National Aeronautics and Space Administration

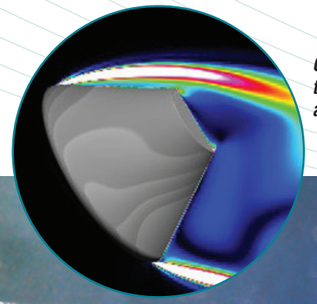
NASA ADVANCED SUPERCOMPUTING DIVISION

Integrated
Supercomputing
Environment

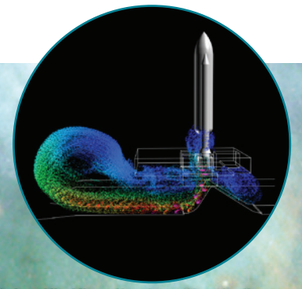
NASA Advanced Supercomputing Division

Delivering Full-Spectrum, Integrated Services to High-End Computing Users

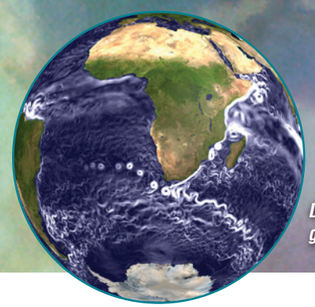
The NASA Advanced Supercomputing (NAS) Division at Ames Research Center is known worldwide for its innovation and expertise in high-end computing (HEC)—a reputation sustained for over 25 years. To achieve exceptional performance and groundbreaking results for NASA's scientific and engineering users, NAS offers a variety of customizable, integrated services and technologies to enhance the power of the Agency's HEC resources. The knowledge, experience, and dedication of the collective NAS team continues to foster remarkable advancements through its comprehensive integrated services approach, encompassing high-end computing, high-speed networking, mass data storage, code performance optimization, scientific visualization, user support, and modeling and simulation. Here's a snapshot of our offerings and contributions to NASA's exciting missions.



Code Optimization: CFD simulation of the Orion CEV showing vorticity of airflow around the crew module



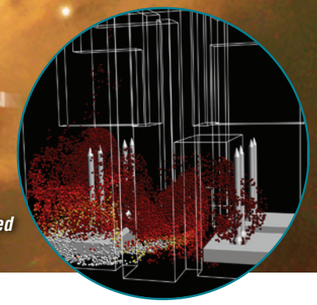
Scientific Visualization: Shuttle flame trench CFD simulation showing instantaneous particle traces colored by Mach number



Data Storage: Ocean surface currents from a global ocean and sea ice data synthesis

Networking: NAS' national wide-area network traffic, in support of high-end computing, has grown exponentially, mirroring growth in HEC use across NASA

User Services: Flight controllers in the Mission Control Center at NASA Johnson watch as Space Shuttle Discovery lands at NASA Kennedy



Modeling & Simulation: CFD simulation of instantaneous particle traces in the VAB colored by temperature

Production Supercomputing

The NAS Division's expertise in developing and delivering HEC technologies is at the core of its integrated service offerings. The terascale systems group manages the HEC life-cycle within NAS' production computing environment to meet the specific needs of our user community. They evaluate new architectures; acquire, install, and manage these systems; and develop custom software tools and advanced security methods. In October 2008, this team, along with industry partners, built the 47,104-core Pleiades supercomputer to meet NASA's growing HEC requirements. At over 8 times the size of the original Columbia supercomputer, Pleiades will have a genuine impact on time-critical science and engineering challenges for NASA missions. For example, the Agency is saving thousands of hours and millions of dollars in experimental tests through computational analysis of Ares crew launch vehicle (CLV) stage separation events, design of the Orion crew exploration vehicle's (CEV) thermal protection system, and early design iterations of the Ares V cargo launch vehicle.

Networking Technologies

NAS' high-speed networking technologies and services are essential to enabling efficient use of the Agency's rapidly increasing HEC power. Our high-capacity network connections and local and wide area network (WAN) expertise allow users' massive data transfers—some exceeding many terabytes—to occur seamlessly between local and remote systems. Through the efforts of NAS engineers, our national WAN has seen sizeable increases in network traffic in the last two years. By taking a multi-pronged approach, addressing both infrastructure and application bottlenecks, NAS' monthly WAN traffic increased to 137.93 terabytes of data transferred—more than doubling the traffic rate in the first 8 months of 2008. NAS engineers also stay on the forefront of, and strongly influence the future of networking technologies to ensure that NASA's unique computational requirements are met.

Data Storage

Our HEC users often require staggering amounts of data storage. With 25 petabytes (PB) of tertiary storage and 2 PB of disk storage on the floor, NAS' mass storage system allows users to archive and retrieve important results quickly, reliably, and securely. We also provide customized training and support to help users efficiently manage large amounts of data. For example, scientists working on ECCO2 global high-resolution ocean data syntheses require dozens of terabytes of disk storage for integrating their models and analyzing results. NAS specialists greatly expanded primary and secondary storage capacities and cross-mounted these to the tertiary storage system, substantially reducing bottlenecks during ECCO2 data generation and analysis.

Application Optimization

NAS' application optimization team specializes in enhancing performance of complex codes so researchers can do more science and engineering in less time. Our comprehensive optimization services range from porting codes to run on current parallel computing architectures, to partnering with users for in-depth code optimization. The team's ongoing improvements to a key aerodynamics code used to analyze CLV and CEV designs recently achieved a 5x performance speedup and 2x decrease in memory requirements—yielding substantial savings in time and money, and enabling completion of time-critical computations that could otherwise not have been completed. NAS scientists also evaluate tools and technologies best suited for our environment and work with tool developers to effectively utilize HEC resources for future mission challenges.

Scientific Visualization

Our visualization experts develop and implement advanced software tools and technologies customized to help scientists and engineers make new discoveries for Agency missions. In spring 2008, this team developed the quarter-billion pixel hyperwall-2 graphics and data analysis system. The team's extensive suite of tools includes a sophisticated concurrent visualization framework, which together with hyperwall-2, allows users to explore high-resolution results in real time and pinpoint critical details in large, complex datasets. Recently, the "vis" team's support provided NASA scientists with valuable insight into assessment and repair of damage caused to Shuttle Discovery's launch pad during ignition. They post-processed time-accurate, 3D simulation data computed on Columbia, and produced detailed animations and images showing flowfield conditions such as pressures, temperatures, and Mach numbers within the pad's flame trench.

User Services

The NAS user services team is dedicated to assuring that Agency users can make the most effective, productive use of HEC systems at Ames, 24x7. Our control room staff provides immediate response to all user questions, and coordinates end-to-end user services with other NAS teams to provide any custom support services needed. The team continuously monitors and fine-tunes all systems, peripherals, job processes, and the physical facility to ensure a stable and secure computing environment. This experienced group plays a key role in guaranteeing timely turnaround of computational analyses during many shuttle missions, ensuring critical support for users who perform real-time assessments needed to make on-orbit decisions and clear shuttles for landing.

Modeling & Simulation

Many NASA missions present unique computational challenges that no off-the-shelf software can address. NAS scientists specializing in physics-based modeling and simulation develop world-class CFD software packages, custom tools, and advanced capabilities that meet these challenges. Our CFD experts provide critical simulation services to NASA teams, often dramatically reducing time-to-solution and substantially increasing model resolution and accuracy. For example, a NAS-developed computational framework was recently employed to determine whether the Vehicle Assembly Building (VAB) at NASA Kennedy (used for the shuttle), is properly equipped to safely handle the storage of significantly more fuel required for the Agency's next-generation vehicles. NAS experts have also developed improved models for radiation, chemistry, and gas-surface interaction effects for high-speed atmosphere reentry simulations, enabling more accurate determination of thermal protection system sizing needs without the need for costly ground-based experimental tests.

The 128-screen hyperwall-2 system is used to view, analyze, and communicate results from NASA's high-fidelity modeling and simulation projects, leading to new discoveries

► Future HEC Environments

With a new generation of supercomputers in place, NAS is now planning even more significant expansion in the coming years–up to a 10-fold increase over today's HEC capability. Preparations include additional upgrades to the NAS facility infrastructure and expanded data storage capacity. In the near-term, the hyperwall-2 visualization system will become more tightly integrated into NAS' computer, storage, and networking environment to deliver even more powerful resources to scientific and engineering users. Together with our industry, university, and government partners, the NAS Division's HEC resources and integrated services will continue supporting Agency missions to conduct pioneering aeronautics research, ensure the safety of remaining shuttle flights, explore the solar system, make scientific discoveries, and gain understanding of the universe.

NAS HEC ENVIRONMENT FACTS

Columbia
- Primary production system for all NASA Mission Directorates
- 14,336-processor SGI Altix system (1.6 GHz Intel Itanium2 processors)
- 28 terabytes main memory, 89 teraflops peak performance

Pleiades
- Major capacity augmentation for all Mission Directorates
- 47,104-core SGI Altix ICE (Intel Xeon 3.0 GHz quad-core processors)
- 47 terabytes main memory, 565 teraflops peak performance

Schirra
- Used for technology evaluation and production computing
- 640 1.9 GHz IBM Power5+ processors
- 128 terabytes main memory, 5 teraflops peak performance

RTJones
- Augmentation for Aeronautics Research Mission Directorate
- 4,096-processor SGI Altix ICE (Xeon 2.66 GHz quad-core processors)
- 4 terabytes main memory, 43 teraflops peak performance

hyperwall-2
- Provides large-scale and concurrent visualization
- 1,024-processor, 128-node GPU cluster
- 74 teraflops peak performance

Storage
- 2 petabytes online Fibre Channel RAID
- 25 petabytes archival storage

Networks
- WAN - 10 GB Ethernet, 1 GB Ethernet
- LAN - 10 GB Ethernet core, 1 GB Ethernet access (to desktop)

Contact Information:
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