NASA SILICON VALLEY

AMES RESEARCH CENTER

ADVANCED COMPUTING

Michelle Moyer, NASA Advanced Supercomputing Division

High-Performance Computing (HPC)

Advanced Computing at Ames

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KEY ATTRIBUTES / COMPETENCY

- NAS supercomputing resources and services are customized to meet the needs of about 1,900 researchers from NASA centers, academia, and industry who use the system for high fidelity modeling and simulation.
- In-house developed hyperwall visualization system and software provides a 300-ft display with over a billion pixels and the ability to display, analyze, and study high-dimensional datasets using multiple parameters.
- NAS provides HPC resources and expertise in data analytics, machine learning, and artificial intelligence, and cloud computing.

TECHNICAL / SCIENTIFIC CHALLENGE ADDRESSED

The NASA Advanced Supercomputing (NAS) facility hosts the Agency's primary high-performance computing (HPC) resources. This capability enables NASA's science and engineering across all mission directorates.

HERITAGE

- Began operation as NASA's Numerical Aerodynamic Simulation (NAS) Program in 1984.
- Columbia debuted as 2nd most powerful supercomputer in the world (2004); Pleiades debuted as 3rd (2008).
- Pioneered modular supercomputing.

SUMMARY

NAS provides an integrated high-performance computing environment, including cutting-edge computing platforms, high-speed networks, mass storage, and visualization systems, as well as application optimization, data processing and analysis, data provenance and distribution, data visualization, targeted training, and machine learning and artificial intelligence.

APPLICATIONS BEYOND

Enhanced HPC; linking of experimental and HPC facilities; advancing artificial intelligence and machine learning; applying next-generation advanced computing paradigms such as quantum and neuromorphic computing.

Michelle Moyer, NASA Advanced Supercomputing Division, Ames Research Center

Modular Supercomputing Facility

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TECHNICAL / SCIENTIFIC CHALLENGE ADDRESSED

To meet the agency's ever-growing need for high performance computing (HPC) capabilities to enable NASA science and engineering, new systems are deployed in modules that cost far less and are much faster to build than replacing or retrofitting an existing building.

SUMMARY

The Modular Supercomputing Facility, or MSF uses energy-efficient, self-contained modules to house its machines. The MSF has reduced water use by as much as 96% and electricity used for cooling by about 90%, compared with running the same computer resources in a traditional data center. Its modular approach makes it easy to upgrade the facility for fast-turnaround work on high-priority missions.

KEY ATTRIBUTES / COMPETENCY

- The MSF's modules use a combination of outdoor air, fan technology, evaporative coolers and a circulating water system to remove the heat generated by the computer's processors.
- Located on a one-acre site at Ames with the infrastructure to support a total of 16 modules for computers and data storage, the MSF currently comprises two modules containing NASA's Aitken supercomputers.

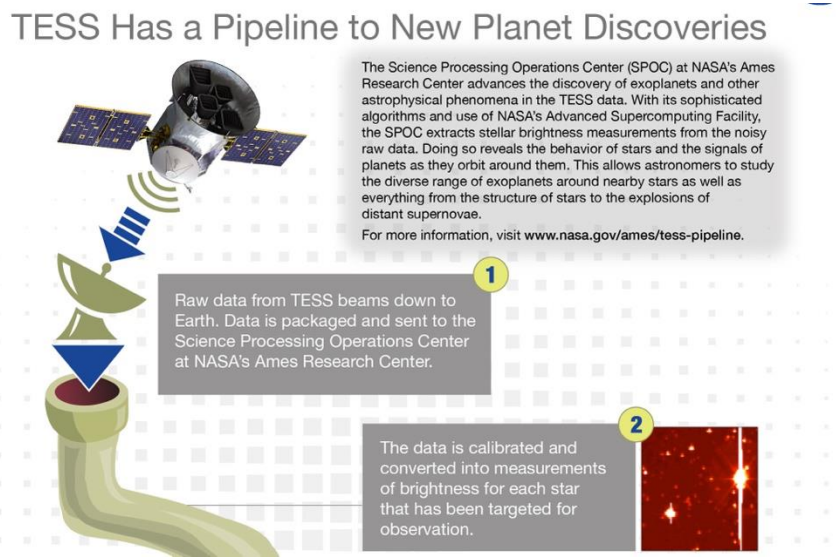
HERITAGE

- The first module containing the prototype Electra supercomputer is deployed near the primary NAS facility in 2017.
- The Modular Supercomputing Facility (MSF) debuts at Ames in 2019; contains the Aitken supercomputer. With an expansion in 2022, Aitken becomes NASA's most powerful supercomputer.
- A second module is installed at the MSF in 2024; NASA's next-generation supercomputer, to be deployed there in 2025, will become the agency's most powerful computer.

APPLICATIONS BEYOND

Continued expansion of the modular facility enables vast expansion of HPC capability and significantly reduced operational cost.

Science Data Processing
Advanced Computing at Ames



TECHNICAL / SCIENTIFIC CHALLENGE ADDRESSED

NASA science missions are collecting ever increasing volumes of data which require processing by specialized algorithms. The NASA Advanced Supercomputing (NAS) facility enables timely compute-intensive processing of large amounts of science data.

SUMMARY

NASA HPC resources are used to expedite the steps involved in processing hundreds of terabytes (TB) of raw data obtained from NASA Astrophysics and Earth Science missions. The processing steps are tailored to the needs of the mission and may include cleaning the data to correct errors, omissions, or inconsistencies, as well as visualizing, modeling, and analyzing the data.

KEY ATTRIBUTES / COMPETENCY

- The NAS enables science data processing by providing expandable compute and data storage; hybrid cloud / on premises computing; appropriate IT security plan infrastructure; and SMEs in science data pipelines.
- The NAS science data pipeline service helps researchers and science teams to design, develop, deploy, and operate complex science data pipelines enabled by NASA's HPC resources.

HERITAGE

- The NAS has processed the enormous amount of data gathered by the Kepler and TESS missions, which have discovered most of the exoplanets known to science.
- The NAS has leveraged the Kepler and TESS pipelines to develop software which provides a standalone application that can be used to build data pipelines for any purpose.
- Numerous data products have been created from GOES satellites, including the identification of thousands of meteor entries.

APPLICATIONS BEYOND

The NAS can enable missions with large data sets and complex data processing needs to leverage NASA's HPC assets and cloud computing as appropriate for the application. These capabilities could be applied to any NASA mission and can furthermore support the fusion of data sets from multiple missions.

Visualization

Advanced Computing at Ames

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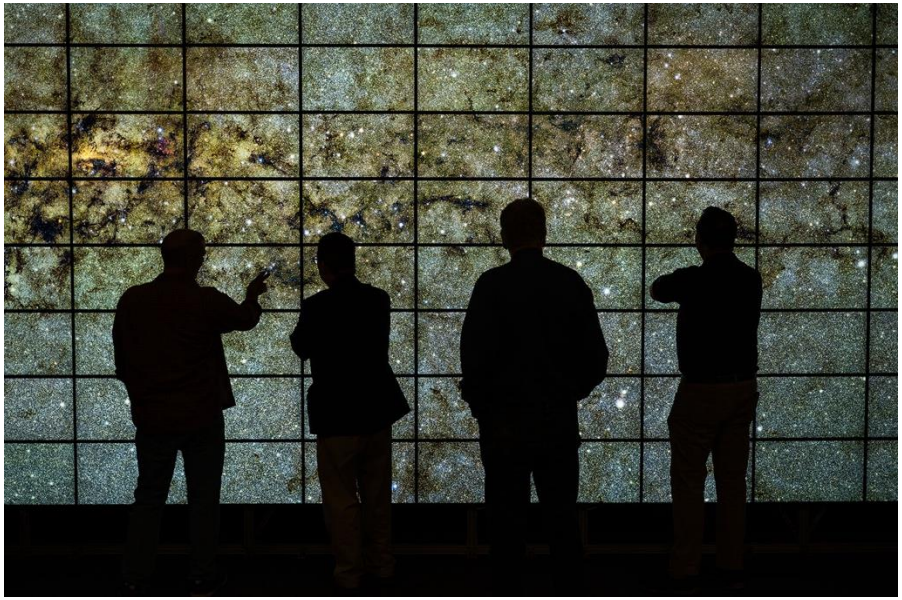


KEY ATTRIBUTES / COMPETENCY

- The NAS in-house developed hyperwall visualization system provides a 300-ft display with over a billion pixels across 128 screens, each served by its own high-performance compute node and graphics processing unit (GPU).
- An extensive portfolio of applications enables researchers to explore and zoom in on their high-resolution results in real time, and pinpoint critical details in their large, complex datasets.
- The system is connected to the Ames Unitary Plan Wind Tunnel to enable the transfer and visualization of experimental data in real time.

TECHNICAL / SCIENTIFIC CHALLENGE ADDRESSED

NASA Advanced Supercomputing (NAS) provides a supercomputer-scale “hyperwall” visualization system that enables researchers working on NASA projects to efficiently analyze the very large, high-dimensional datasets produced by the agency’s supercomputers and instruments, enabling science and engineering across all mission directorates.

HERITAGE

- The agency’s first hyperwall was developed at the NAS facility in 2002; it is now in its fourth generation.
- Concurrent visualization of data, enabling analysis while calculations are still running, was developed by the NAS visualization team in 2006.
- The system has enabled scientists to share NASA science and engineering achievements with researchers and leaders from across the U.S. and all over the world.

SUMMARY

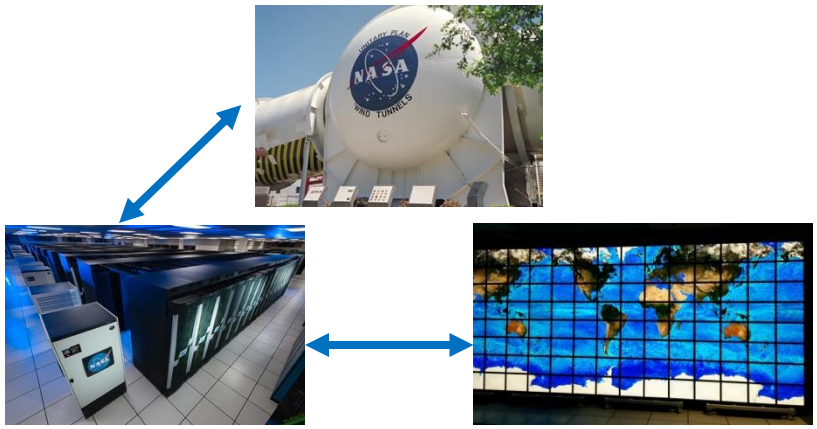
The hyperwall combines a powerful compute cluster with a large, multi-view tiled display that brings numerical data to life on screen. Working closely with researchers, NAS visualization experts develop advanced software tools using physics-based and statistical modeling approaches and customized techniques to reveal intricate details in computational models and in data from NASA observatories.

APPLICATIONS BEYOND

The hyperwall’s ability to tightly couple high performance computing, big data, and visualization will enable teams to reach new and unexpected insights.

Integrated Research Infrastructure

Advanced Computing at Ames



KEY ATTRIBUTES / COMPETENCY

- Connect the NASA Advanced Supercomputing (NAS) facility with select research instruments, testbeds, and experimental facilities across the Ames campus through high-speed networking and IT infrastructure.
- Enable near real-time analysis, simulations, data assimilation, and insights by tightly integrating NAS HPC resources, automation tooling, and the expertise provided by NAS visualization and analysis experts.
- The hyperwall visualization system is also integrated with the HPC systems, enabling near real-time data analysis.

TECHNICAL / SCIENTIFIC CHALLENGE ADDRESSED

Integrating experimental research infrastructure with high-performance computing (HPC) enables NASA science and engineering by accelerating the research and development cycle, improving process automation, and optimizing instrument development timelines while fostering technological advancement.

HERITAGE

- A secure, high-speed connection between the Ames Unitary Plan Wind Tunnel and HPC resources at the NAS facility was first established in 2020, providing a new capability to confirm data quality and to detect behavior while wind tunnel tests are in progress, allowing corrective action and guiding further data acquisition.

SUMMARY

Integrated Research Infrastructure (IRI) brings together experimental facilities, science and engineering instruments, and sensors with HPC to accelerate the modeling and analysis of complex science and engineering phenomena. Tightly integrating these facilities allows for near real-time feedback between experiments and simulations and analysis of results, enabling researchers to refine models, optimize parameters, and explore scenarios, and reduce time to solution and insights.

APPLICATIONS BEYOND

Additional facilities such as the NASA Ames Coronagraph Experiment Laboratory, vacuum chamber, and other instruments can be connected to NAS HPC resources to significantly data reduce processing time and accelerate research. Artificial Intelligence can be leveraged to further optimize and automate IRI research and development.