and coordinate federal agency networking activities, operations, and plans.



In 2008, DREN exceeded its target availability goal of 99.8%, providing connectivity to customers throughout the country.

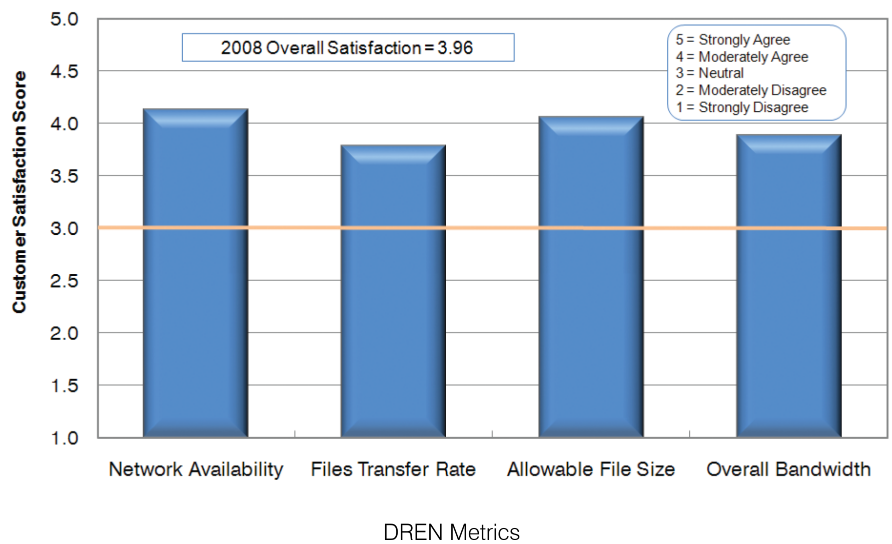
Month	Target Availability >99.8%
Jan-08	99.967%
Feb-08	99.963%
Mar-08	99.961%
Apr-08	99.978%
May-08	99.969%
Jun-08	99.962%
Jul-08	99.920%
Aug-08	99.967%
Sep-08	99.929%
Oct-08	99.972%
Nov-08	99.982%
Dec-08	99.955%

Mass Storage Recovery and Expansion

Disasters may strike, but the DREN is ready. With large, remote mass storage poised for data recovery, customers can feel at ease; the DREN is used to transfer large, single stream data flows in the multiple Gigabit range to mass storage, continuously. New protocol architectures to keep up with technological advances use 9,000 bytes maximum transmission units. Massive data transfers occur from coast-to-coast through high-end tuning of DREN's computational resources.

Internationally, the DREN enables key exchange points in Chicago, Seattle, Maryland, and California. International science exchanges with the Australian Meteorological and Oceanographic Society and Asian Pacific Advanced Networks projects empower DREN personnel to keep in step with on-going competitive advances around the world.

The DREN continues to expand as new computer technology, mass storage, and distributed computing environments place growing demands on bandwidth and network architecture. Core architecture will grow to 40 gigabits per second or more over the next few years and optics architecture will play an increasingly central role in the DREN core.



As a result of the annual survey, conducted by the HPCMPO, the DREN received high customer satisfaction scores in 2008, especially in network availability and allowable file size. The DREN received a score of 3.96 meeting overall customer satisfaction.

Internet Protocol Version 6 (IPv6)

As part of DoD's information age transformation, the DREN is emerging as an important contributor to combat power and protection. On June 9, 2003, the DoD CIO issued a memorandum stating that the DoD information infrastructure of the future would depend on the effective implementation of IPv6 in building a DoD-wide Global Information Grid (GIG) to achieve the DoD's Network-Centric Operations (NCO) and warfare goals. DREN was the first DoD IPv6 network to accomplish the following:

1. To enable the entire DREN WAN to routinely support end-to-end IPv6 traffic between and among all DREN sites and multiple external peering networks.
2. To maintain the performance and security levels of the IPv6 pilot at the levels existing on the IPv4-only side of the network.
3. To develop a process that facilitates activation of the IPv6 protocol suite at all DREN sites within minutes.
4. To enable IPv6 in selected applications provided by the HPCMP.
5. To document and provide lessons learned to help facilitate IPv6 implementations at all levels and across Federal Agencies on the DREN IPv6 knowledge base Web site, https://kb.v6.dren.net/ (Note: This is a CAC-enabled Web site that will be opened for sharing across the Federal Agencies).

The DREN achieved most IPv6 pilot goals by FY 2008 with less than $100,000 in additional funding and existing personnel. The DREN team took little time to enable IPv6 at the IPv6 pilot sites and shared lessons learned with many organizations through conference presentations, journal papers, magazine articles, interviews, the IPv6 knowledge base, and participation in DoD, Intelligence Community, Federal, and industry working groups and workshops. In 2009, the DREN will complete the transition in implementation, as well as in mindset, from an IPv4 networks that supports IPv6 to an IPv6 network with legacy support for IPv4. The "HPC Tests Network Modernization for DoD" success story on p. 38 discusses the IP software responsible for retrieving data from one location and sending it to another location on a network. In this success story, John Baird discusses IPv6 as a next generation protocol that offers a wider range of support compared to IPv4.

Security and Innovation

As advisors on DoD control boards and technical councils, the DREN contribution to the DoD networking and security communities creates resounding effects. The DREN fends off hostile acts of intrusion and network compromise with their Tier 2 DoD Computer Emergency Response Team. In FY 2008, the DREN team released a new CSA Tool v5.2.1 that integrates baseline configuration compliance modules and support issues for operations. DREN offers all of their customers Computer Network Defense Services. These types of services benefit the security of everyone by introducing a wide variety of toolsets focused on network monitoring, incident response, and vulnerability assessment. Using cryptographic keys, the DREN provides Kerberos network authentication system as a tool to secure valued information. There are many methodologies in place for the DoD and other Federal Agencies to securly exchange information with communities of interest on the network.

Powerful resources, such as the VirtualToken (VT) project, continue to provide hardware-based authentication to remote systems for research and collaboration. As partners in the VT project, the DREN and Ericsson enhance ViPr video session encryption and conferences to include multicast key exchange, multiple video and audio stream encryption, and key control for conference participants.

HPC Tests Network Modernization for DoD

The DoD's HPC Modernization Program Helps Make The Transition To IPv6

by John Baird, HPC Modernization Program

The Internet is nearly forty years old, and it's starting to show its age. One of the critical pieces that needs to be modernized is the Internet Protocol (IP) software that runs the network.

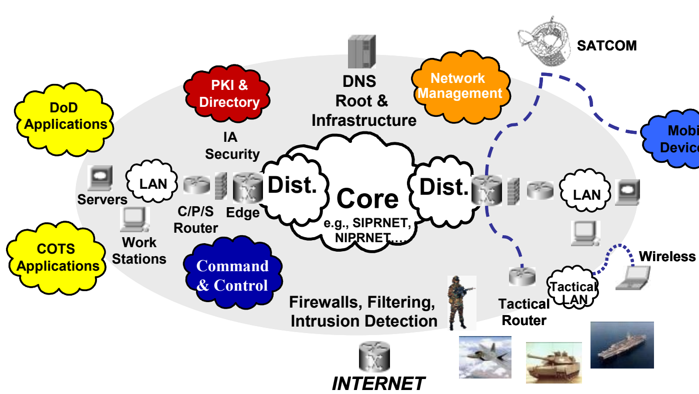
IP is the software that is responsible for getting data from one place to another on the network. Without it, a computer could only talk to itself - no email, no web browsing, and no iTunes. Most of the Internet today runs IP version 4 (or IPv4), which was designed in the 1960s and is able to address about 4 billion unique devices on the network. When IPv4 was first deployed, that seemed like a huge number. But by the early 1990s, engineers had recognized that as networks became increasingly complicated and as more of the 6+ billion people on the planet owned a computer or a cell phone (or both) connected to the Internet, IPv4 would become a serious impediment to progress. By 1996, many of the standards that define the next generation protocol, known as IP version 6 (or IPv6), were complete.

IPv6 is different in several important ways from IPv4. Two differences stand out. First, IPv6 uses 128 bits for device addresses rather than just 32 bits as IPv4 does which means that IPv6 can directly address many more devices than version 4 without the need to resort to complicated schemes. Another important difference is that IPv6 was designed to support mobile devices, such as laptops and cell phones and mobile users who want to remain connected in the car and on the airplane as if they are at home or in the office.

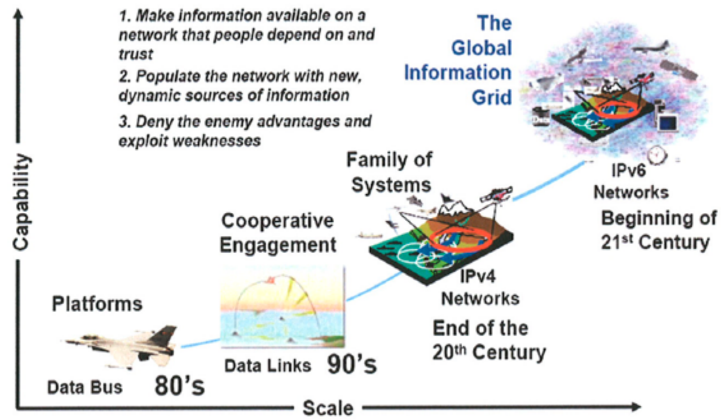
In 2005, the Office of Management and Budget issued a memorandum to chief information officers of Agencies throughout the Executive branch of the U.S. government, mandating that network backbones support IPv6 traffic by June 2008. Earlier, the Department of Defense (DoD) had gone even further, identifying the deployment of IPv6 networks as critical to achieving its net-centric operations and warfare (NCOW) goals.

The DoD information infrastructure of the future will depend on the effective implementation of IPv6 to build a fully distributed, available, and secure DoD-wide Global Information Grid (GIG). Enterprise-wide deployment of IPv6 was initiated by the Assistant Secretary of Defense (Networks & Information Integration or NII)/DoD Chief Information Officer (ASD (NII)/DoD CIO) in June 2003. That month, the ASD (NII)/DoD CIO also designated the Defense Research and Engineering Network (DREN) operated by the DoD High Performance Computing Modernization Program (HPCMP) Office as the first DoD IPv6 pilot network, in part, because DREN is DoD's recognized network for the DoD scientific research, engineering, and test and evaluation (T&E) communities.

Effective implementation of IPv6 in concert with other aspects of the GIG architecture will depend on the successful outcome of a full spectrum of testing methodologies, including standards-based analysis, conformance, interoperability, performance, and functional testing. To further test the IPv6 functional capabilities of multiple devices operating simultaneously across several locations at full performance levels, which are required to achieve the DoD's NCOW goals, all of these testing methodologies are not sufficient. A production-level wide area network test facility is required. The high-capacity, low-latency, nationwide DREN is such an IPv6 test facility.



Extent of IP in DoD



Evolution of the GIG

When the FY 2007 DoD IPv6 T&E report was sent to Congress in September 2007, it stated that one of the best reasons why the DREN IPv6 pilot has been developed is that it has given the DoD community a production environment to more directly test a functional network, as opposed to a closed, limited test bed. It is also assisting other DoD agencies in configuration, management, security, and deployment of an IPv6 network. The lessons learned and research to be conducted for this effort will greatly benefit the DoD community.

Since its creation in 1992, DREN's major thrusts have been high performance computing, security, and testing of new technologies; its designation as a DoD IPv6 pilot network early in the DoD IPv6 deployment was not surprising. The DoD relies upon the DREN to advance basic and applied research, enhance engineering design and development activities, and support ongoing test and evaluation efforts, according to Mr. Cray Henry, HPCMP Director. The DREN has been and will continue to be an important factor in enabling the DoD to maintain and even increase the capabilities of the Global Information Grid.

The DREN shares lessons learned from its 4+ years of operating a production network in a mixed IPv4/IPv6 environment with federal Agencies and Departments outside the DoD through the IPv6 Working Group of the Federal CIO Council Architecture and Infrastructure Committee.

About the DoD High Performance Computing Modernization Program

The DoD's High Performance Computing Modernization Program is responsible for the acquisition and modernization of the hardware, software, networks, and expertise that provide some of the world's most advanced computing capability in support of the DoD mission. The Program has six large supercomputing centers and supplies expertise and resources at numerous other military sites throughout the country.

For more information on the IPv6 Pilot Project, go to http://www.hpcmo.hpc.mil/Htdocs/DREN/dren_ipv6.pdf.

Contact

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IPv6 Pilot Project

John Baird, HPCMP IPv6 Pilot Implementation Manager
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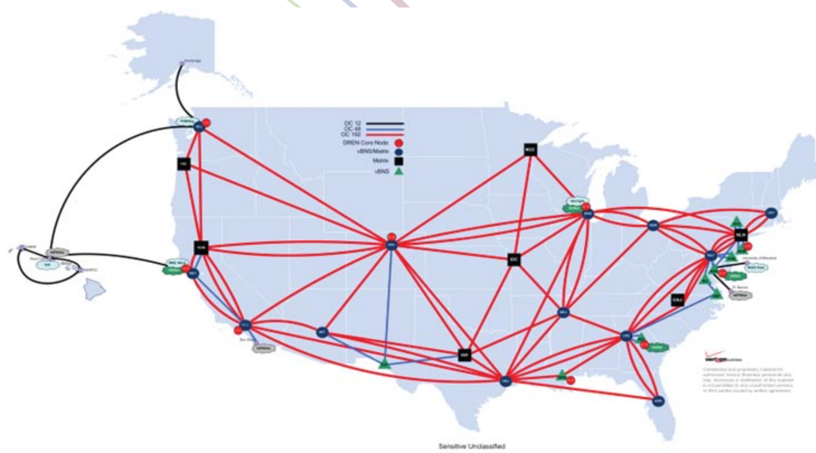
The DREN activated HPCMP's first host-based security system server and shipped a server to the Secret Defense Research and Engineering Network (SDREN) NOC for installation. Serving customers with secure and personalized support, the DREN sets the pace for enduring progress into FY 2009 as a primary computer network defense security provider.

DREN Connectivity

The DREN delivers network services, such as IPv6, multicast, and Voice over Internet Protocol (VoIP). The following map displays DREN accessibility and the benefits satisfied customers enjoy across the country.

- High bandwidth-low latency networks with extremely low loss
- Classified and unclassified network layers
- DREN backbone is OC-192
- Multicast-enabled to support video broadcasts
- Dual-stacked (IPv4 and IPv6)



Value to the Customer

DREN customers span several Services and Agencies providing network support. The Army, Navy, Department of Justice, and Joint programs need the DREN to accomplish the most vital tasks.

Navy

- Provide Computer Network Defense Service Provider (CNDSP) IT services to ensure efficiency and quality
- Space and Naval Warfare Systems Command (SPAWAR)
- Naval Air Systems Command (NAVAIR)
- Naval Sea Systems Command (NAVSEA) Research Development Test and Engineering (RDT&E) sites

Army

- Enhance infrastructure to DREN enclaves
- Implement Internet Protocol version 6 (IPv6) compliance
- Army Training and Doctrine Command (TRADOC) Battle Labs
- Future Combat Systems (FCS)
- Army Test and Evaluation Command (ATEC) Integrated Range Command Center

Air Force

- Establish RDT&E security boundaries for AF enclaves
- Unmanned air vehicle WAN support coast-to-coast for Global Hawk testing
- Joint concept technology, “C2 Gap Filler,” demonstrations
- Air Forces Northern
- Air Force Operational Test and Evaluation Center (AFOTEC)
- Joint Surveillance and Target Attack Radar System (JSTARS)
- Airborne High Energy Laser Program
- Air Force Institute of Technology

Joint Programs

- Research to establish a distributed test environment for next generation Global Command and Control System (GCCS)
- Provide emergency response to Detect and Respond Services for the Defense Contract Administration Agency (DCAA), US Military Academy, and US Air Force Academy

Other Federal Programs

- National Aeronautics and Space Administration (NASA)
- United States Geological Survey (USGS)
- National Oceanic and Atmospheric Administration (NOAA)
- Department of Justice (DOJ)

Federally Funded R&D Centers

- Massachusetts Institute of Technology (MIT) Lincoln Laboratory (LL)
- MITRE Corporation
- Aerospace Corporation

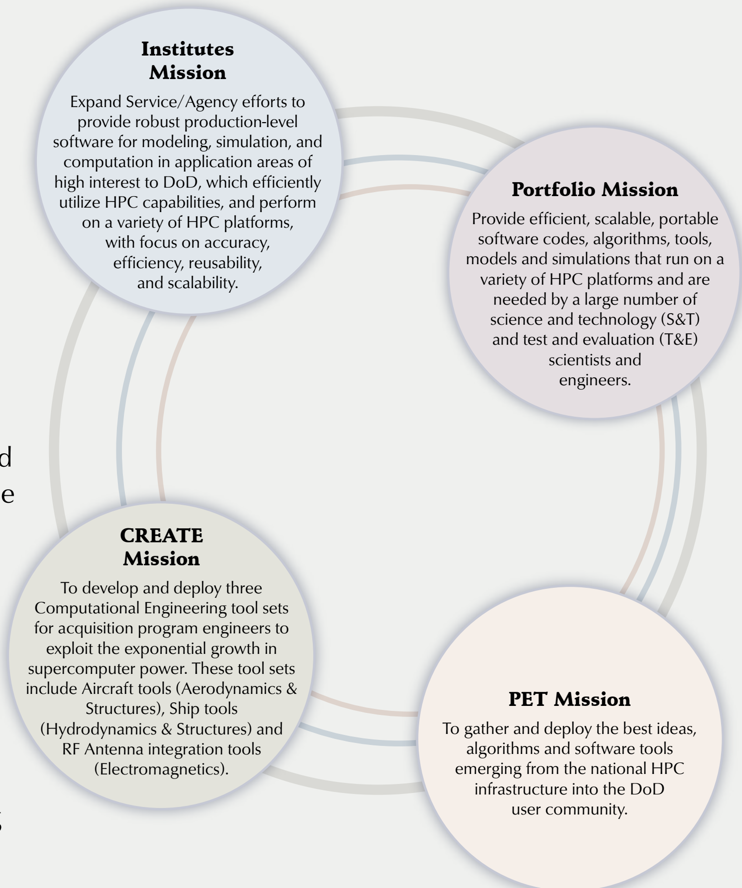
Collaborative Efforts

- Metropolitan Research and Education Network (MREN)
- National Science Foundation (NSF)
- Large Scale Network (LSN)
- Joint Engineering Team (JET)
- Hawaiian Internet Consortium (HIC)

Software Applications Support (SAS)

Software Applications Support (SAS) provides DoD scientists and engineers with capabilities to design, develop, test, and deploy superior weapons systems by modeling the physical world to support the Warfighter. SAS components include:

- Institutes
- Portfolios
- User Productivity Enhancement and Technology Transfer (PET)
- Computational Research and Engineering Acquisition Tools and Environments (CREATE)
- Software Protection Initiative (SPI)



Institutes

Each Institute forms a critical mass of experts focused on using computational science and high performance computing to solve the DoD's highest priority challenges. With cross-Service and Agency teams and a multi-disciplinary approach, Institutes transform traditional operational processes with computational insight by using legacy or newly-developed computational tools.

Institutes transform DoD's technological challenges into high performance solutions through the following goals:

- Enhance existing Service/Agency high priority projects.
- Utilize science and technology resources to develop, apply, and transition DoD HPC software applications.
- Build HPC experience in defense laboratories, engineering, and test centers for defense applications among DoD industrial and academic scientists and engineers.
- Leverage other HPC efforts across DoD, government, industry, and academia.

Awards for FY 2008

The DUSD(S&T) evaluated a number of proposals from military Services and Agencies in FY 2007. DoD subject matter experts evaluated and approved the following Institutes to begin in FY 2008:

- Institute for High Power Microwave (HPM) Employment, Integration, Optimization, and Effects, AFRL, Kirtland AFB, NM.
- Mobile Network Modeling Institute (MNMI), ARL, Aberdeen Proving Ground, MD.
- Institute for Multi-Scale Reactive Modeling and Simulation of Insensitive Munitions (MSRM-IM), ARL, Aberdeen Proving Ground, MD.

Altogether, the HPCMP supports nine Institutes, three new and six continuing Institutes.

Institute for High Power Microwave (HPM) Employment, Integration, Optimization, and Effects

The Institute's vision is to enable seamless integrated end-to-end simulation, design and optimization of HPM weapons, from HPM subsystem to platform to desired effect. It links multiple software development efforts into a coherent software package that can model and optimize HPM systems on platforms. The Institute facilitates the rapid development, acquisition, and fielding of effective HPM weapon systems providing revolutionary capabilities to the Warfighter.

All level models support optimization, experiment design, and uncertainty quantification for Analysis of Alternatives. This framework propagates accurate and traceable information from engineering level models to mission and campaign-level models for faster acquisition of HPM systems.

Highly integrated end-to-end HPM system model → Mission-Level & Campaign-Level Analysis

Engineering Level Models		Abstract Models		
HPM Source	Platform EMI/EMC	Propagation Models	Pe Models Predictive models	Pk Models Fault trees Advanced network models

EMC - Electromagnetic Compatibility
EMI - Electromagnetic Interference
Pe - Predicting Probability of Effect
Pk - Predicting Probability of Kill

The Mobile Network Modeling Institute (MNMI)

The Institute's vision is to exploit high performance computing through the development of computational tools that enables DoD to design and test networks at sufficient levels of fidelity and speed to understand the behaviors of Net-Centric Warfare technologies for realistic operational conditions.

MNMI will develop multi-disciplinary expertise and software tools that transform the ways in which DoD model, simulate, emulate, and experiment with dynamic reconfigurable mobile warfighter networks. MNMI conducts three phases in an HPC environment: experimentation, simulation, and emulation.

Experimentation

- Actual hardware in field experiment
- Traffic generated from applications
- Realistic scenarios
- HPC used to augment and stimulate environment

Simulation

- Objective function
- Behavioral relationships
- Parameters
- Variables

Emulation

- PC processors represent nodes
- Laboratory environment
- MANET software to mode node movement and radio access
- Actual MANET protocols run on nodes

Institute for Multi-Scale Reactive Modeling & Simulation of Insensitive Munitions (MSRM-IM)

The Institute will develop a science-based capability to simulate munition response to insults by capturing the effects that microstructural heterogeneities, inherent in composite energetic materials (EMs), imposed on macroscopic events. This effort will transform the modeling and simulation (M&S) process that DoD presently utilizes in the design of insensitive munition (IM)-compliant weapons by incorporating essential micro- and meso-level modeling capabilities needed to capture key physiochemical properties in continuum codes.

MSRM-IM's vision is to transform costly and inefficient DoD IM development processes. Results include safer munitions and quick delivery of technology at lower costs. The MSRM-IM team planned a strategy in FY 2008 to accomplish five strategic goals:

Produce a multi-scale, physics-based software suite that describes energetic material response at length scales ranging from atomistic through mesoscale to continuum.
Develop, augment, assess, and implement HPC-based software for mesoscale simulation of chemical/physical properties of energetic materials and/or materials used in energetic formulations used in munitions.
Augment and assess existing continuum models to incorporate the results and methods developed from atomistic or mesoscale simulations. Apply enhanced continuum models to salient IM practical and verification problems.
Develop, augment, assess, and implement multiscale homogenization algorithms using consistent or rigorous coarse graining procedures to link one or more length scales.
Develop and demonstrate a robust predictive capability for system-context response of munitions to IM threats through application of chemistry- and physics-based algorithms in the meso and continuum regimes of energetic materials.

The following lists six continuing Institutes:

Continuing FY 2008 Institutes

Institute for Space Situational Awareness (I-SSA)

I-SSA supported Search and Determine (SAD) software work beginning in December. SAD is a track association algorithm developed by the NRL to generate candidate orbits from uncorrelated tracks. The astrodynamics code constructs satellite orbits from uncorrelated observations. The process involves constructing orbits from pairs of observations that are not associated with a known object. This resulted in a greater number of orbits being discovered than was previously possible and the run times have been significantly reduced.

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

BHSAI optimized the performance of the original Unified Nucleic Acid Folding (UNAfold) source program by simplifying the I/O operations and developing a Perl interface to UNAfold. UNAFold is a comprehensive software package for nucleic acid folding and hybridization prediction.

Institute for Maneuverability and Terrain Physics (IMTPS)

The IMTPS focused on the parallelization of new models to support the countermine test bed, implementation of a human seismic model, and the numerical formulation of simplex elements for coupled deformation fluid flow problems.

Battlespace Environments (BEI)

BEI's development activity is focused on getting the first public release of the Earth System Modeling Framework (ESMF) 3 series, 3.1.0r. In this release, reworked lower-level general data structures are used consistently all the way up through the higher level Field, Bundle, State, and Component classes. The interfaces at the Field and Bundle level have been modified to correspond to the new Grid and Array data structures on which they are newly based.

Institute for HPC Applications of Air Armaments (IHAAA)

The IHAAA team renamed the technical area called Fluid Structure Interaction to Aircraft Mechanics and Dynamics because the main emphasis of the work being conducted in this technical area remains F-16 Limit Cycle Oscillations (LCO). Joint Model Library (JML) software 2.1 was released 9 June 2008; beta and acceptance testing completed as of 8 July 2008.

HPC Institute for Advanced Rotorcraft Modeling and Simulation (HI-ARMS)

HI-ARMS focused on the critical path elements of the HI-ARMS software development process. The Schools Interoperability Framework (SIF) is a Python-based framework that links all the constituent HI-ARMS modules, including:

- NSU3D – the near-body CFD code
- HiMARC – the off-body adaptive Cartesian solver
- RCAS – the structural dynamics and comprehensive analysis module
- PUNDIT – the domain connectivity module

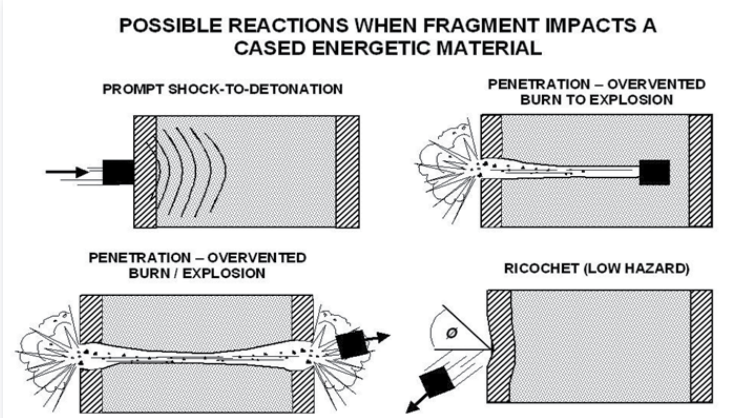
Portfolios

Nine years ago, the HPCMP initiated integrated Portfolios to focus on multidisciplinary challenges. Portfolio development teams accelerate technological solutions with efficient, scalable, and portable software codes, algorithms, tools, models, and simulations. Teams emphasize reusability, scalability, and portability. This initiative produces a new generation of world-class scientists and engineers trained in scalable software techniques to reduce future costs and increase our defense capabilities.

The HPCMP provides the DoD with results that advance the design, acquisition, and utilization of military technologies and aid in the development of improved military capability for the 21st century. In FY 2008, the Rocket Motor and Warhead Impact Modeling (RMWIM) Portfolio, formerly known as Insensitive Munitions (IM), provided the capability for the DoD to predict the severity of violence from explosions and costs to replace military assets. With HPC tools, the RMWIM Portfolio empowers DoD decision makers to thwart undue warfighter injuries or deaths.

Rocket Motor and Warhead Impact Modeling (RMWIM)

The RMWIM Portfolio enhances legacy modeling and simulation tools to predict the response of munitions to bullet and fragment impact (BFI). To this end, RMWIM uses Department of Energy (DOE) multi-physics codes to model BFI against rocket motors and confined energetic warheads. This Portfolio addresses the issue of munition sensitivity in design, storage, packaging, and transport.



T.L. Boggs and C.W. Dickinson. "Activities of the Technical Corporation Program W-Action Group." 1991 JANNAF Propulsion Systems Hazards Subcommittee Meeting, CPIA Publication

The end product is to provide government and industrial munitions designers with a new toolkit to design and develop munitions compliant with DoD regulations for effectiveness, safety, and insensitivity to prescribed insults. The advancement of state-of-the-art BFI-compliant munitions systems expands the fidelity of tools and, ultimately, provides security to the Warfighter on the ground.

In FY 2008, the RMWIM Team led by the Department of Army at Picatiinny Arsenal, successfully completed implementation of an implicit method and demonstrated results for a test case. Efforts continue to improve the multiphase flow aspects of the modeling and include enhancements in the mesh motion terms; the variable particle velocities for the multiphase flow; and the convective burn model.

User Productivity Enhancement and Technology Transfer (PET)

PET enables the DoD HPC user community to make the best use of HPC capacity and provides and extends the range of DoD technical problems solved on HPC systems. PET is enhancing the total capability and productivity of the HPCMP's user community through HPC-related science and technology support, training, collaboration, tool development, support for software development, technology tracking and transfer, and outreach to users.

Groundbreaking PET work by the Mississippi and Ohio State (MOS) University Consortium and High Performance Technologies, Incorporated (HPTi) helps the HPCMP's users provide tangible results for the Warfighters of today and tomorrow. The following success stories highlight PET achievements: "Simulation Support for the MRAP Vehicle Program", "Large Scale Parallelization of TDDFT in GAMESS", and "Parallelization and Enhancement of RMA2 (TABS-MD)."

> PET teams performed computations to investigate and improve Mine Resistant Ambush Protected (MRAP) armor design through weapon-target interactions and parametric numerical studies. Analyses of ballistic behavior of advanced ceramics and composite materials for the vehicle ultimately save lives. These PET investigations helped counter enemy threats through computational ingenuity. See page 49 to read more about the MRAP.
>
> *"The modeling, analysis, and assessment you performed were precise and showed the excellence of your endeavor." –Todd Bjerke, Modeling and Simulation (M&S) MRAP Coordinator.*
>
> "Large Scale Parallelization of TDDFT in GAMESS," the PET team discusses the GAMESS code, widely used in the DoD CCM community for research, and the HPCMP's modifications to GAMESS. See page 50 to learn more about the GAMESS performance enhancement.
>
> "The Parallelization and Enhancement of RMA2" success story discusses the RMA2, a 2-D hydrodynamic model, widely used for the modeling of rivers and watershed. See page 51 to learn more about the model.

In FY 2008, PET contracts offered 47 training events, attended by 579 students, covering subjects ranging from code profiling and error estimators to user training on codes, such as FLUENT, ABAQUS®, EnSight, and Xpatch®. PET video courses instruct students online throughout the country.

Courses	Courses
ACAD Workshop	Introductory MPI
Advanced GridGen	Joint ENS/FMS Workshop
ANSYS	Large Scale Design Optimization
Atomistix	LS-DYNA Applications to Protective Structures, Blasts, Vehicles (IED and mines), and Home Land Security
Case Management System for CFD Solvers	LS-PrePost and User Defined Materials in LS-DYNA
CFD/MIME/CFD FSI	OVERFLOW Short Course
Chemkin Fundamentals and Applications and Design	Parallel Computing in CSM
CTH	ParaView
Cybersecurity	Performance Evaluation of Multi-Language Scientific Applications
Data Analysis and Assessment Day (EnSight)	Photonics Seminar
Fieldview Workshop	Pointwise and Advanced GridGen
Fundamentals of XPatch	Seminar on Scalable Chemistry Code: ACES, Amber 9, ATAT, CP2K, LAMMPS, NWChem, ReaxFF (GRASP)
FY90 Overview	Shock and Detonation Waves
GPU Programming	Smooth Particle Hydrodynamics in LS-DYNA
HPC Network Simulation for the DoD	SolidMesh
HPC Network Simulation Workshop: GTNetS	STAR-CCM
Introduction to LS-DYNA	STARS3D

Simulation Support for the MRAP Vehicle Program

by James Cazamias, CSM On-site - ARL, UAB

Problem

MRAP vehicles are designed to survive insurgent and terrorist attacks and ambushes, which cause the majority of US deaths in Iraq. There are currently designs from several vendors, and there is a need to evaluate the competing designs. There is also a continuing need to improve upon MRAP designs to meet more sophisticated weapons systems employed now and in the future by insurgent and terrorist forces.

MRAP vehicle under attack

Methodology

ARL is performing computations to improve the armor design for the MRAP armored vehicle program. In support of this activity, Cazamias has investigated improved methods for simulation of weapon-target interactions and for parametric numerical studies. Efforts have focused on the ballistic behavior of advanced ceramics and composite materials.

Users Supported

This work supports the Armor Mechanics Branch of ARL-WMRD, Scott Schoenfeld (Branch Chief) and Todd Bjerke (M&S MRAP Coordinator),

DoD Impact

MRAP is currently the highest priority DoD acquisition program. This effort will assist the Army in improving armor for these vehicles and thereby improve survivability of the vehicle and safety of the occupants.

Bjerke commented: "Thank you very much for participating in the M&S portion of the MRAP program. This was a critical part of the program and your persistence in developing geometrically accurate and physically-based simulations paid off. ARL management was impressed with our effort and I commend you for your contribution to a successful test series. The modeling, analysis, and assessment you performed were precise and showed the excellence of your endeavor. Please accept my gratitude for the time and obvious effort you expended on improving our Soldiers survivability."

Large Scale Parallelization of TDDFT in GAMESS

by Michael Lasinski (CCM Support, ARL), Nichols Romero (CCM Support, ARL), Shawn Brown (CCM Support, PSC), Anthony Yau (CCM Support, ARL), and Jean Blaudeau (CPOC, ARL)

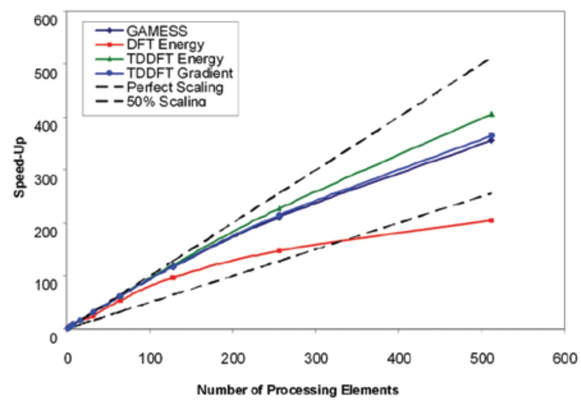
Problem

PET project CCM-KY6-002 was tasked with making a number of performance enhancements to the GAMESS quantum chemistry code (see success story, "Large Speedups in Quantum Chemistry Code - Profiling & Optimization of GAMESS on MJM," above). These include: 1) integration grid replacement, 2) parallelization of the time-dependent density functional theory (TDDFT), and 3) profiling and optimization. In this success story, we focus on the parallelization of the TDDFT, and present benchmark results demonstrating its scaling on DoD HPC systems.

GAMESS is widely used in the DoD CCM community for research in novel propellants, insensitive munitions, and non-linear optical (NLO) materials. Several quantum chemistry methods are available, but our performance enhancements are solely focused on the (DFT) and (TDDFT) methods. DoD users perform millions of CPU hours per year of calculations with GAMESS on DoD HPC systems. In a previous PET project, CCM-KY5-002, we determined that GAMESS exhibited superior scaling on shared-memory HPC architectures. Hence, our benchmarks focused on this HPC architecture type with our target computers being Eagle (SGI Altix 3700 at AFRL MSRC), Hawk (SGI Altix 4700 at AFRL MSRC), and Sapphire (Cray XT3 at ERDC MSRC).

Methodology

Our modifications to GAMESS focused on the parallelization of the TDDFT method which initially operated only serially. We parallelized both the TDDFT energy and TDDFT gradient calculations in GAMESS using the existing DDI library. By taking advantage of the Tuning and Analysis Utilities (TAU) Performance SystemsTM, we were also able to identify serial bottlenecks in the GAMESS TDDFT implementation. We demonstrated the performance of this new TDDFT parallelization capability on an input file for Coumarin 152A, a dye used in lasers. Figure 4 shows the parallel speed-up [extrapolated from a normalization to 16 Processing Elements (PEs)] for a TDDFT gradient calculation from 16-512 PEs on Sapphire. We have also run the same input file on Hawk for 256 and 500 processors (not shown). Both the



Parallel speed-up of Coumarin 152A TDDFT gradient calculation on Sapphire (normalized by extrapolation from 16 processors)

energy portion and the gradient portion of the TDDFT perform above 50% scaling even at 512 PEs. The TDDFT components of the calculation scale better than the DFT counterparts due to less computation in the latter.

Users Supported

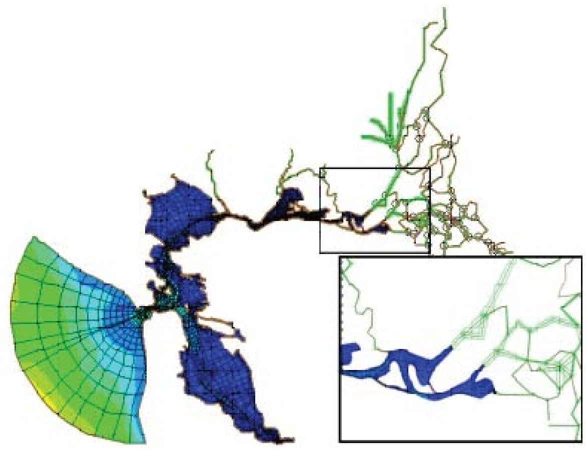
The DoD users supported by our work include Jerry Boatz and Project Partners Douglas Dudis, Ruth Pachter, and Todd Yeates, as well as all HPCMP users of GAMESS.

DoD Impact

Performing DFT and TDDFT calculations on complex molecules is of particular interest to the DoD CCM community, and significantly impacts modeling of high-energy density materials used in propellants, NLO materials used for sensor applications, and energy storage used for battery simulations. More efficient execution of GAMESS reduces time-to-delivery for several DoD material research and development efforts. The previous version of GAMESS possessed only serial implementations of both the TDDFT energy and gradient calculations which limited the size of molecules that could be treated with TDDFT. As the graph shows, a 500 processor run will run ~400 times as fast as the serial run – enabling much larger molecules to be simulated with this method, greatly expanding the capability of the code. This parallel implementation of TDDFT, along with a number of other DFT optimizations and a newly implemented Lebedev quadrature grid, are available in the 11APRIL2008R1 version of GAMESS. This is presently the default version on Hawk, Eagle, Sapphire, and Jade ERDC MSRC.

Parallelization and Enhancement of RMA2 (TABS-MD)

by Jeff Hensley, EQM On-site - ERDC, UT



Problem

RMA2 is a 2-D depth-averaged finite element hydrodynamic model widely used for surface water modeling. However, its usefulness for newer, large problems has been restricted because it has been limited mostly to shared memory machines.

Methodology

Two different parallel versions of RMA2 were completed using a distributed solver (MUMPS). Additionally, unnecessary code was eliminated and other improvements made. As a result of these improvements, the total run time on one large-scale problem was reduced by nearly 40%.

Users Supported

Joe Letter and Barbara Donnell (ERDC/CHL)

DoD Impact

RMA2 is a widely used tool for the modeling of rivers and watersheds, and is a critical tool for the analysis of flood control and environmental impact studies in many USACE projects across the United States. However, the need for higher-resolution modeling has increased the memory requirements and the size of the meshes needed to a point where HPC platforms are needed. The code was unable to take advantage of general, distributed memory parallel machines. The effort undertaken by Hensley has made it possible to use these HPC resources.

Letter commented: "The Corps finite element modeling system TABS-MD supports ERDC and Corps District modelers on flood control, navigation, and environmental quality studies. The retirement of the Digital and SGI parallel machines put a number of projects in jeopardy of being significantly impacted. Your assistance in porting the RMA2 code to the XT3 has kept at least three projects that I am involved in on track. This could not have been accomplished without your knowledge and skill with the HPC machines. Thanks for your help."

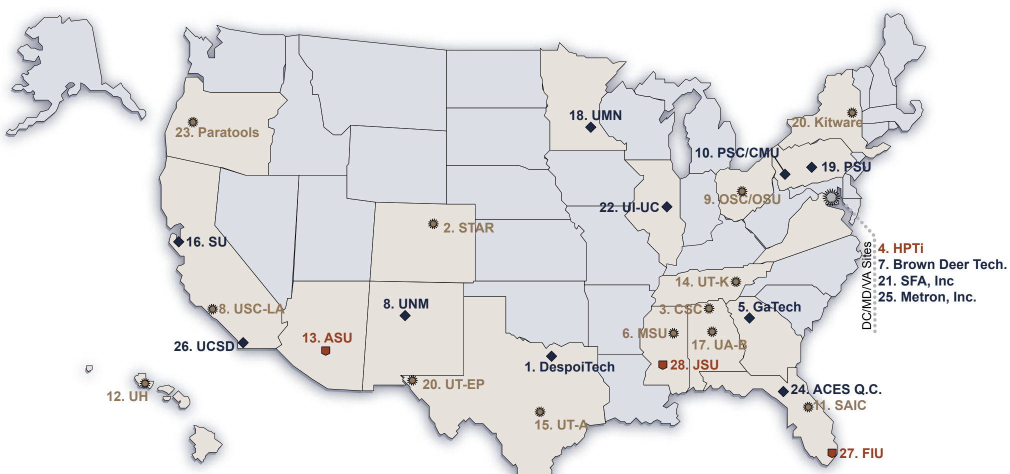
Courses	Courses
Introductory/Intermediate MATLAB	Surveying Key Issues in Shock and Detonation Waves
Training in CCM Scientific Visualization	Using LSPREPOST and dummies in LS-DYNA
Unstructured Grid Technology for CFD	

Webcasts	
CFD/MIME/CFD FSI	ParaView Developers Course
GPU Programming	Pointwise and Advanced GridGen

While the Online Knowledge Center (OKC) contains online training opportunities, as well as points-of-contact for scientific and technical support, it also is a repository of PET-developed technical reports and presentations. The OKC front page features computational electromagnetics and acoustics for all PET functional areas. Complete information regarding PET activities, training, current and past projects, and technical reports can be found at https://okc.erdc.hpc.mil.

HPCMP technical and program management emphasize and encourage our entire team of functional experts, on-site personnel, principal investigators, and business administrators to focus on the key goals of PET program: technology transfer, user productivity, and DoD mission impact.

This map displays the teams, comprised of experts, from a range of universities and companies, that provide one-on-one scientific assistance to HPCMP users.



PET Contractor Teams

1. DeposiTech, Inc., Haslet, TX
2. STAR Institute, Boulder, CO
3. Computer Sciences Corporation, Huntsville, AL
4. High Performance Technologies, Inc., Reston, VA
5. Georgia Institute of Technology, Atlanta, GA
6. Mississippi State University, Starkville, MS
7. Brown Deer Technology, Bel Air, MD
8. University of New Mexico, Albuquerque, NM
9. Ohio Supercomputer Center/The Ohio State University, Columbus, OH
10. Pittsburgh Supercomputing Center/Carnegie-Mellon University, Pittsburgh, PA
11. Science Applications International Corporation, Orlando, FL
12. University of Hawaii*, Honolulu, HI
13. Arizona State University, Tempe, AZ
14. University of Tennessee, Knoxville, TN
15. University of Texas, Austin, TX
16. Stanford University, Palo Alto, CA
17. University of Alabama, Birmingham, AL
18. University of Minnesota, Minneapolis, MN
19. Pensylvania State University, University Park, PA
20. University of Texas*, El Paso, TX
21. SFA, Inc., Crofton, MD
22. University of Illinois, Urbana-Champaign, IL
23. Paratools, Eugene, OR
24. ACES Q.C., Gainesville, FL
25. Metron, Inc., Reston, VA
26. University of California at San Diego
27. Florida International University*, Miami, FL
28. Jackson State University*, Jackson, MS

** denotes Minority Serving Institution (MSI)*

Legend
- HPTi Team
- MOS University Consortium
- HPTi and MOS

Computational Research and Engineering Acquisition Tools and Environments (CREATE)

CREATE became a funded program in FY 2008, chartered to develop and deploy three sets of physics-based computational engineering design tools for acquisition programs:

- CREATE-Air Vehicles (AV) – Military Air Vehicle Design
- CREATE-Ships – Military Ship Design
- CREATE-Radio Frequency (RF) Antennas – Antenna Design and Integration with Platforms

In FY 2008, a fourth project, CREATE-Meshing and Geometry (MG), was added to address the meshing and geometry needs of the other three projects.

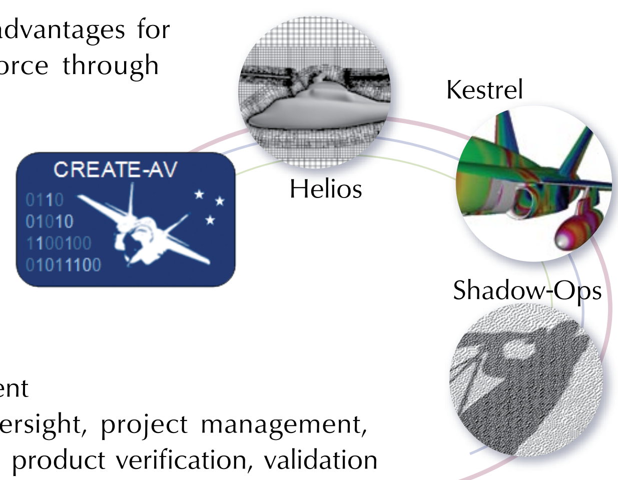
CREATE tools will enhance the productivity of the DoD acquisition engineering workforce by providing high fidelity design and analysis tools with capabilities greater than today's tools, reducing the acquisition development and test process cycle. CREATE projects will provide enhanced engineering design tools within three to four years after project start dates and mature tools at the end of the 12-year project schedule. Final tool set design will capitalize on the next generation of supercomputers available in 2020.

In FY 2008, the HPCMP established four CREATE Boards of Directors (BoDs): CREATE-AV, CREATE-Ships, CREATE-RF, and CREATE-MG. During FY 2008, the CREATE BoDs met to endorse requirements and software gaps cited in the Initial Capabilities Documents.

No single DoD institution has the staff with the broad collection of skills needed to execute all elements of one project; therefore, each CREATE project is multi-institutional, with participation from Air Force, Navy, and Army engineering centers, laboratories and acquisition organizations, DoD contractors, and other federal agencies.

CREATE-AV

CREATE-AV provides significant strategic and competitive advantages for the DoD aeronautical weapon systems acquisition workforce through Computationally Based Engineering (CBE) and next generation computers. CBE software products have a three-fold impact: increased capability of acquisition program engineers; reduced workload through streamlined and more efficient acquisition workflows; and minimized need for rework due to early detection of design faults and performance anomalies.



The CREATE-AV Project is headquartered at NAVAIR, Patuxent River, MD, but includes elements that provide project oversight, project management, requirements gathering, CBE software product development, product verification, validation and quality control, and technology transition.

The FY 2008 initial CREATE-AV BoD consisted of the following senior representatives from the service engineering organizations: Dr. Ed Kraft (Chair), Chief Technologist, Arnold Engineering Development Center (AEDC), Air Force Materiel Command; Dr. William Lewis, Director, Aviation Engineering, US Army Aviation and Missile Research (AMRDEC), Development & Engineering Center; Dr. Michael Scully, Senior Staff Engineer, US Army Aero-flight Dynamics (AFDD) Directorate, AMRDEC; Mr. Richard Gilpin, Director, Aircraft & Unmanned Aerial Vehicles, NAVAIR; and Mr. Jorge Gonzalez, Technical Director, Engineering, AFMC Headquarters (HQ AFMC/EN); and Mr. Cray Henry, Director, DoD HPCMP.

CREATE-AV Teams began collaboration with researchers and project planning in FY 2008 to fulfill the needs of the defense acquisition workforce.

Planning

The Planning Team, comprised of senior acquisition engineers across the Services, ensured that project activities and products responded to the needs of the defense acquisition engineering workforce by providing project management and developers with cognizance of key acquisition process workflows and code building environment impact, developing plans to build bridges between developers and the targeted workforces, and providing recommendations to the Board of Directors.

Kestrel Software Product Development

The Kestrel Team was established in FY 2008 and core team members are hosted at the Air Force SEEK EAGLE Office (AFSEO) at Eglin AFB, FL and University of Alabama, Birmingham, AL. Kestrel will enable integrated, CBE-based, test and analysis of fixed-wing aircraft designs via simulation methods to verify vehicle performance; perform flight certifications and qualifications; rehearse ground-based and full-scale flight tests; and evaluate planned or potential operational use scenarios. Through regular release cycles, the team will deliver the full suite of Kestrel capabilities over several years. The first release of Kestrel to targeted acquisition engineering organizations is scheduled for late FY 2009.

Helios Software Product Development

The Helios Team is hosted at AMRDEC, AFDD at Moffett Field, CA, with other key members at the University of Wyoming. During FY 2008, Helios organized a Technical Advisory Board comprised of technical experts from defense laboratories, NASA, the domestic rotorcraft industry, and academia, to ensure the physical accuracy, computational efficiency, and usability of the Helios product within the defense acquisition engineering workforce. Through regular release cycles, the team will deliver the full suite of Kestrel capabilities over several years. The first release of Helios is scheduled for late FY 2009.

Helios will ultimately enable integrated, CBE-based, test and analysis of rotary-wing aircraft designs via simulation methods to verify vehicle performance; perform flight certifications and qualifications; rehearse ground-based and full-scale flight tests; and evaluate planned or potential operational use scenarios. In time, Helios will also allow variable fidelity physics selection to facilitate effective CBE use in early-phase acquisition process workflows.

Shadow-Operations

The Shadow-Operations Team is headquartered at NAVAIR in Patuxent River, MD. In collaboration with management of targeted acquisition programs, this team “shadows”, or copies, current acquisition activities using the newest releases of CREATE-AV CBE software products to positively impact the targeted acquisition program, gather requirements, and accumulate real acquisition test cases. The targeted acquisition program archives case conditions, simulation results, and test data for validation testing of future releases of CREATE-AV CBE software products. Activities of the Shadow-Operations Team support all strategic goals of the project.

In FY 2008, the team shadowed the following acquisition programs:

- EP-3E Flight Qualities Assessment
- UCAS Conceptual Design
- JSF Short Take-off and Vertical Landing (STOVL) Weapons Bay Emergency Jettison
- JSF Aero-Propulsion Integration
- GBU-39 Weapon Integration

The team made huge impacts on the EP-3E assessment and UCAS projects this year. Through the use of computational fluid dynamics tools to analyze different flight conditions, the Shadow-Operations Team reduced the required time for the Navy EP-3 reconnaissance aircraft Flying Qualities Flight Clearance from one year to three months! The elimination of subsequent tests, construction costs, and flying quality reports allows the acquisition program to meet present deployment dates in the forward theater. The Navy EP-3 combats terrorism, supporting the Warfighter in today's wars.

Computational fluid dynamics tools assisted the team for the optimization study of the proposed UCAS conceptual design. The Shadow-Operations Team identified improvements for stability, control, and potential ratio improvements of lift to drag from 50 percent to 90 percent! These successes not only eliminate extra costs, they provide the Warfighter with state-of-the-art tools to defend our nation.

CREATE-RF Antennas

As integral components of DoD weapon systems, antennas perform critical communication, identification, and navigation functions to increase the Warfighter's effectiveness and survivability. Antenna systems and computational electromagnetics (CEM) tools require advanced, fast, and accurate methods to take advantage of upcoming multi-node, multi-core high performance computing hardware with ease-of-use to encourage more users, eliminate errors, and facilitate productive analysis.

CREATE-RF's vision is to develop and transition maintainable, extensible, validated, and productive geometry, CEM, and user interface tools to support rapid antenna system design and integration into DoD structures, air, sea, land, and space-based platforms for an estimated 20-year life span. Properly constructed tools have the potential to increase the current user base and set up antenna systems with high performance at low cost. Accuracy and advanced computational ability to obtain systems that meet different specifications, eliminating costly redesigns, saves the DoD money, time, and effort.

In addition, CREATE-RF aims to improve the ability of DoD institutions to develop and exploit large-scale computational science and engineering tools by building the technical capability of DoD institutions. The development of antenna modeling capabilities represents the best tools for our nation. Therefore, the project plans to employ both software and hardware-based protection measures to safeguard its intellectual property during the development, distribution, and application stages.

The CREATE-RF project office established a geographically dispersed team working on the same codes through a collaborative development enclave. The project headquarters is located in the Sensors Directorate, AFRL, Wright-Patterson AFB, OH, and several participating institutions via small workgroups. The CREATE-RF team has members from the Army, Navy, and Air Force.

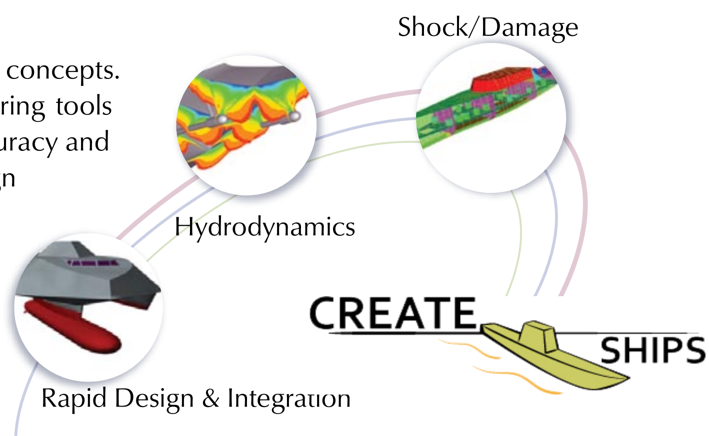
The CREATE-RF project office also established a contracting framework to obtain required software engineering and coding support by industrial contractors. 60 people attended an "Industry Day" on 18 April 2008 at Wright-Patterson Air Force Base; 44 attendees represented 27 different companies and universities. The CREATE-RF team also hosted various software training classes at Wright-Patterson AFB for the Automated Computer Aided Design tool (ACAD); ILANS, a Virtual Electromagnetic Design (VED)-developed graphical user interface; and CARLOS, a VED-developed CEM code engine.

The CREATE-RF BoD consists of the following members: Dr. Frederick Tokarz (Chair), Technical Advisor for Low Observables, AFMC, Aeronautical Systems Center; Dr. William Baker, Chief Scientist, Directed Energy Directorate, AFMC, AFRL; Dr. Janet Fender, Chief Scientist, Air Combat Command; Mr. Dennis DeCarlo, Chief Antenna Systems Engineer, NAVAIR; Ms. Betsy DeLong, Deputy, Transition and Innovative Naval Prototypes, Office of Naval Research (ONR); Dr. Mahbub Hoque, Chief Scientist, Space and Terrestrial Communication Directorate, Army Communication Engineering Research and Development Electronic Center; and Mr. Cray Henry, Director, DoD HPCMP.

Future Plans

CREATE-RF foresees FY 2009 as the first execution year for software design, integration, and test activities. More formal oversight and tracking tools are to be put in place to ensure effective program management. In addition to releasing the first iteration of its developed software tools, CREATE-RF and its partners will vet the requirements identified in its Initial Capabilities Document. CREATE-RF expects additional focus areas to emerge in FY 2009 based on continuing discussions with antenna system designers and their organizations.

CREATE-Ships



New ship design depends on new technologies and concepts. While existing physics-based computational engineering tools provide a base for research, they need improved accuracy and more complex physics. In addition, they provide design information too slowly to impact the system design process and meet time constraints.

To remove this deficiency, the CREATE physics-based tools will use the next generation of high performance computers to provide accurate design information within timeframes mandated by the Navy's design decision process. The Ship Design Project, also known as CREATE-Ships, plans to develop the engineering software to support a reconfigurable ship design and acquisition process. HPC engineering tools will create an optimized total warship design through properly designed hull, mechanical, and electrical systems integrated with combat and other mission systems early in the acquisition process. Navy development of cost-effective ship designs to meet performance requirements on schedule and within budget is feasible with CREATE-Ships solutions.

The Naval Surface Warfare Center, Carderock Division (NSWCCD), West Bethesda, MD, is the headquarters for CREATE-Ships.

CREATE-Ships is currently composed of three product areas:

- Rapid Design and Integration: Comprehensive, rapid exploration of the feasible design space
- Hydrodynamics: Integrated Hydrodynamics Design Environment (IHDE) and high-fidelity code with object-oriented open source software
- Shock/Damage: Enhanced Dynamic Systems Mechanics - Advanced Simulation (DYSMAS) for close-in underwater explosions

Rapid Design and Integration

CREATE-Ships breaks new ground for the Navy's LEAPS product model database to accept parallel queries for ship design data. FY 2008 set the groundwork for many activities CREATE-Ships will execute in FY 2009 , including multi-disciplinary optimization, using response surface methodologies to replace the traditional spiral approach.

Hydrodynamics

CREATE-Ships began development of the IHDE for use by naval architects and hydrodynamicists to promote design processes and provide access to a suite of analysis software, automated meshing, shape optimization, job submission, and validation against existing experimental data. FY 2009 marks the IHDE's first formal release.

Planning new high-fidelity code for the Navy using available object-oriented open source software began in FY 2008. CREATE-Ships coordinates this effort with NSWCCD, Pennsylvania State University Applied Physics Laboratory, University of Iowa, and Science Applications International Corporation (SAIC).

Shock/Damage

The DYSMAS fluid-structure interaction software creates predictions for full ship shock trials, to alleviate potential environmental impacts and demonstrate ship survivability capabilities. CREATE-Ships and other members of the Shock/Damage Product Team, NSWCCD, Naval Surface Warfare Center Indian Head (NSWCIH), and Sandia National Laboratory, developed detailed enhancement plans for FY 2008–2013.

In response to a FY 2007 JASON Defense Advisory Group review of DYSMAS, the Shock/Damage Product Team's development activity initiated required structural improvements by making use of portions of Sandia's Sierra mechanics software suite, as well as parallelization of the fluid-structure coupler software. CREATE-Ships coordinated efforts with its Technical Advisory Group to further enhance ship design methods. These enhancements provide both functionality and timeliness improvements to support ship design decisions.

CREATE-Ships Shock/Damage Technical Advisory Group includes representatives from the following groups:

- Navy Technical Authority for Ship Vulnerability
- Program Executive Office (PEO) Ships
- PEO Aircraft Carriers
- PEO Submarines
- OSD Live Fire T&E
- ONR

The CREATE-Ships BoD consists of the following members: RDML T. Eccles (Chair), Chief Engineer, Naval Systems Engineering Directorate, NAVSEA; Dr. Walter Jones, Executive Director, ONR, Mr. Charles Reeves, Technical Director, NSWCCD; Mr. Glen Sturtevant, Director for Science and Technology, Program Executive Office (SHIPS); and Mr. Cray Henry, Director, DoD HPCMP.

With CREATE-Ships as catalysts, NAVSEA initiated the development of a comprehensive Ship Design Tools Roadmap as a plan to develop ship design, analysis, and integration computer tools. CREATE-Ships and its Board of Directors approved the project's requirements and initial development plans for shock/damage and hydrodynamics performance analysis.

CREATE-Ships met with representatives of the National Shipbuilding Research Program, from General Dynamics-Electric Boat and Northrop-Grumman Ship Systems, to explore mutual interests in ship design and analysis tools for ship geometry generation and exchange, mesh generation, and tool-to-tool exchange of analysis results.

The ONR, NAVSEA, and CREATE-Ships organized one of six workshops on the ship design process on 28–30 May 2008. Approximately 100 participants from Navy, industry, academia, and national laboratories attended the first workshop.

Future Plans

CREATE-Ships anticipates FY 2009 as an execution year for rapid design and integration activities, as well as a HPC planning year for additional products. CREATE-Ships and the design community will vet the requirements for the IHDE to continue software development for the formal release in FY 2009. FY 2009 marks the final decision for the high-end software development also. CREATE-Ships expects additional product areas to emerge in FY 2009, based on continuing discussions within the Navy ship design community.

CREATE-MG

In mid-FY 2008, CREATE added the Meshing and Geometry (MG) Project, to support CREATE-AV, CREATE-RF, CREATE-Ships, and their stakeholders. MG provides meshing and geometry tools for automation, interoperability, and ease-of-use for CBE software for each major CREATE project.

The core team is located at the NRL and acts as a joint DoD NRL/DOE partnership effort to leverage existing geometry and meshing technology from Sandia National Laboratory.

The FY 2008 CREATE-MG BoD consisted of: Dr. Robert Meakin (Chair), CREATE-AV Project Lead; Mr. Cray Henry, Director, HPCMP; Dr. Kueichien Hill, CREATE-RF Project Lead; Mr. Myles Hurwitz, CREATE-SHIPS Project Lead; Dr. David Fisher, CREATE Chief Scientist; and Dr. Steven Owen, Sandia National Laboratories/DOE.

During FY 2008, the project efforts focused on requirements gathering, formalization, and reconciliation, and project planning, team-building, and staffing.

Outreach

Outreach

The objective of HPCMP Outreach is to offer opportunities for scientists and engineers to present ideas to peers, young people, and the DoD community. Outreach promotes collaborative relationships among the DoD, national science communities, and Minority Serving Institutions (MSIs), and encourages active involvement to achieve Program goals. Collectively, all HPCMP departments and the user community determine outreach success by actively participating in HPCMP Outreach efforts.

In 2008, HPCMP Outreach efforts included:

- Users Group Conference (UGC)
- DREN Network and Security Conference
- Joint Educational Opportunities for Minorities (JEOM) summer colloquium, institutes, workshops, and scholarships for science, technology, engineering, and mathematics (STEM) faculty at Historically Black Colleges and Universities (HBCUs) and MSIs
- National Defense Science and Engineering (NDSEG) Fellowship Program
- DoD Institutes for Higher Learning Program – Cadets and Midshipmen Summer Projects

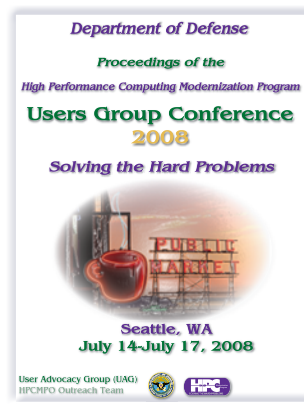
Users Group Conference (UGC)

The 2008 DoD HPCMP UGC was held on July 14–17 in Seattle, WA. This annual conference enables the DoD S&T and T&E communities to share their computational science and engineering results with colleagues and other members of the community. The conference brings together a community of scientists

and engineers with common interests, encourages the sharing of techniques and methods, and allows the users to interact with staff from HPC Centers and the HPCMPO. Users gain an appreciation of the technical breadth of the entire community. In FY 2008, the UGC was organized by the Program's User Advocacy Group and the HPCMPO staff.

The UGC included six invited speakers: Capt. Vic Addison discussed the role of supercomputers for the Navy; Dr. Steve Scott summarized the advances in HPC productivity through CRAY's achievements with DARPA High Productivity Computing System project; Mr. Kevin Gildea summarized the advances in HPC productivity through IBM's achievements; VADM Daniel Oliver discussed the role of supercomputing at the Naval Postgraduate School; Mr. Doug Ball summarized the role that supercomputing played in commercial aircraft design for Boeing; Dr. Dan Reed discussed emerging fields that supercomputing will enable; Mr. Chris Castello discussed the Google Earth project; and Dr. David Bacon summarized the status of quantum computing. Mr. Cray Henry presented the Director's Report that highlighted new, available computing power to the DoD; the start of three new Institutes (insensitive munitions, high power microwaves, and network modeling); the plans for the next PET contract; the status of the CREATE program; and the Program Office's successful move from Ballston to Lorton, VA.

There were four invited presentations on technical results by DoD HPCMP users: Dr. James Doyle (NRL-MRY) summarized progress on predicting weather for the naval battlespace environment and the impact of those predictions; Dr. Jerry Boatz (AFRL/RZSP) presented work on the design of energetic ionic liquids; Dr. Scott Fawaz (USAFA) presented work on modeling fatigue issues for aircraft; and Dr. Andrew M. Rappe (U. of Penn.) discussed results using computational techniques to explore the acoustic properties of complex ferroelectric oxides for sonar applications.



Attendance increased from 400 to 451 attendees from last year's conference. There were 116 technical talks, 12 Birds of a Feather meetings, 7 tutorials, and 57 posters. Eighty-four presenters wrote papers, an increase from 2007. (Refer to the Appendix for a list of papers and posters presented.)

The papers were written to capture the interest of scientists and engineers with general scientific backgrounds. Papers covered unclassified scientific research and engineering development technical areas that address the latest computational techniques. General topics included:

Computational Fluid Dynamics (CFD)	12 papers
Multi-Physics (CFD, CSM, CCM Plasma Physics, etc.)	12 papers
Computational Chemistry and Materials Science (CCM)	15 papers
Climate/Weather/Ocean Modeling and Simulation (CWO)	8 papers
Signal/Image Processing (SIP) and Sensors; Electronics, Networking, and Systems/C4ISR (ENS) and Testing	8 papers
Software and Hardware Infrastructure	9 papers
Software Performance and Performance Modeling	9 papers
Computational Methods	9 papers
Education	2 papers

The papers presented at the UGC provide a good overview of the unclassified computational science and engineering research and development in the DoD S&T and T&E community. The conference format and schedule provided time for discussions among attendees during breaks, lunch, and after the day's presentations.

Hero Awards

Every year, the HPCMP requests nominations from the HPCMP community for the UGC Hero Awards. The Hero Awards seek to recognize outstanding individuals who support researchers and the Program to make a positive impact to the DoD and the Warfighter, contributing to the overall mission of the HPCMP. Hero Awards recipients receive recognition at the UGC Hero Awards Ceremony.

Eligibility extends to personnel within the HPCMP components, such as the DSRCs, DREN, SAS, and the Program Office. The Hero Awards are given in the following categories:

1. Innovative Management – Demonstrates creative business practices to improve overall HPCMP business model
2. Technical Excellence – Demonstrates scientific or engineering excellence using HPCMP resources to advance creative and effective technology
3. Long Term Sustained Award – Provides overall contribution to the science and technology (S&T) and test and evaluation (T&E) HPCMP communities for the last five years
4. Up & Coming within the HPCMP – Provides a contribution to the S&T and T&E HPCMP communities and recipient must have two or less years in the Program

In 2008, the following winners received HPCMP Hero Awards at the UGC in Seattle, WA:

- *Innovative Management* as chairperson of the NGTS Source Selection Team – Mr. Thomas Brown, HPCMPO
- *Technical Excellence* for management at ERDC MSRC – Mr. Robert Alter, ERDC
- *Long Term Sustained* for technical leadership as one of the founders of HPCMP – Dr. Larry Davis, HPCMPO
- *Up & Coming* as a key member of the AFRL MSRC PKINIT project – Mr. John Hoffman, AFRL

DREN Networking and Security Conference

The 2008 DREN Network and Security Conference was held on August 11–15, 2008 in San Diego, CA. This annual conference was a five-day event that showcased tutorials, hands-on technical sessions, and lectures. A total of 262 people attended the conference. (Refer to the Appendix for a list of presentations.)

DREN conference attendees included the HPCMP program managers, directors of MSRCs, service enclaves on the DREN, and technical and financial DREN users.

DREN Networking and Security Conference 2008

DREN tutorial topics included: DREN Network Visibility and Troubleshooting with CNIC and Remedy, Aaron Gibson and Patrick Hughes; Arbor S-Flow, Rob Hartman; Performance Tools, Phil Dykstra; SSG, Ben Eater; Advanced Linux Security (While Wearing a Red Hat), Drew York; Introduction to Multicast with Hands on Lab, Terry Jones and Stan Carver; Comprehensive Security Assessment 101, Drew York and Gerald Fowler; Advanced Multicast with Hands on Lab, Tim Owen and Raul Fernandez; CSA Checklist Tutorial, Steve Simpson; and Dr. Larry Smarr, the Director for the California Institute for Telecommunications and Information Technology was the Keynote Speaker.

Joint Educational Opportunities for Minorities (JEOM)

The HPCMP JEOM Program is an educational outreach effort that strives to increase access to the HPC community for underrepresented groups in the science, information technology, engineering, and mathematics disciplines. The 2008 JEOM Program recruited students through HPCMP program investigators; counselors and professors at colleges and universities around the country; intern and career Web sites; and MSIs, such as tribal colleges, Historically Black Colleges and Universities, and Hispanic-Serving Institutions.

The JEOM Program received more than 250 applications for 36 positions at 11 DoD sites for this 10-week program. Host institutions included:

- Air Force Research Laboratory, WPAFB, OH
- Air Force Research Laboratory, Rome, NY
- Arctic Region Supercomputing Center, Fairbanks, AK
- Army Research Laboratory, Aberdeen, MD
- Army Research Laboratory, Adelphi, MD
- Georgia Institute of Technology, Atlanta, GA
- HPC Modernization Program Office, Lorton, VA
- Iowa State University, Ames, IA
- Maui High Performance Computing Center, Kihei, HI
- Naval Air Warfare Center Aircraft Division, Patuxent River, MD
- Naval Air Warfare Center Weapons Division, China Lake, CA
- Space and Missile Defense Command, Huntsville, AL

The HPCMP sponsored 36 interns, including 8 graduate students, 3 seniors, 11 juniors, 11 sophomores, and 3 freshmen in JEOM internships for the summer. Over 250 applicants applied from several universities, including Harvard, Cornell, Rutgers, Grambling, and Hampton.

JEOM interns assisted work in many areas. The following project descriptions provide a sample of their work: characterization of DNA-derived biopolymer composites to optimize their performance in optoelectronic devices; development of a numerical model for honeycomb composite sandwich panels capable of predicting the mechanical response of beam components during bending loads; creation of a simplified 100X JBI installation that is convenient for a user to follow a basic set of instructions; creation of a new benchmark for the Fast Fourier Transform (FFT) that is quicker than the previous two benchmarks; reduction of random noise within images; optimization of a missile defense scenario; determination of minimum time-to-target path for a simple missile and design of a system of lenses; development of baseline performance tools for various scenarios, including bullet and fragment impact against confined warheads and rocket motors using HPC assets to track changes in performance (improvements); writing a parallel program in FORTRAN using Message-Passing Interface (MPI) for the General Cartesian Mesh Flow Solver; determine if the amount of transmission loss can be estimated using reverberation plots; and model and solve electromagnetism problems using computational methods.

JEOM Summer Colloquium

The JEOM Summer Colloquium for the interns is designed as a "seminar for success" for the interns. This year, the three-day workshop was held in Seattle, WA from 9–11 July 2008. Interns received an introduction to high performance computing, the HPCMP, and listened to technical talks from leaders in their fields, mentoring and ethics in research. JEOM interns also attended the HPCMP UGC from 14–17 July 2008. The UGC was the capstone to the Colloquium.

The JEOM Summer Colloquium promotes interns' professional development as scientists, engineers and researchers to build a successful career within the DoD RDT&E community. The following speakers discussed a variety of topics, including: Introduction to High Performance Computing Modernization Program; Women and Minorities in Information Technology; High Performance Computing in Test and Evaluation; HPC Research; Aeromechanics and Computational Fluid Dynamics; Science and Technology within the DoD HPC Community; Building Enzymes from Scratch; Dr. Rajiv Berry, Introduction to Computational Science; and The Application of Computational Science and High Performance Computing to the Design of DoD Systems.

University Workshops

In FY 2008, students and faculty attended one of two HPCMP-sponsored workshops:

- Computational Science Workshop for Underrepresented Groups
- Computational Science and Engineering Workshop

The Computational Science Workshop for Underrepresented Groups at the University of Southern California (USC) in May 2008 provided hands-on learning experiences including building systems, networking clusters, programming languages, and libraries. The institute provided work experience and an introduction to the DoD supercomputers and applications, to train STEM students and faculty from HBCUs and MSIs and build an awareness about computational science methods in STEM disciplines. In FY 2008, this workshop took place at USC for faculty and students from North Carolina Agricultural & Technical University (NCA&T), the only historically black university that offers a doctoral degree in computational science.

The Computational Science and Engineering Workshop provided education for faculty from HBCUs and MSIs at NCA&T in June 2008. The overall scope of this workshop was to provide faculty hands-on training and exposure to computational science and engineering and high performance parallel scalable computing. Approximately 20 faculty members attended the workshop for professional development to listen to presentations on Unix/Linux operating systems; programming for HPC; parallel programming methodologies and models; large-scale data analysis; and scientific visualization.

National Defense Science and Engineering (NDSEG) Fellowship Program

In FY 2003, the HPCMP joined the NDSEG Fellowship Program and, in FY 2004, began providing fellowships to students interested in employing high performance computing defense-related science and engineering disciplines. The NDSEG provides the US with a highly trained workforce to tackle state-of-the-art research projects in disciplines meeting the greatest payoff to national defense requirements. The HPCMP focuses on helping students interested in the breadth of disciplines related to computational science and engineering.

Between FY 2003-2008, the HPCMP supported 30 fellowships through the NDSEG program, and continues to sponsor approximately 10 new fellows every year. Participating host institutions vary from year-to-year. In addition, these students were invited to attend the 2008 UGC. Several fellows are highly involved in working with DoD scientists and engineers and attended the FY 2008 UGC's plenary sessions and presented posters of their work at the 2008 UGC (Refer to UGC section). In FY 2008, the HPCMP sponsored 10 new students from the following disciplines: computer sciences, biological sciences, mechanical engineering, and electrical engineering.

DoD Institutes for Higher Learning Program—Cadet and Midshipmen Summer Projects

The High Performance Computing at DoD's Institutions of Higher Learning Program was established by the DUSD(S&T) in 2001. Its goal is to provide HPC opportunities to DoD Service academies and institutions of higher learning in order to prepare our future military leaders to excel in tomorrow's technologically complex world. Specifically, the HPCMP:

- Provides high performance computing systems for DoD educational institutions. (These systems are those retired from the DSRCs.)
- Creates opportunities for faculty and students of these institutions to participate in off-site research, including summer research programs at laboratories and test centers where computational research is performed.
- Enables faculty and student participation in technical symposia sponsored by the HPCMP, including its annual DoD Users Conference.
- Provides specialized training in high performance computing topics at DoD educational institutions.

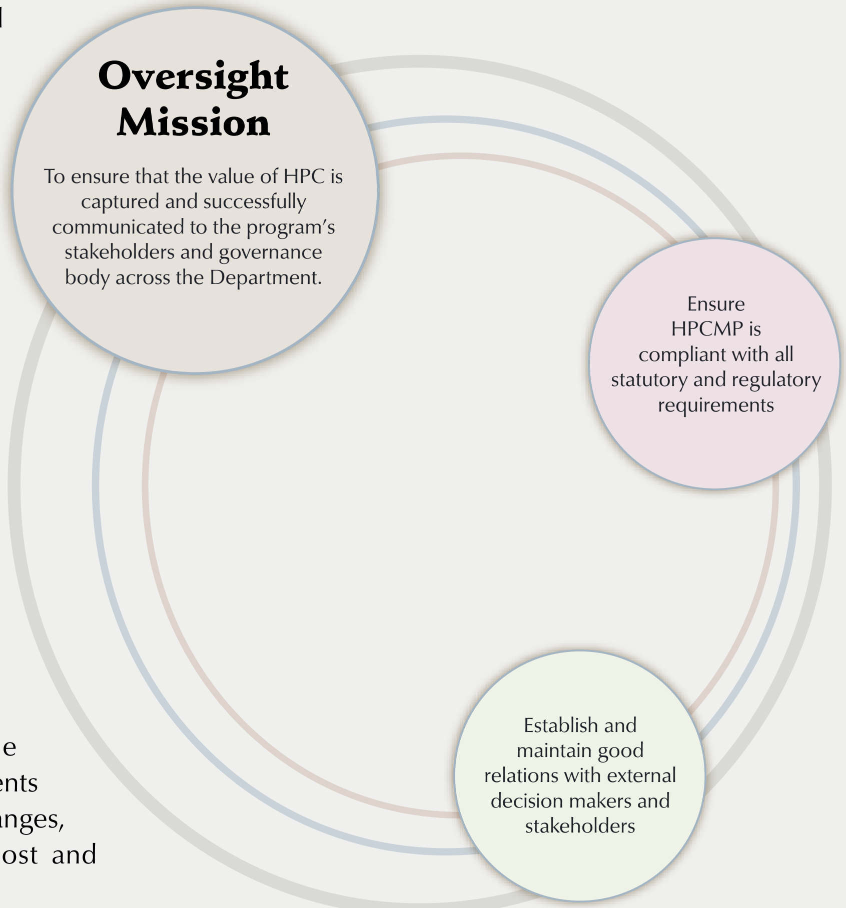
In FY 2008, the HPCMP sponsored 18 academy faculty members, cadets, and midshipmen working 13 projects submitted by the DoD laboratories and test centers. Faculty and students participated in the FY 2008 UGC and several students gave presentations at other scientific and technical forums. Host institutions included:

- Army Engineering Research and Development Center, Information Technology Laboratory, Vicksburg, MS
- Maui High Performance Computing Center, HI
- Naval Postgraduate School, Monterey, CA
- Opposing Forces (OPFOR) Tech Unit, Aviation & Foreign Systems Division, Warfighter Directorate, Aberdeen Test Center, Aberdeen Proving Ground, MD

Cadets and midshipmen assisted work in the following areas, as a sample: Computer Security; Computer Graphics and Visualization; Playstation 3 Cluster; Multicore Programming Using the Playstation 3; Parallel Monte Carlo Atmospheric Radiative Transfer Code; General Test Support with OPFOR Tech Unit; High Resolution Simulations of Aero-optical Flow Fields; Flow Control Using Atmospheric Plasmas; High Resolution Simulation of Full Aircraft Stability and Control; Special Physics Projects; and Effect of Targeting Pod on F-18C Flowfields.

Oversight

The goal of HPCMP Oversight is to ensure the HPCMP meets DoD guidelines and provide guidance for improvement to Program decision-makers. The highest level body responsible for oversight of HPCMP is the Overarching Integrated Product Team Configuration Steering/Configuration Steering Board (OIPT/CSB) chaired jointly by Deputy Director of Defense (Science and Technolgy) [DUSD(S&T)] and Assistant Secretary of Defense, Networks and Information Integration ASD(NII). HPCMP Oversight gathers data and provides the HPCMP performance information for the annual metrics established by the OIPT/CSB. This data, which is obtained through stakeholder surveys and from HPCMP operational databases, is used not only by the OIPT/CSB for Program oversight, but also by HPCMP decision makers for continuous improvement of the Program.



HPCMP Metrics Reporting

In Feb 2008, the OIPT/CSB/High Performance Computing Advisory Panel (HPCAP) discussed an overview of the Program, status of CREATE, and established metrics, thresholds, and objectives for the following year. During the meeting, the OIPT/CSB/HPCAP reviewed all requirements and significant technical configuration changes, which have the potential to result in cost and schedule impacts to the Program.

Metrics include objective, thresholds, and achievements from all facets of the HPCMP: DREN, Program Security, HPC Centers, Contracts/Procurement, HPC Software Applications Support, and Resource Management/System Utilization Tracking. The FY 2008 HPCMP metrics, with results that show the high achievement record of the HPCMP, are shown on the next page.

Output/Outcome Measure	Objective	Threshold	Achieved
Defense Research and Engineering Network (DREN)			
Total aggregate bandwidth delivered to the user community	29 Gbps	25.9 Gbps	30.6 Gbps
Customer Satisfaction: Users/Customers rating DREN (on 1–5 scale)	5	3	4
Program Security			
Number of annual Comprehensive Security Assessments completed	MSRCs & ADCs yearly; new SDREN 100%	DoD guidelines (once every three years or major configuration change)	100%
Cat 1 & Cat 2 security incidents on HPC resources as percent of total number of events	0	30 incidents or 0.0002%	0 Cat 1 and 2 Cat 2
High Performance Computing (HPC) Centers			
Value Metric (Sum of work accomplished weighted by importance of work) – Operational utility metric (Habu Equivalent-years)	75% increase	25% increase	107%
HPCMP system availability	98%	96%	97%
Customer Satisfaction: Users rating HPC Centers (on 1–5 scale)	5	3	3.8
Contracts/Procurement			
Acquire the best commercially available high-end HPC capability – Procurement effectiveness metric (Habu Equivalent-years)	75% increase over previous year	25% increase over previous year	49%
Acquire (including Congressional Adds) the best commercially available high-end HPC capability (Habu Equivalent-years)	75% increase over previous year	25% increase over previous year	64%
Provide (including Congressional Adds) the best commercially available high-end HPC capability (Habu Equivalent-years)	75% increase over previous year	25% increase over previous year	69.50%
Customer Satisfaction: Users rating HPC systems (on 1–5 scale)	5	3	3.8
HPC Software Applications Support			
Percent of successful annual Institute evaluations accomplished	100%	80%	100%
Percent of successful Software Portfolio Alpha/Beta tests accomplished	100%	80%	100%
*Number of acquisition programs introduced to CREATE tools	—	—	5
*Number of acquisition programs continuing to use CREATE tools	—	—	—
Customer Satisfaction: Impact of HPC Software to RDT&E (on 1–5 scale)	5	3	4.4
Resource Management/System Utilization Tracking			
Percent of non-real-time system requirements satisfied	75%	25%	50%
Percent of real-time system requirements satisfied	50%	15%	17%
Number of Challenge Project reallocations	3	1	3
HPCMP Impact Examples			
Customer Satisfaction: Users/RDT&E activities rating HPCMP (on 1–5 scale)	5	3	4.1

*On 12 February 2009, the CSB/OIPT/HPCAP proposed these two output/outcome measures. The HPCAP will report this data in FY 2009.

Satisfaction Surveys

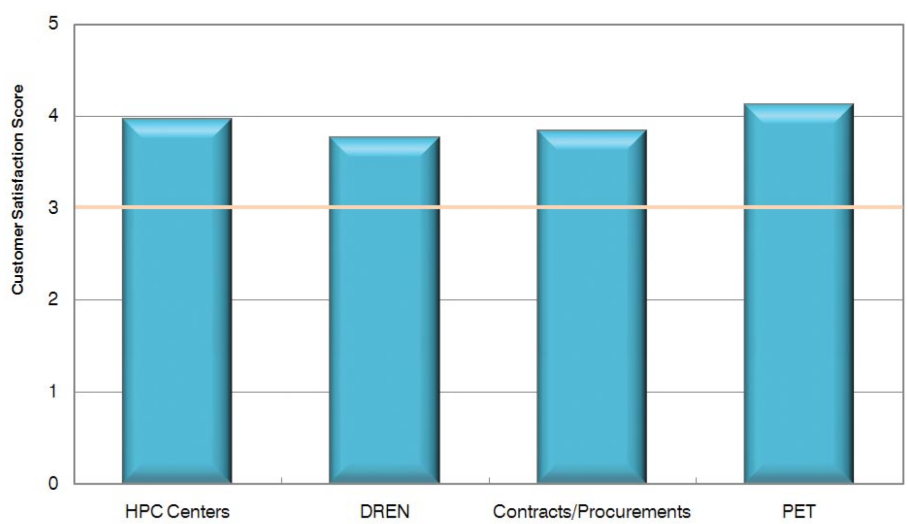
Customer User Satisfaction Survey (C-USS)

The Customer User Satisfaction Survey (C-USS) provides feedback from the user community to support the ongoing operational assessment of the HPCMP. The HPCMPO conducts user surveys as an aid in major decision-making to distribute resources and continually improve the HPC investments. Additionally, the HPCMPO reports survey results to DUSD(S&T) and OASD(NII).

Each year, one third of the total users of the HPCMP are surveyed. In 2008, there were over 1,434 users and 3,963 active accounts. The Oversight component collected information for the C-USS between 25 March and 25 April 2008. The survey was distributed to 579 users and the HPCMP received 269 responses, 43 percent participation, giving the Program a 97 percent confidence level with a +/- 5% margin of error.

C-USS Highlights

Survey results provided insight and suggestions to meet HPC customer needs. Questions in the following areas, such as DREN and HPC Centers, provide the Program with an assessment of current performance and target opportunities for improving customer product delivery. In the following graph, the threshold for all areas is 3.0.

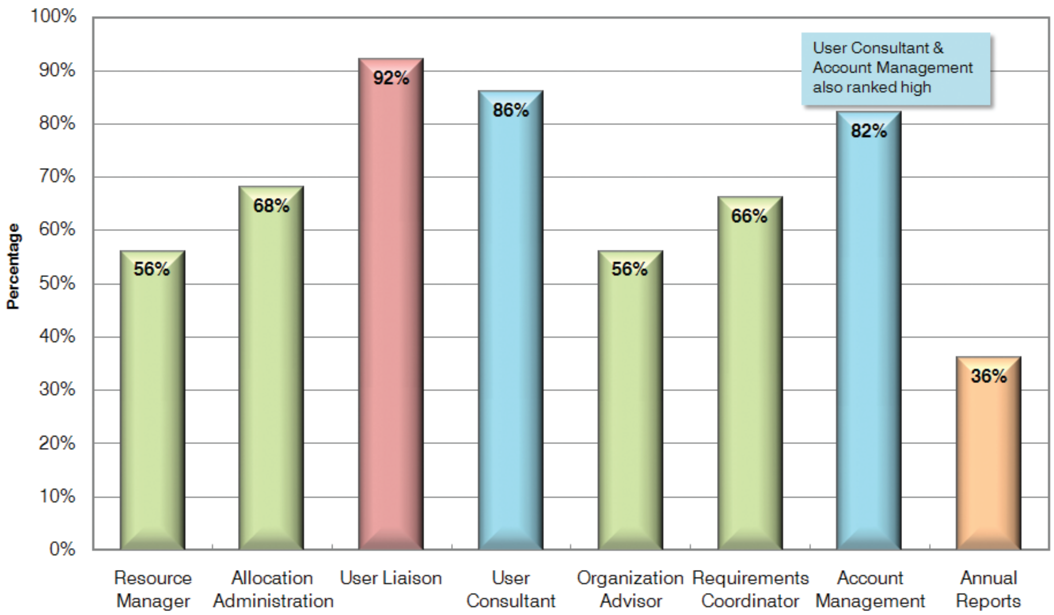


2008 C-USS Results

S/AAA Survey

The HPCMP community includes approximately 100 Service/Agency approval Authority (S/AAA) to represent every organization. The role of the S/AAA is essential to providing the computational resources to DoD scientists and engineers. The S/AAA serves as the liaison between the Program and the user. They allocate Service/Agency controlled CPU hours on HPCMP systems; provide day-to-day linkage with customer organizations; the HPCMP and other S/AAAs; ensure Project Leaders and authorized users are performing work in support of DoD; implement requirements surveys; resource allocation; resource monitoring and resource reallocation; and provide guidance to users on which HPC assets are appropriate for their projects.

The S/AAA survey is administered every other year, including FY 2008. In FY 2008, 56 of 100 S/AAAs participated in this survey. S/AAA respondents with two or more years S/AAA experience made up 76 percent. S/AAA respondents with one to two years S/AAA experience made up 16 percent, while S/AAA respondents with less than one year S/AAA experience made up 8 percent. Overall, the S/AAA's were very satisfied with the workshops, their role, and all aspects of the duties as an S/AAA.



S/AAA Survey Results

Appendix

Continuing FY 2008 Challenge Projects

Computational Chemistry Modeling of the Atmospheric Fate of Toxic Industrial Compounds

Project Leaders: Steven Bunte and Margaret Hurley (ARL) and David Curran (AFTAC)

Sponsor: Army

This project used state-of-the-art computational quantum chemistry/quantum dynamics models to compute rate constants of compounds in the atmosphere. The addition of finite chemistry will result in the improved models, resulting in a more realistic representation of the contamination zone.

Computational Simulations of Combustion Chamber Dynamics and Hypergolic Propellant Chemistry for Selectable Thrust Liquid/Gel Rocket Engines

Project Leader: Michael Nusca (ARL)

Sponsor: Army

The project applied high performance computing to accelerate the development of hypergolic propulsion systems (one that employs a pumpable liquid or gel fuel and a pumpable oxidizer that ignites spontaneously when mixed at ambient temperatures and pressures for tactical missiles). Computational fluid dynamics was employed to model the chemically reacting flow within a system's combustion chamber, and computational chemistry is employed to characterize propellant physical and reactive properties. The US Army will use the project's results to develop the Impinging Stream Vortex Engine (ISVE) for tactical missile applications.

DARPA Underwater Express

Project Leader: Robert Kunz, Pennsylvania State University

Sponsor: Office of Naval Research

The project presented several large scale multiphase Navier-Stokes simulations of flows of relevance to the Defense Advanced Research Projects Agency (DARPA) Underwater Express Program. The project explored the role of free-surface proximity to the physics and performance of high speed supercavitating vehicle components under the DARPA Underwater Express Program.

Decision Support for Seismic and Acoustic Sensors in Urban Terrain

Project Leader: Stephen Ketcham, (ERDC)

Sponsor: Army

This project highlighted statistical scattering measures from high-performance computations of urban sound propagation and concluded that these wave-field measures, which are impractical to obtain experimentally, provide a unique understanding of urban sound scattering and produce information that can be readily integrated into sensor-placement decision-support tools.

Direct Numerical Simulations of Active Control for Low-Pressure Turbine Blades

Project Leader: Hermann Fasel, University of Arizona

Sponsor: Air Force Office of Scientific Research

One of our objectives for FY 2008 was to continue controlled and uncontrolled flow simulations to obtain better averaged data and converged turbulent statistics. The turbulent statistics allow a comparison with experimental data assessment of the physical grid resolution. The DoD can drastically improve efficiency of jet engines, increase reduction in engine component weight, and increase range of flight vehicles.

Direct Quantum Mechanical Simulations of Shocked Energetic Materials Supporting Future Force Insensitive Munitions (IM) Requirements

Project Leader: William Mattson (ARL)

Sponsor: Army

This project provides a quantum mechanical characterization of the properties and behavior of shocked energetic materials under a variety of initiating conditions. This work will provide critical information that supports DoD Insensitive Munitions initiatives and the need for multi-purpose energetics for Urban Operations.

Integrated Analysis of Scramjet Flowpath with Innovative Inlets

Project Leader: Datta Gaitonde (AFRL)

Sponsor: Air Force

During the second year of this effort, the project employed combustion simulations to provide significant insight into the relative impact of flow distortion arising in different inlet designs. The results represent a high-fidelity effort to employ simulations to guide the development of high-speed vehicles capable of survivable atmospheric (air-breathing) flight, facilitating conventional munitions strike with adaptive target selection, including ability to plan en route to the mission.

Continuing FY 2008 Challenge Projects

Integration of Simulation and Test for Strike Aircraft Design and Development

Project Leader: Bradford Green, NAVAIR

Sponsor: Navy

This project intends to improve the performance of the aircraft by focusing on flow control to attach the boundary layer on the wing and increase lift on the aircraft at low speeds. Two wind-tunnel tests provide wind-tunnel data for comparison of the CFD results. CFD can assist the DoD in providing estimates of the impact of changes on aircraft forces and moments.

Large-Scale Deterministic Predictions of Nonlinear Ocean Wave-Fields

Project Leader: Dick K.P. Yue, Massachusetts Institute of Technology

Sponsor: Office of Naval Research

Using the direct simulation capability, the project investigated the statistics of the nonlinear wavefield. By comparing the results with the field measurements, our model showed to be a reliable and useful tool capable of predicting the key characteristics of nonlinear ocean surface wavefields. An accurate spatial-temporal prediction of large-scale ocean wavefields is essential for environmental input to the design and operation of Navy ships.

Modeling of Mine Countermeasure Dart Dispense: Multiple-Body Six Degree-of-Freedom (6-DOF) Computational Fluid Dynamics (CFD) with Collisions

Project Leader: Gary Prybyla (NSWC)

Sponsor: Navy

To support the development and evaluation of dart dispense concepts, the project developed a set of computational tools to accurately predict the dispersion pattern, velocities, and orientations of darts. The Navy and Marine Corps will use the capability to rapidly clear mines in the surf-zone and beach-zone regions to permit rapid, effective, transition from the sea to land.

Polynitrogen/Nanoaluminum Surface Interactions

Project Leader: Jerry Boatz (AFRL)

Sponsor: Air Force

Investigation of the interactions of energetic high-nitrogen compounds with ultrafine or nanophase aluminum particles is a topic of current DoD interest with potential applications in rocket and missile propulsion. The project examined first-principles density functional theory (DFT) calculations using the generalized gradient approximation (GGA) to study the adsorption of a series of all-nitrogen and high-nitrogen compounds of increasing sizes and complexity. The overall impact of the proposed work is cost effective and gains more reliable access to space via development of advanced energetic materials for rocket propulsion applications.

Signature Evaluation for Thermal Infrared Countermine and IED Detection Systems

Project Leader: John Peters (ERDC)

Sponsor: Army

The results of the simulations were used to determine the optimal times of day for thermal imagery based on using relative automated target recognition (ATR) performance as an objective measure and later confirmed in field tests. The DoD can use sensor simulations to optimize mission parameters and reduce false alarms from ATR algorithms.

Unsteady, Multidisciplinary Rotorcraft Simulations for Interactional Aerodynamics

Project Leader: Mark Potsdam (ARDEC)

Sponsor: Army

The project used state-of-the-art, large-scale, parallel, moving body computations to view flow field interactions on complete aircraft geometries, leading to possible investigation of adverse phenomena and aircraft performance. Current DoD weapons systems will benefit directly from this work, including the MH-47 Chinook and UH-60 Blackhawk. Both exhibit complex, 3-D, interactional aerodynamics.

Continuing FY 2008 DHPIs

Advanced LINUX Cluster Optimized to Support the Interactive Joint Futures Laboratory

Project Leader: Jack Wagner, JFCOM/J7 & J9, Suffolk, VA

Sponsor: JFCOM

This uniquely configured 256-node Linux cluster, with a General Purpose GPU on each 4-core node, enables JFCOM to model urban battlespaces with 10M independent agents, providing a cost-effective and socially-acceptable way to look at the use of new tactics and sensors for future conflicts in urban areas.

Automated Generation of Nomografs for Urban Chemical Dispersion Scenarios

Project Leader: Jay Boris, NRL, Washington, DC

Sponsor: Navy

This project allows real-time analysis of urban chemical dispersion through the prior calculation of events under many different conditions in order provide a database of possibilities providing live, near CFD-quality results instantly in a crisis for any complex geometry region.

Joint Ensemble Forecast System, AFWA, Offutt AFB, NE and FNMOC, Monterey, CA

Project Leader: Capt. Tim Nobis, AFWA, Offutt AFB, NE and Michael Sestak, FNMOC, Monterey, CA

Sponsor: Air Force and Navy

This project provides accurate meteorological and oceanographic intelligence to air, ground and fleet decision-makers to facilitate a more realistic evaluation of the potential environmental impact of weather on combat operations.

HPC Upgrade of the Joint Warfare Systems Server

Project Leader: Al Sweetser, OSD(PA&E), Washington, DC

Sponsor: OSD

This project supports campaign-level analysis, combining asset mobility, theater logistics, and joint service warfighting, to provide a robust simulation of complex military scenarios.

PS3 Cluster for Neuromorphic Computing

Project Leader: Richard Linderman, AFRL/RI, Rome, NY

Sponsor: Air Force

This project provides cell-based computing via a cluster of 336 PS3 gaming consoles. Applications benefiting from the >10X $/performance advantage of this system include: 1) large scale simulations of neuromorphic models, 2) GOTCHA radar video SAR for wide-area persistent surveillance, and 3) real-time PCID image enhancement for space situational awareness.

Publications

UGC 2008 Papers

Computational Fluid Dynamics (CFD)

A New Approach to Streambed Modeling and Simulation Using Computational Fluid Dynamics, J. Allen, D. Smith, O. Eslinger, and M. Valenciano

Active Separation Control for Lifting Surfaces at Low-Reynolds Number Operating Conditions, A. Gross, W. Balzer, and H.F. Fasel

An Undergraduate Computational Aerodynamics Curriculum, K. Bergeron, R. Cummings, D. McDaniel, Capt R. Decker, Maj J. Freeman, Capt C. Hoke, J. Seidel, and S. Morton

Free-Surface Proximity Effects in Developed and Super-Cavitation, M. Kinzel, J. Lindau, and R. Kunz

High-Fidelity Computations of Moving and Flexible Wing Sections with Application to Micro Air Vehicles, R. Gordnier, M. Visbal, and M. Galbraith

High-Resolution Simulations of Nonlinear Internal Gravity Waves in the South China Sea, O. Fringer and Z. Zhang

Modeling of Mine Countermeasure Dart Dispense, G. Prybyla, M. Neaves, and W. Dietz

Numerical Investigation of Internal and External Three-Dimensional Flow Separation, A. Gross, R. Jacobi, S. Wernz, and H.F. Fasel

Numerical Simulation of Non-Resonant Cavity Flow, C. Wagner and S. Slimon

Ocean Wave Prediction Using Large-Scale Phase-Resolved Computations, W. Xiao, L. Henry, Y. Liu, K. Hendrickson, and D.K.P. Yue

Prediction of High-Amplitude Forces During Propeller Crashback, P. Chang, III, M. Ebert, J. Shipman, and K. Mahesh

The High Speed Sea Lift (HSSL) Ships Challenge Effort, J. Gorski, R. Miller, P. Carrica, M. Kandasamy, and F. Stern

Multi-Physics (CFD, CSM, CCM, Plasma Physics)

Application of 3-D, Unsteady Navier-Stokes Simulation to Chemical Oxygen-Iodine Laser Technology Development, T. Madden

Characterization of Hot-Wire Detonators Using Analytical Modeling and Computational Tools, M. Lambrecht, C. Baum, E. Schamiloglu, and K. Cartwright

Combustion Chamber Fluid Dynamics and Hypergolic Gel Propellant Chemistry Simulations for Selectable Thrust Rocket Engines, M. Nusca, C-C. Chen, and M. McQuaid

Comparisons of Two-Fluid Plasma Models, B. Srinivasan and U. Shumlak

Fast and Reliable Solution of GDoF-Problems on NAVO/BABBAGE and AFRL/HAWK Systems, S. Fawaz and B. Andersson

Generation of Aerodynamic Coefficients using Time-Accurate CFD and Virtual Fly-Out Simulations, J. Sahu, S. Silton, J. DeSpirito, K. Heavey, and M. Costello

Integrated Analysis of Scramjet Flowpath with Innovative Inlets, D. Gaitonde, F.J. Malo-Molina, H. Ebrahimi, and D. Risha

MHD Turbulence Studies Using Lattice Boltzmann Algorithms-Physical Simulations Using 9,000 Cores on the Air Force Research Laboratory HAWK Supercomputer, G. Vahala, J. Yepez, M. Soe, L. Vahala, J. Carter, and S. Ziegler

Multidisciplinary Modeling of the CH-47 Helicopter with CFD/CSD Coupling and Trim, A. Dimanlig, H-A. Saberi, E. Meadowcroft, R. Strawn, and M. Bagwhat

Regions of Validity for the 10-Moment, Two Fluid Plasma Model, R. Lilly and U. Shumlak

Virtual Prototyping of Directed Energy Weapons, M.T. Bettencourt, K.L. Cartwright, A.D. Greenwood, T.P. Fleming, M.D. Haworth, N.P. Lockwood, and P.J. Mardahl

Vulnerability of Structures to Weapons Effects, J. Baylot, S. Akers, J. O'Daniel, B. Armstrong, and R. Weed

Computational Chemistry and Materials Science (CCM)

Ab-Initio Molecular Dynamics Simulations of Molten Ni-Based Superalloys, C. Woodward, M. Asta, D. Trinkle, J. Lill, and S. Angioletti-Uberti

Calculations of Lithium+ Carborane Complexes, J. Vacek, J. Chocholousova, and J. Michl

Critical Carbon Nanotube Length in Fibers, C.F. Cornwell, D. Majure, R. Haskins, N.J. Lee, R. Ebeling, R. Maier, C. Marsh, A. Bednar, R. Kirgan, and C.R. Welch

Crystal Structures from Nonempirical Force Fields, R. Podeszwa, B. Rice, F. Rob, and K. Szalewicz

Direct Quantum Mechanical Simulations of Shocked Energetic Materials Supporting Future Force Insensitive Munitions (IM) Requirements, W. Mattson, R. Balu, and B. Rice

Design of Energetic Ionic Liquids, J. Boatz, M. Gordon, G. Voth, and S Hammes-Schiffer

Large-Scale Atomic/Molecular Massively Parallel Simulator (LAMMPS) Simulations of the Effects of Chirality and Diameter on the Pullout Force in a Carbon Nanotube Bundle, D.L. Majure, R.W. Haskins, N.J. Lee, R.M. Ebeling, R.S. Maier, C.P. Marsh, A.J. Bednar, R.A. Kirgan, C.R. Welch, and C.F. Cornwell

Membrane Insertion Profiles of Peptides Probed by Molecular Dynamics Simulations, I-C. Yeh, M. Olson, M. Lee, and A. Wallqvist

Modeling of Materials for Naval SONAR, Pollution Control and Nonvolatile Memory Application, J. Bennett, I. Grinberg, Y-H. Shin, and A.M. Rappe

Multiscale Simulations of High Performance Capacitors and Nanoelectronic Devices, J. Bernholc, J. Jiang, V. Ranjan, L. Yu, M. Buongiorno Nardelli, and W. Lu

Novel Mechanism for the Dissociation of H_2O and the Diffusion of O and H Along the Al_2O_3 (0001) Surface, J. Synowczynski, J. Andzelm, and D. Vlachos

Performance of DFT Methods in the Calculation of Optical Spectra of

Chromophores, J. Andzelm, A. Rawlett, J. Dougherty, N. Govind, and R. Baer

PIPA: A High-Throughput Pipeline for Protein Function Annotation, C. Yu, V. Desai, N. Zavaljevski, and J. Reifman

Polynitrogen/Nanoaluminum Surface Interactions, J. Boatz and D. Sorescu

Structure and Dynamics of Squalane Films on Solid Surfaces, M. Tsige and S. Patnaik

Climate/Weather/Ocean Modeling and Simulation (CWO)

Dedicated High Performance Computer Project Investment (DHPI) for the Fleet Numerical/Air Force Weather Agency - The Navy Side, M. Sestak, C. Bishop, T. Holt, J. Nachamkin, S. Chen, J. McLay, and J. Doyle

High-Resolution Simulations and Atmospheric Turbulence Forecasting, J. Werne, D. Fritts, L. Wang, T. Lund, and K. Wan

Multi-Scale Predictability of High-Impact Upper Tropospheric Ice Clouds for Air Force Platforms, A. Mahalov

Multi-scale Predictability of High-Impact Weather in the Battlespace Environment, J. Doyle, C. Reynolds, C. Bishop, J. Goerss, T. Holt, and J. McLay

Numerical Exploration of the Stable Atmospheric Boundary Layer, B. MacCall, P. Haines, E. Measure, D. Marlin, W-Y. Sun, W-R. Hsu, and D. Grove

Towards the Development of an Operational Mesoscale Ensemble System for the DoD Using the WRF-ARW Model, T. Nobis, E. Kuchera, S. Rentschler, S. Rugg, J. Cunningham, C. Synder, and J. Hacker

Use of HPC to Provide Operational Mesoscale Meteorological Support for ATEC Test Ranges, J. Pace, E. Astling, S. Halvorson, Y. Liu, T. Betancourt, J. Hacker, J. Knievel, S. Swerdlin, and T. Warner

Wave Information Studies (WIS) Pacific Regional Hindcast, B. Tracy and D. Spindler

Signal/Image Processing (SIP) and Sensors; Electronics, Networking, and Systems/C4ISR (ENS) and Testing

Comparison of Turbo Decoder and Packet Acquisition Error Rates in Frequency-Hop Spread-Spectrum-Systems in Partial-Band Interference, E. Huang and F. Block

Development of Biological Warfare Sensors Using High Performance Computer Systems, M. Lanzagorta, J. Eversole, and W. Anderson

Improved Parallel 3D FDTD Simulator for Photonic Crystal, J. Ayubi-Moak, S. Goodnick, D. Stanzione, G. Speyer, and P. Sotirelis

PVTOL: Providing Productivity, Performance, and Portability to DoD Signal Processing Applications on Multicore Processors, H. Kim, E. Rutledge, S. Sacco, S. Mohindra, M. Marzilli, J. Kepner, R. Haney, J. Daly, and N. Bliss

Scattering of Seismic Waves by Shallow Building Foundations Using High-Order FEM, M. Parker, S. Ketcham, and S. Dey

Scattering of Urban Sound Energy from High-Performance Computations, S. Ketcham, M. Parker, H. Cudney, and D.K. Wilson

Signature Evaluation for Thermal Infrared Countermine and IED Detection Systems, J. Peters, S. Howington, O. Eslinger, J. Fairley, J. Ballard, R. Goodson, and V. Carpenter

Validating Simulations of Acoustic Propagation in Complex Terrain, H. Cudney, S. Ketcham, D. Albert, and M. Parker

Software and Hardware Infrastructure

Asymmetric Core Computing, J. Clarke, D. Shires, J. Vines, and E. Mark

Coprocessor Computing with FPGA and GPU, S.J. Park, D. Shires, and B. Henz

HPCC Support to Campaign Level Analysis “HPCC Solving the Problem”, S. Barnes, LTC J. Crino, and LtCol T. Smetek

Improvements to Multiple Path Secure Copy, B. Guilfoos, L. Humphrey, and J. Unpingco

Real-Time Hardware-in-the-Loop Testing with Common Simulation Framework, J. Gardiner

The Computational Science Environment (CSE), J. Renteria and E. Mark

User Friendly High Productivity Computational Workflows Using the VISION/HPC Prototype, J. Unpingco

Using Mitrion-C to Implement Floating-Point Arithmetic on a Cray XD1 Supercomputer, K. Liu, C. Cameron, and A. Sarkady

Visualization of Time-Varying Features, M.J. Mohammadi-Aragh, S. Ziegeler, J. Martin, and R. Moorhead

Software Performance and Performance Modeling

Enabling High Productivity Computing Through Virtualization, J.C. Chaves

High Performance Information Management for HPC Parallel Computing, G. Ramseyer, S. Emeny, D. Fitzgerald, R. Linderman, S. Tucker, and S. Spetka

High Productivity Languages for Parallel Programming Compared to MPI, S. Spetka, H. Hadzimujic, S. Peek, and C. Flynn

Improving Parallel Code Performance for Systems with Dual-Core Processors, S. Emeny, S. Spetka, G. Ramseyer, and R. Linderman

Modeling Mixtures of Different Mass Ultracold Atoms in Optical Lattices: An Illustration of High Efficiency and Linear Scaling on the Cray XT4 via a Capability Applications Project at ERDC, J.K. Freericks

Observing Parallel Phase and I/O Performance Using TAU, S. Shende, A. Malony, A. Morris, and D. Cronk

Optimization and Parallelization of DFT and TDDFT in GAMESS on DoD HPC Machines, M. Lasinski, N. Romero, A. Yau, G Kedziora, J-P. Blaudeau, and S. Brown

Performance Evaluation of the Multi-Language Helios Rotorcraft Simulation Software, A. Wissink and S. Shende

Performance Modeling and Mapping of Sparse Computations, N. Bliss, S. Mohindra, and U-M. O’Reilly

Computational Methods

A Scalability Study on Multicore Cluster Systems of an AFRL Radar Frequency Tomography Imaging Code Written in MATLAB® for Parallel Execution using Star-P®, B. Elton and K. Magde

Early Experiences with Algorithm Optimizations on Clusters of Playstation 3's, R. Linderman

Exploring New Architectures in Accelerating CFD for Air Force Applications, J. Dongarra, G. Peterson, S. Tomov, J. Allred, V. Natoli, and D. Richie

Multicloud Convergence Acceleration for Complex Applications on Arbitrary Grids, A. Katz and A. Jameson

Paradigms for Parallel Computation, Gil Speyer, Natalie Freed, Richard Akis, and Dan Stanzione

Parallel Implementation of Certain Robust Regression Methods Using Lazy Evaluation in Python, J. Unpingco

Progress in Applying HPC to Support Operational Use of CT-Analyst, G. Patnaik, J. Boris, K. Obenschain, R. Rosenberg W. Anderson, and M. Xu

Some Comparative Benchmarks for Linear Algebra Computations in MATLAB and Scientific Python, J. Unpingco

Task and Conduit Framework for Multi-Core Systems, S. Mohindra, J. Daly, R. Haney, and G. Schrader

Education

Educating the Educator: High Performance Computing Training Workshop for Faculty from Under-Represented and Minority Serving Institutions, R. Mohan, N. Radhakrishnan, A. Kelkar, and V. Thomas

Women and Minorities in Information Technology, V. Ross and V. Thomas

UGC 2008 Poster Presentations

CREATE/HSAI/Portfolio

Computational Research and Engineering Acquisition Tools and Environment, Doug Post and the CREATE Team (K. Hill, D. van Veldhuizen, G. Zelinski, AFRL; S. Arevalo, T. Blacker, D. Fisher, P. Genalis, A. Harris, M. Hurwitz, R. Meakin, P. Bell, HPCMP; C. Atwood)

Computational Research and Engineering Acquisition Tools and Environments (CREATE) - Ships Project, Myles Hurwitz

CREATE-Air Vehicles: A Suite of Scalable Software Products for the Design and Simulation of Next Generation, Robert Meakin

CREATE - RF Antenna Group, David van Veldhuizen

Computational Research and Engineering Acquisition Tools and Environments (CREATE), David Fisher and Richard Kendall

Institute for Maneuverability and Terrain Physics Simulation (IMTPS), David A. Horner

Institute for High Performance Computing Applications in Air Armament (IHAAA), Mark Lutton

HPC Software Applications Institute for Advanced Rotorcraft Modeling and Simulation (HI-ARMS), Rodger Strawn

Institute for Multi-Scale Reactive Modeling, Steven Bunte, Brad E. Forch, Betsy M. Rice, William H. Davis, and Ernest L. Baker

Battlespace Environments Institute: Building the Whole-Earth Infrastructure, Richard A. Allard, Timothy J. Campbell, Sue Chen, Hwai-Ping Cheng, and Jing-Ru C. Cheng

Biotechnology HPC Software Applications Institute, Jaques Reifman

The Air Force Research Laboratory's Directed Energy Directorate, Matthew Bettencourt

High Performance Computing Software Applications Institute for Space Situational Awareness, Chris Sabol, Maj David Strong, and Paul Schumacher

Space Surveillance Network Analysis Model (SSNAM) SP Integration Performance Study, Erika Montgomery, Robert Massey, Kevin Roe, and Tim Payne

Mobile Network Modeling Institute, Raju Namburu, Jerry Clarke, Ananthram Swami, Brian Rivera, and Monica Farah-Stapleton

Insensitive Munitions Portfolio, Stanley DeFisher

Education

New Features Coming to the OKC, Renee Mullinax, Abdul Mohamed, and John Mason

User Training in the User Productivity Enhancement and Technology Transfer (PET) Program, Susan T. Brown

An Undergraduate Computational Aerodynamics Curriculum, Keith Bergeron, Russell Cummings, Dave McDaniel, Capt Robert Decker, Maj Jacob Freeman, Capt Charlie Hoke, Jurgen Seidel, and Scott A. Morton

Science/Technical

Multi-Abstraction Levels in HPC: Enabling Consistency, Integration, and Validation, Thomas D. Gottschalk, Dan M. Davis, and David R. Pratt

Multi-Disciplinary Teams for Large-Scale, Massively-Parallel, Multi-Physics Code Development, Michael Zika

WIS Pacific Regional Hindcast, Barbara Tracy and Deanna Spindler

Implementation of a Real-Time Coastal Ocean Model for the California Current System (RT-NCOMCCS), Sergio deRada, Stephanie Anderson, and Igor Shulman

Predictability of Tropical Cyclones in Global Atmospheric Forecasts, Carolyn Reynolds, Justin G. McLay, James D. Doyle, and James Goerss

Community Portal for Collaborative Research on Tsunamis, Tom Logan, Cherri Pancake, Dylan Keon, and Craig Stephenson

HPM Simulations of a Commercial Magnetron, John D. Keisling

Hybrid Partitioned Layer Movement Method for Fluid-Structure Interaction, Young-Ho Kim, Jong-Eun Kim, Riy Koomullil, and Bharat Soni

Regions of Validity for the 10-Moment, Two Fluid Plasma Model, Robert Lilly and Uri Shumlak

Comparisons of Two-Fluid Plasma Models, Bhuvana Srinivasan and Uri Shumlak

Extending Automated Meshing to Large Multi-Block Domains: Countermine Mesh Generation on HPC Platforms, Owen J. Eslinger and Amanda M. Hines

Incorporation of Detonation Shock Dynamics into CTH, David Littlefield and Young-Ho Kim

Energetics and Warheads Modeling and Simulation, Chuck L. Chin, Stanley DeFisher, and Ernie Baker

Modeling, Inference, and Analysis of Complex Nonlinear Interaction Networks, W. Garrett Jenkinson and John Goutsias

Parallel Implementation of Certain Robust Regression Methods Using Lazy Evaluation in Python, Alan Chalker

Some Comparative Benchmarks for Linear Algebra Computations in MATLAB and Scientific Python, Jose Unpingco

SSH Toolbox for MATLAB: Point and Click HPC Access From the Desktop, Siddharth Samsi, John Nehrbass, Harrison B. Smith, Tanner Suttles, and Andrew Warnock

A Scalability Study on Multicore Cluster Systems of an AFRL Radar Frequency Tomography Imaging Code Written in MATLAB® for Parallel Execution Using Star-P®, Bracy H. Elton and Kevin M. Magde

DREN Internet Protocol version 6 (IPv6) Support for HPC, John M. Baird and Ron Broersma

Comparison of Turbo Decoder and Packet Acquisition Error Rates in Frequency-Hop Spread-Spectrum Systems, Everest W. Huang and Frederick J. Block, IV

Compression of Network Packet Traces to Facilitate Sharing of Security Information, Jean Blaudeau and William Yurcik

Metadata-Based Network Traffic Database Management System Model, Keesook J. Han, Matthew Bentz, Chales George, Christopher Hall, Ross Marullo, and John C. Kieffer

Structure and Dynamics of Liquid Squalane on a Solid Surface, Meslin Tsige and Soumya S. Patnaik

Molecular Dynamics Simulation of the Kinetic Reaction of Ni and Al Nanoparticles, Brian J. Henz, Takumi Hawa, and Michael R. Zachariah

LAMMPS Simulations of the Effects of Chirality and Diameter on Pullout Force in a Carbon Nanotube Bundle, Dustin Majure, Richard Haskins, Robert Maier, Nicholas J. Lee, Robert M. Ebeling, Charles P. Marsh, Anthony Bednar, and Charles C. Cornwell

Novel Mechanism for the Dissociation of H_2O and the Diffusion of O and H Along the αAl_2O_3 (0001) Surface, Jennifer Synowczynski, Jan Andzelm, and Dionisios Vlachos

Calculation of Substituent Effects on CH Acidity of CB11H12-, Jaroslav Vacek, Jana Chocholousova, and Josef Michl

Targeting Jitter: Identification and Reduction of Excess Operating System Noise on Commodity Cluster, Don Bahls and Oralee Nudson

Accelerated Design Space Search Techniques for Computer Experiments on High Performance Computers, Aytekin Gel, Allan Grosvenor, Esma S. Gel, and Murat Kulahci

Improving Parallel Code Performance for HPC Systems with Multi-Core Processors, Scott Spetka, Scot Tucker, Susan Emeny, Dennis Fitzgerald, George Ramseyer, and Richard Linderman

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Compiler Comparisons on ARSC Resources, Edward A. Kornkven, Don Bahls, and Tom Logan

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Presentations

CAC Enabling Your Website, Lee Hinman and Jay Kline

Carriers of Carriers, Ben Eater, Juniper Networks, Federal

Changing the Game - National and DoD Science and Technology Initiatives to Secure Cyberspace, Steven King

Data Protection, Tim Yeager

Defense Research Engineering Network (DREN) Resources Used to Disseminate High Resolution Displays for Missile Defense Agency (MDA) Research Development Test and Evaluation (RDT&E) Events, Ray May

Distributed Data Logging for Analysis, Detection, and Prevention of Network Attacks, John J. Tran and Ke-Thia Yao

DREN CERT/CNDSP, Jeremy Batson and Joe Molnar

DREN Vision, Walt Williams

Effective Security Operations Management, Sunil Bhargava, CTO, Intellitactics, Inc.

HPC CERT South Build Out, Tony George

HPCMP Return on Investment, Danny Weddle

HPCMP Storage Initiatives, Ralph McEldowney

HPWREN Wireless Research Network, Hans-Werner Braun, UCSD

Internet2 Network: Developing and Deploying a Hybrid Optical and Packet Network, Christian Todorov

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Mission Critical Communications - The Role of Video in Next Generation Video Communication for the Warfighter, Michael Coyne

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Securing Today's Networks, Rich Whittney, Juniper Networks, Federal

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The Identification and Demonstration of Advanced Applications and Capabilities for the Department of Veterans Affairs, Steven Pirzchalski, Department of Veteran Affairs

Threat Cell Presentation – HPC CERT North, Tim Dunn

Use of Operations Security (OPSEC) Procedures to Safeguard DoD Networks and Private Industry's Research Data, Joyce Schulte

Acronyms

2D	Two-Dimensional
3D	Three-Dimensional
ABL	Airborne Laser
ACAD	Automated Computer Aided Design
ACM	Association for Computing Machinery
ADA	Atmospheric Decision Aid
ADC	Allocated Distributed Center
AEDC	Arnold Engineering Development Center
AF	Air Force
AFB	Air Force Base
AFDD	Aeroflightdynamics Directorate
AFFTC	Air Force Flight Test Center
AFGROW	Air Force Crack Growth Program
AFOSR	Air Force Office of Scientific Research
AFRL	Air Force Research Laboratory
AFRL/RB	Air Force Research Laboratory, Air Vehicles Directorate
AFRL/RD	Air Force Research Laboratory, Directed Energy Directorate
AFRL/RH	Air Force Research Laboratory, Human Effectiveness Directorate
AFRL/RI	Air Force Research Laboratory, Information Directorate
AFRL/RV	Air Force Research Laboratory, Space Vehicles Directorate
AFRL/RW	Air Force Research Laboratory, Munitions Directorate
AFRL/RX	Air Force Research Laboratory, Materials and Manufacturing Directorate
AFRL/RY	Air Force Research Laboratory, Sensors Directorate
AFRL/RZSP	Air Force Research Laboratory, Space and Missile Directorate, Propulsion Division
AFSEO	Air Force SEEK EAGLE Office
AFWA	Air Force Weather Agency
AHPCRC	Army High Performance Computing Research Center
AMCOM	Army, Aviation and Missile Command
AMOS	Air Force Maui Optical and Supercomputing Site
AMRDEC	Army Aviation and Missile Research Development and Engineering Center
AMSAA	Army Material System Analysis Agency
APB	Acquisition Program Baseline
API	Application Program Interface
ARC	Affiliated Resource Center
ARDEC	Armament Research Development and Engineering Center
ARL	Army Research Laboratory
ARL/WMRD	Army Research Laboratory Weapons and Materials Research Directorate
ARO	Army Research Office
ARSC	Arctic Region Supercomputing Center
ASD(NII)	Assistant Secretary of Defense, Networks and Information Integration
ATFLIR	Advanced Targeting Forward Looking Infrared
ATR	Automatic Target Recognition
AV	Air Vehicles
BEI	Battlespace Environments Institute
BFI	Bullet and Fragment Impacts
BHSAI	Biotechnology HPC Software Applications Institute
BoD	Board of Directors
C4I	Command, Control, Communications, Computers and Intelligence
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance
CAP	Capability Applications Project
CBE	Computationally Based Engineering
CCAC	Consolidated Customer Assistance Center
CCD	Charge Coupled Device
CCM	Computational Chemistry and Materials Science
CDLT	Collaborative and Distance Learning Technologies
CE	Computational Environment
CEA	Computation Electromagnetic and Acoustics
CECOM	Communications Electronics Command
CEM	Computational Electromagnetic
CERT	Computer Emergency Response Team
CFD	Computational Fluid Dynamics
CID	Combat Identification
CNDSP	Computer Network Defense Service Provider
CNMOC	Commander, Naval Oceanography and Meteorological Center
COOP	Continuous Operations Plan
CPU	Central Processing Unit

CREATE	Computational Research and Engineering Acquisition Tools and Environments
CSA	Comprehensive Security Assessment
CSB	Configuration Steering Board
CSE	Computational Support Environment
CSM	Computational Structural Mechanics
CST	Collaborative Simulation and Testing
CTA	Computational Technology Areas
C-USS	Customer-User Satisfaction Survey
CWO	Climate/Weather/Ocean Modeling and Simulation
DAAC	Data Analysis and Assessment Center
DARPA	Defense Advanced Research Projects Agency
DCAA	Defense Contract Audit Agency
DDG	Guided Missile Destroyer
DDR&E	Director of Defense Research and Engineering
DE	Directed Energy
DFT	Density Functional Theory
DHPI	Dedicated HPC Project Investment
DNS	Direct Numerical Simulations
DoD	Department of Defense
DOE	Department of Energy
DOT&E	Director, Operational Test and Evaluation
DPG	Dugway Proving Ground
DREN	Defense Research and Engineering Network
DSRC	DoD Supercomputing Resource Center
DSYMAS	Dynamic Systems Mechanics-Advanced Simulation
DT&E	Developmental Test and Evaluation
DTO	Defense Technology Objectives
DTRA	Defense Threat Reduction Agency
DUSD(S&T)	Deputy Under Secretary of Defense (Science and Technology)
EM	Electromagnetic
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EMS	Energetic Materials
ENS	Electronics, Networking, and Systems/C4I
EOTC	Education, Outreach, and Training Coordination
EQM	Environmental Quality Modeling and Simulation
ERDC	Engineer Research and Development Center
ESM	Enterprise Security Management
ESMF	Earth System Modeling Framework
ET	Enabling Technologies
FCS	Future Combat Systems
FDTD	Finite Difference Time Domain
FEM	Finite Element Method
FFT	Fast Fourier Transform
FLIR	Forward Looking Infrared
FLOPS	FLoating-point OPerations Per Second
FMS	Forces Modeling and Simulation
FY	Fiscal Year
GB	Gigabytes
GCCS	Global Command and Control System
GF	Gigaflop
GIG	Global Information Grid
GPS	Global Positioning System
GSA	General Services Administration
GWOT	Global War On Terror
HBCUs	Historically Black Colleges and Universities
HI-ARMS	HPC Institute for Advanced Rotorcraft Modeling and Simulation
HPAC	Hazard Prediction and Assessment Capability
HPC	High Performance Computing or High Performance Computer
HPCAP	High Performance Computing Advisory Panel
HPCC	High Performance Computing Centers
HPCMP	High Performance Computing Modernization Program
HPCMPO	High Performance Computing Modernization Program Office
HPM	High Power Microwave
HPTi	High Performance Technologies, Incorporated
HYCOM	Hybrid Coordinate Ocean Model
ICD	Initial Capabilities Document
IHAAA	Institute for HPC Applications to Air Armament
IED	Improvised Explosive Devices
IEEE	Institute of Electrical and Electronics Engineers
IHDE	Integrated Hydrodynamics Design Environment
ILM	Information Lifecycle Management
IM	Insensitive Munitions
IMT	Integrated Modeling and Test Environments
IMTPS	Institute for Maneuverability and Terrain Physics Simulation
I/O	Input/Output
IP	Internet Protocol
I-SSA	Institute for Space Situational Awareness

JEOM	Joint Educational Opportunities for Minorities
JET	Joint Engineering Team
JFCOM	Joint Forces Command
JHL	Joint Heavy Lifting
JITC	Joint Interoperability Test Command
JML	Joint Model Library
JSF	Joint Strike Fighter
J-UCAS	Joint Unmanned Combat Air Systems
JWCO	Joint Warfighting Capability Objective
KE	Kinetic Energy
KEI	Kinetic Energy Interceptor
LAN	Local Area Network
LCO	Limit Cycle Oscillation
LCS	Littoral Combat Ship
LEAPS	Leading Edge Advanced Prototyping for Systems
LES	Large Eddy Simulations
LHA	Amphibious Assault Ship-Tarawa Class
LHD	Amphibious Assault Ship-Wasp Class
LLNL	Lawrence Livermore National Laboratory
LSN	Large Scale Network
M&S	Modeling and Simulation
MAGIC	Meshing and Geometry Innovation Collaboration
MAV	Micro Air Vehicles
MDA	Missile Defense Agency
MDAP	Major Defense Acquisition Program
MFT	Multiphase Flow Target Response
MFS	Manned Flight Simulator
MHD	Magnetohydrodynamics
MHPCC	Maui High Performance Computing Center
MIT	Massachusetts Institute of Technology
MNMI	Mobile Network Modeling Institute
MOA	Memorandum of Agreement
MOS	Mississippi and Ohio State University
MPI	Message Passing Interface
MRAP	Mine Resistant Ambush Protected
MSI	Minority Serving Institution
MSRC	Major Shared Resource Center
MSRM-IM	Multi-Scale Reactive Modeling and Simulation of Insensitive Munitions
MTBF	Mean Time Between Failures
NASA	National Aeronautics and Space Administration
NAVAIR	Naval Air Systems Command
NAVO	Naval Oceanographic Office
NAVSEA	Naval Sea Systems Command
NAWC	Naval Air Warfare Center
NCA&T	North Carolina Agricultural and Technical University
NDSEG	National Defense Science and Engineering
NDU	National Defense University
NGTS	Next Generation Technical Services
NOC	Network Operation Center
NOGAPS	Navy Operational Global Atmospheric Prediction System
NRL	Naval Research Laboratory
NRT	Near Real Time
NRTC	Near Real Time Computing
NSF	National Science Foundation
NSWC	Naval Surface Warfare Center
NUWC	Naval Undersea Warfare Center
NVL	Night Vision Laboratory
NVRAM	Non-Volatile Random Access Memory
NWDC	Navy Warfare Development Command
OC	Optical Carrier
OIPT	Overarching Integrated Product Team
OKC	Online Knowledge Center
ONR	Office of Naval Research
OPFOR	Opposing Force
OSD	Office of Secretary of Defense
PE	Predicting Probability of Effect
PEO	Program Executive Office
PET	User Productivity Enhancement and Technology Transfer
PEUO	Physics-Based Environment for Urban Operations
pIE	Portal to the Information Environment
Pk	Predicting Probability of Kill
PKI	Public Key Infrastructure
RBD	Rigid Body Dynamic
RDT&E	Research, Development, Test and Evaluation
RF	Radio Frequency
RFP	Request For Proposals
RMWIM	Rocket Motor and Warhead Impact Modeling
ROI	Return On Investment

RT	Real-Time
RTC	Real-Time Computing
RTTC	Redstone Technical Test Center
S/AAA	Service/Agency Approval Authority
S&T	Science and Technology
SABL	Stable Atmospheric Boundary Layer
SAD	Search and Determine
SAS	Software Applications Support
SC	Supercomputing
SDP	Service Delivery Points
SDREN	Secret Defense Research and Engineering Network
SIF	Schools Interoperability Framework
SIP	Signal/Image Processing
SLM	Storage Lifecycle Management
SMDC	Space and Missile Defense Command
SMCCOM	Soldier Biological Chemical Command Research Development Engineering Center
SMDC	Space and Missile Defense Command
SOF	Special Operations Force
SOP	Standard Operating Procedure
SPAWAR	Space and Naval Warfare Systems Command
SPI	Software Protection Initiative
SSA	Space Situational Awareness
SSN	Space Surveillance Network
STEM	Science, Technology, Engineering, and Mathematics
STOVL	Short Take-Off and Vertical Landing
T&E	Test and Evaluation
TACOM	Tank-Automotive Command
TARDEC	Tank-Automotive Research, Development and Engineering Center
TB	Terabytes
TI	Technology Insertion
TPD	Technical Planning Document
UAV	Unmanned Air Vehicles
UCAS	Unmanned Combat Air Systems
UCAV	Unmanned Combat Air Vehicles
UGC	Users Group Conference
UIT	User Interface Toolkit
UNAfold	Unified Nucleic Acid Folding
US	United States
USACE	US Army Corps of Engineers
USAFA	US Air Force Academy
USAMRIID	US Army Medical Research Institute of Infectious Diseases
USAMRMC	US Army Medical Research and Materiel Command
USD(AT&L)	Under Secretary of Defense for Acquisition Technology and Logistics
UTC	User Training Coordination
VED	Virtual Electromagnetic Design
VSIPL	Vector Signal Image Processing Library
VT	Virtual Token
WAN	Wide Area Network

Opportunities to Use HPCMP Resources

Any researcher or developer who is actively supporting the Department of Defense in the areas of R&D and/or T&E may have access to HPCMP resources. This includes potential users who are government employees, government contractors, and researchers from the academic community.

To get started, you must sign a DoD Information Systems User Agreement and take the following DoD training:

- Information Assurance Awareness Training
- Personal Electronic Devices/Removable Storage Media
- Phishing Awareness

Next, apply for an account via the Portal to the Information Environment (pIE) at https://ieapp.erdc.hpc.mil/info/userRequestHome.jsp.

For assistance, contact your Service/Agency Approval Authority (S/AAA). Each government organization within the HPCMP community has an assigned S/AAA who is responsible for setting up new accounts; modifying new accounts; creating projects in pIE; allocating resources to subprojects; and approving project requirement questionnaires. Locate your S/AAA in pIE (under "Report Information Environment" or at https://www.hpcmo.hpc.mil/bridge/). Your S/AAA approves your account request and assists in its activation. A National Agency Check (NAC) may be required.

You can work with your S/AAA to establish a new project in pIE, complete a requirements questionnaire, and access HPCMP resources at one or more of the DSRCs. Allocation of resources are made by the Service organization and not by the HPCMP Office.

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