# The Federal HPCC Program

**HPCC program flier, (April 1996)**

**HPCC Agencies:** DARPA NSF NASA DOE NIH NSA NIST VA ED NOAA EPA AHCPR

## Applications and technologies: HPCC program applications and technologies

HPCC technologies have revolutionized U.S. scientific and engineering research and development (R&D). This has led to better understanding and management of our environment, safer and more energy-efficient cars and planes, better understanding of the human body, new and more effective medical treatments, advanced national defense and national security systems, and advances in fundamental science and engineering. They continue to revolutionize how virtually every sector of the economy functions and how we teach, learn, work, and live.

These accomplishments are the result of long-term strategic R&D conducted by the Federal High Performance Computing and Communications (HPCC) Program in cooperation with U.S. academia and industry. The Program has accelerated the development of:

- Fundamentally new computing systems - scalable parallel systems - that are a thousand times faster than systems available five years earlier
- Totally new computer communications paradigm manifested in today's Internet
- Advanced software technologies including high performance systems software and tools for parallel computations

Building on these technologies, the Program has developed new applications software to address the complementary Grand Challenges and National Challenges; for example, many Grand Challenges provide computational services for information-intensive National Challenges.

**Grand Challenges** are computation-intensive fundamental problems in science and engineering, with broad economic and scientific impact, whose solution can be advanced by applying HPCC technologies and resources.

**National Challenges** are information-intensive fundamental applications that have broad and direct impact on the Nation's competitiveness and the well-being of its citizens, and that can benefit from the application of HPCC technologies and resources.

In FY 1996 the HPCC Program is a $1.1 billion effort that is planned and implemented by 12 Federal organizations. HPCC R&D is conducted at U.S. academic institutions, corporations, and Federal R&D laboratories; a variety of funding mechanisms are used. The National Coordination Office for High Performance Computing and Communications coordinates the Program and outreach to interested communities.

The HPCC Program builds upon decades of successful Federal R&D in high performance computing and communications. The U.S. Congress signaled its bipartisan support by passing the High Performance Computing Act of 1991 (Public Law 102-194). Today the Program is focusing on new challenges in Federal R&D in computing and communications technologies through its support of the Committee on Information and Communications R&D of the National Science and Technology Council.

Addressing these challenges is critical to establishing a National Information Infrastructure and a Defense Information Infrastructure, as well as for enabling a Global Information Infrastructure. Steady, sustained, and well-managed Federal R&D in computing and communications, particularly at the high end, is vital to maintaining U.S. leadership in the Age of Information.

## HPCC applications

- Environment
- Manufacturing
- Biomedicine
- National security & National defense
- Research, education, & information

## HPCC Applications - The Environment

| **Climate modeling**<br>NSF, NASA, DOE, NOAA, EPA | **National Benefits** | **HPCC Examples** |
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| | Fundamental understanding of global climate change for use in forecasting weather & managing the environment | 10-by-10 mile resolution & more realistic ocean simulations over longer time periods accurately predict currents such as the Gulf Stream that transport heat between ocean regions |

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| | | Tropical Pacific observations used for short-term (up to a year) prediction of El Niño conditions, which cause flooding/drought/fires worldwide |
| **Weather modeling**<br>NSF, NASA, NOAA, EPA | **National Benefits**<br>More accurate weather & severe storm forecasts, leading to greater safety & a more efficient economy | **HPCC Examples**<br>New parallel 3-D models used for 24-hour through 72-hour forecasts of 1995 Atlantic Ocean & Eastern Pacific hurricanes predict paths better than all other computer forecasts |
| **Environmental modeling**<br>NSF, NASA, DOE, NOAA, EPA | **National Benefits**<br>Improved air & water quality<br>More effective environmental policies<br>Protection of human health & ecosystems | **HPCC Examples**<br>Using the results of a 1,400-hour simulation, Chesapeake Bay air shed estimated to extend west beyond the Allegheny Mountains, impacting Bay restoration plans |
| **Ecosystem modeling**<br>NSF, DOE, NOAA, EPA | **National Benefits**<br>Parallel, 3-D software modeling groundwater flow & transport, accounting for complex processes such as bioremediation | **HPCC Examples**<br>Simulations of varying earthquake impact over Greater Los Angeles Basin |
| **Environmental monitoring**<br>NSF, NASA, DOE, NOAA, EPA | **National Benefits**<br>More accurate, more detailed knowledge of the environment, leading to better natural resource management | **HPCC Examples**<br>Visual 3-D model of San Diego Bay based on physical, biological, & chemical data from 35 data collection programs<br>Model predictions of ozone concentrations in Los Angeles corroborated by observational data |
| **Energy management**<br>NSF, DOE | **National Benefits**<br>More efficient use & conservation of energy resources | **HPCC Examples**<br>Evaluation of horizontal wells with vertical drain holes for tertiary oil recovery with carbon dioxide<br>Remote monitoring & control of energy use in buildings |

## HPCC Applications - Manufacturing

| **Design**<br>NASA, DOE, NIST | **National Benefits** | **HPCC Examples** |
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| | Safer & more fuel-efficient cars, trucks, & planes | Environment for designing and simulating aircraft engine configurations & for analyzing those configurations, in one case reducing design time by 50 percent |
| | More energy-efficient homes, offices, & factories | Computer simulations for designing internal combustion engines, & industrial & utility burners |

| **Manufacturing processes & products**<br>DARPA, NSF, NASA, DOE, NIST | **National Benefits** | **HPCC Examples** |
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| | New products that are lighter, stronger, safer, & cheaper to manufacture & use | Product improvements through parametric design |
| | Faster time to market for new products | Better manufacturing support tools via data sharing over the Internet |
| | Improved competitiveness of the U.S. manufacturing & processing industries | Testbeds for developing voluntary manufacturing standards |

## HPCC Applications - Biomedicine

| **Biomedical imaging & biomechanics**<br>NSF, NIH | **National Benefits** | **HPCC Examples** |
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| | Improved understanding of the human body & the effects of disease, injury, & surgical intervention | Visible Man & Visible Woman data sets - cadavers digitized at submillimeter resolution |
| | | Simulation of knee joint motion in which large forces pass through thin layers of soft tissue that function as frictionless load-bearing surfaces |

| **Molecular biology**<br>NSF, DOE, NIH, NIST | **National Benefits** | **HPCC Examples** |
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| | Medical advances resulting from a better understanding of biological molecules | Estimation of 3-D molecular structure from 1-D amino acid & nucleic acid sequence data, such as determining the structure of the RNA molecule to study viral infections including the common cold, HIV, & polio |

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| **Health care**<br>DARPA, NSF, NIH, VA, AHCPR | **National Benefits** | **HPCC Examples** |
| | A more effective & more efficient health care system | Design of 3-D radiation beam placements & dosages in treating cancer, resulting in reduced irradiation of healthy tissue |
| | Improved clinical decision making | Telemedicine demos of remote real-time patient treatment |
| | More accurate, uniform, & retrievable patient care data | Standards for & evaluation of the use of computer-based patient records |

## HPCC Applications - National security & National defense

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| **Civil & defense infrastructures**<br>DARPA, NSF, NASA, DOE, NOAA | **National Benefits** | **HPCC Examples** |
| | Improved management of the country's civil & defense infrastructure including its transportation, energy, & communications systems | Visualization system displaying satellite, aerial, map, underground, environmental, census, & demographic information, for information & intelligence gathering & distribution |

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| **Crisis & emergency management**<br>DARPA, NSF, NASA, NSA, NOAA | **National Benefits** | **HPCC Examples** |
| | Protection of critical information systems against attack & in times of emergency | Integrated intelligent information systems in support of the Nation's defense, command & control systems, & security needs |

## HPCC Applications - Research, Education, & Information

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| **Basic research**<br>NSF, NIH | **National Benefits** | **HPCC Examples** |
| | Better understanding of the physical world & the universe | Quantum chromodynamic studies of elementary particles |
| | Simulation of events that are too large, too small, too fast, too slow, or too far away to observe directly | Numerical simulations used to guide observations of the Shoemaker-Levy 9 comet crashing into Jupiter |

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| **Education & lifelong learning**<br>all HPCC organizations | **National Benefits**<br><br>Better educational, vocational, & cultural materials available to all citizens & military personnel regardless of age, geographic location, or ability | **HPCC Examples**<br><br>Interactive visits among classrooms across the country<br><br>Use of simulations to train pilots & surgeons for difficult or dangerous situations |
| **Public access to government information**<br>all HPCC organizations | **National Benefits**<br><br>Government-funded information freely & easily available to all citizens | **HPCC Examples**<br><br>Internet-availablity of Federal Earth data, environmental data, health care data, & information & curricula for teachers, educators, & librarians (one starting point is the HPCC Program's Web site:http://www.ccic.gov/) |

## HPCC Applications - Major technologies

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| **Networking**<br>DARPA, NSF, NASA, DOE, NSA, NIST | **National Benefits**<br><br>Fundamentally new & effective ways to communicate | **HPCC Examples**<br><br>The Internet, a worldwide network of networks that today interconnects more than four million computers |
| **Gigabit-speed networking**<br>DARPA, NSF, NASA, DOE, NSA, NIST | **National Benefits**<br><br>Cost-effective multimedia (integrated data, voice, & video) | **HPCC Examples**<br><br>World host-to-host speed record of 0.8 gigabits (billions of bits per second) (almost 1,000 times faster than 1992 record) |
| **Wireless networks**<br>DARPA, NSF, NASA, DOE, NSA, NIST | **National Benefits**<br><br>High-speed connectivity to distant or isolated locations | **HPCC Examples**<br><br>Advanced Communications Technology Satellite |
| **Scalable parallel computing systems** | **National Benefits** | **HPCC Examples** |

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| DARPA, NSF, NASA, DOE, NSA, NIST | Fast, cost-effective parallel computing<br><br>More realistic mathematical modeling of physical phenomena | World speed record of 281 gigaflops (billions of floating point operations per second) on linear algebra benchmarks in 1995 (compared with 1 gigaflop in 1992) |
| **Networked heterogeneous computing**<br>DARPA, NSF, NASA, DOE, NSA | **National Benefits**<br><br>Efficient use of the most appropriate computing resources available | **HPCC Examples**<br><br>Scalable parallel computing using networked workstations |
| **Parallel software**<br>DARPA, NSF, NASA, DOE, NIH, NSA, NIST, NOAA, EPA | **National Benefits**<br><br>Easier programming of parallel systems | **HPCC Examples**<br><br>National HPCC Software Exchange, a repository for algorithms, languages, applications, & tools |
| **Scientific visualization**<br>DARPA, NSF, NASA, DOE, NIH, NIST, EPA | **National Benefits**<br><br>Easy & fast understanding of large numerical data sets | **HPCC Examples**<br><br>Interactive 3-D display of severe storm simulations |
| **Virtual reality**<br>DARPA, NSF, NASA, DOE, NIH | **National Benefits**<br><br>Interactive sight/sound/touch immersion in simulated environments | **HPCC Examples**<br><br>CAVEs - room-size virtual environments used for applications such as molecular biology simulations & product design |
| **Internet access technologies**<br>DARPA, NSF, NASA | **National Benefits**<br><br>Tools to access & search vast information repositories easily | **HPCC Examples**<br><br>The public-domain NCSA Mosaic & many commercial browsers |
| **Digital library technologies**<br>DARPA, NSF, NASA, DOE, NIH, NSA, NIST, NOAA, EPA | **National Benefits**<br><br>Easy use of growing collections of information by the U.S. research & education communities, work force, & general public | **HPCC Examples**<br><br>New technologies for the management & interactive use of very large & interoperable libraries |
| **Security & privacy**<br>DARPA, NSF, NASA, DOE, NSA, NIST | **National Benefits**<br><br>Feasibility of secure applications in medicine, finance, & industry | **HPCC Examples**<br><br>Increasingly secure computing systems, networks, software, & information |

| **Electronic commerce**<br>DARPA, NSF, NIST | **National Benefits** | **HPCC Examples** |
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| | More efficient & cost-effective business transactions | Electronic bidding, ordering, & payments |

| **Human/Machine interfaces**<br>DARPA, NSF, NASA, NIST, ED | **National Benefits** | **HPCC Examples** |
|---|---|---|
| | Broader base of information developers, providers, & users | Technologies for recognizing spoken natural language & for recognizing handwriting |