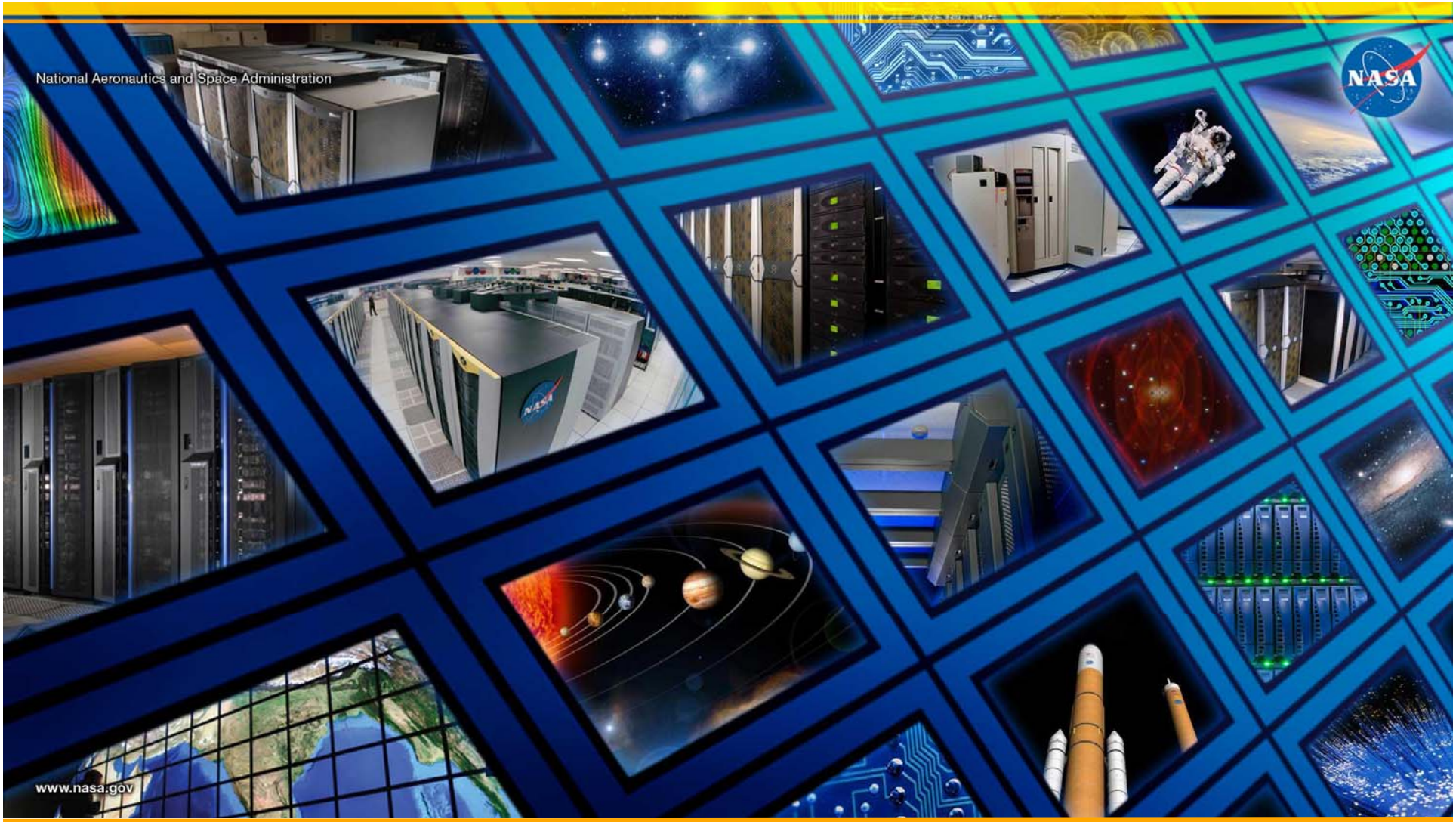


NASA Supercomputing

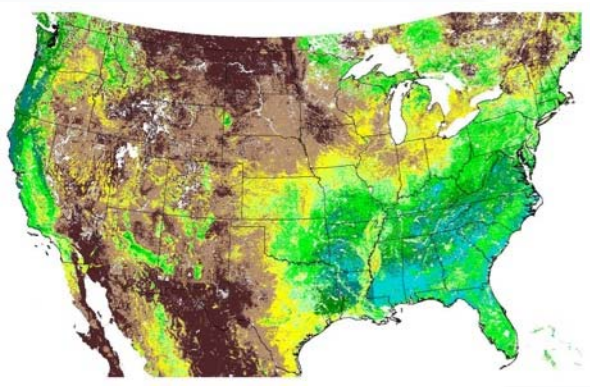
Bryan Biegel, Deputy Chief, NAS Division, Ames Research Center

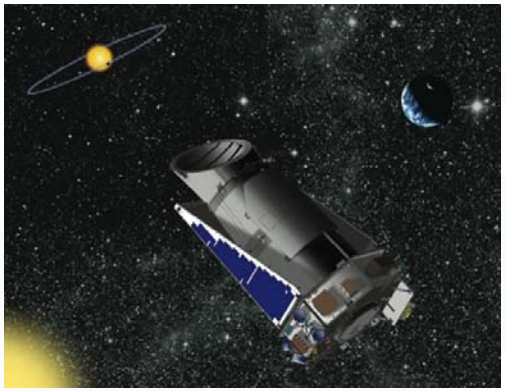
February 27, 2013

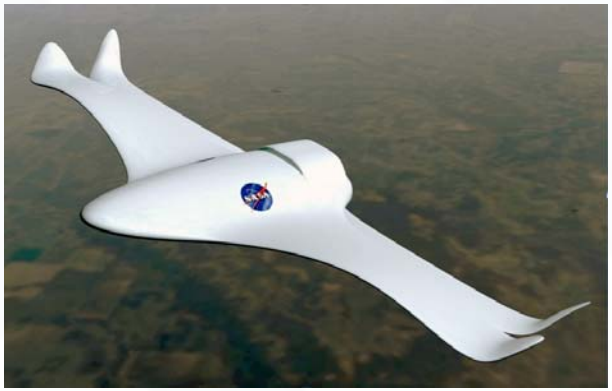
Why NASA Uses Supercomputing

NASA's mission to greatly extend boundaries of human knowledge and technological achievement requires…

- Unique satellites to observe Earth systems and telescopes to observe the universe
- Powerful rockets/spacecraft to take humans/cargo/probes safely into space (& back)
- Wind tunnels and prototypes to design more environmentally friendly, safer aircraft







High-fidelity modeling & simulation (M&S) and big data analysis, powered by high end computing (HEC), enable NASA to…

- Make the leap from massive data observation to complex system understanding
- Ensure mission success of expensive, often unique, sometimes dangerous systems

M&S is essential tool to cost-effectively, rapidly advance NASA missions!

NASA Supercomputing

NASA Advanced Supercomputing (NAS) facility at Ames

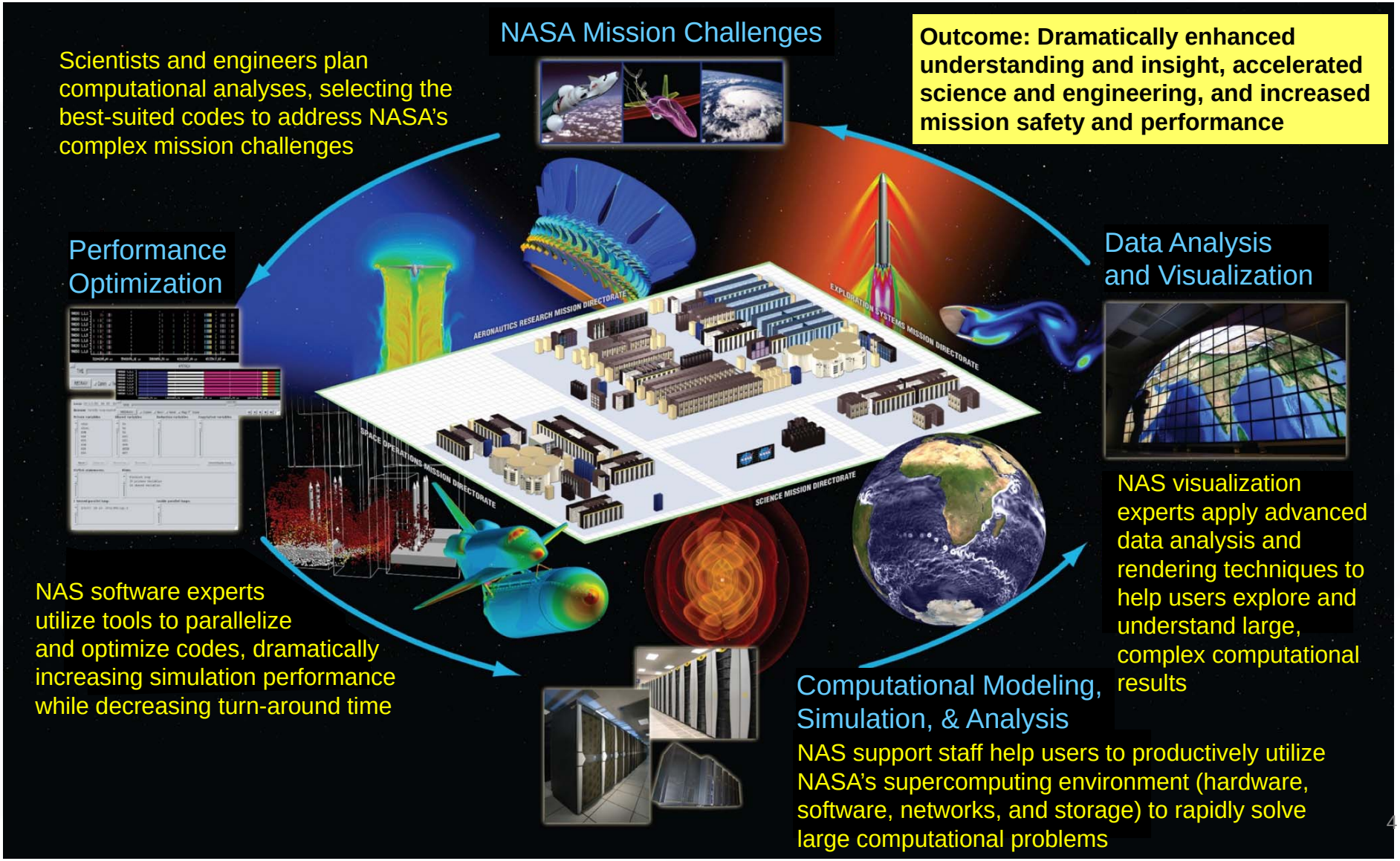
- Funded at Agency level as Shared Capability Asset
- Supports entirety of NASA's mission
- 80-90% of NASA's HEC capacity; comprehensive support services
- Primary supercomputer is Pleiades, 14th fastest in world
- Hyperwall !

NASA Center for Climate Simulation (NCCS) at Goddard

- Funded by Science Mission Directorate, primarily Earth science
- 10-20% of NASA's capacity; less comprehensive support services

Fully Integrated Spiral Support for Advanced Computational Modeling and Simulation

Develop and deliver the most productive high-end computing environment in the world, enabling NASA to extend technology, expand knowledge, and explore the universe



World-Class Supercomputing Capabilities

Computing Systems

Pleiades – 1.8 PetaFlops (PF) peak

- 129,024-core SGI Altix ICE
- 4 generations of Intel Xeon processors
- 184 racks, 237 TeraBytes (TB) of memory
- Debuted as #3 on TOP500 in 11/08; now #14

Endeavor – 32 TF peak

- 1,536-core SGI Ultraviolet
- Large shared-memory computing

Maia – 300 TF peak

- Testbed for Intel Phi computational accelerator

hyperwall-2 – 146 TF peak

- 1,024-core (Opteron), 136-node GPU cluster
- Large-scale rendering, concurrent visualization

Balanced Environment

Storage: 9.3 PetaBytes (PB) disk; 110 PB tape

- Archiving >1PB/month

WAN: 10 Gb/s to some Centers and high-bandwidth external peering

- Transferring hundreds of TB/month to distributed users

- Resources enable broad mission impact
  - MDs select projects, determine allocations
  - More than 500 science & engineering projects
  - Over 1,200 user accounts
  - Typically 300 to 500 jobs running at any instant
  - Demand for computing cycles extremely high
  - ~83 million CPU-hours delivered each month
- HEC demand & resources growing rapidly
  - NASA HPC requirements projected to multiply by at least 4X every 3 years (Moore's Law)
  - Capacity growth ~1.8X/year since 1988

Advanced Visualization: hyperwall-2 and CV

Supercomputer-scale visualization system to handle massive size of simulation results and increasing complexity of data analysis needs

- 8x16 LCD tiled panel display (23 ft x 10 ft)
- 245 million pixels
- Debuted as #1 resolution system in world
- In-depth data analysis and software

Two primary modes

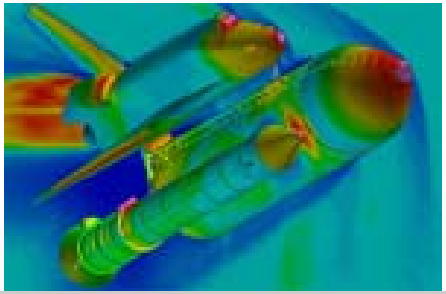
- Single large high-definition image
- Sets of related images (e.g., a parameter space of simulation results)

High-bandwidth to HEC resources

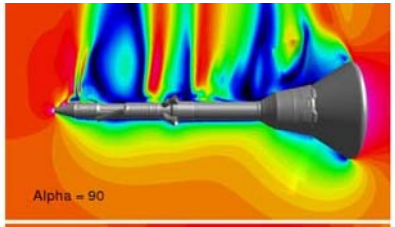
- *Concurrent Visualization:* Runtime data streaming allows visualization of every simulation timestep – ultimate insight into simulation code and results with no disk i/o
- *Traditional Post-processing:* Direct read/write access to Pleiades filesystems eliminates need for copying large datasets

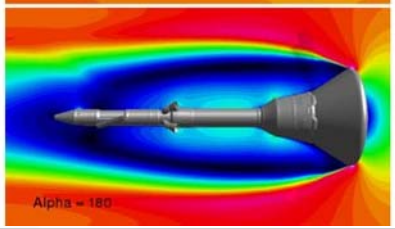
GPU-based computational acceleration R&D for appropriate NASA codes

Critical Support Across NASA's Mission

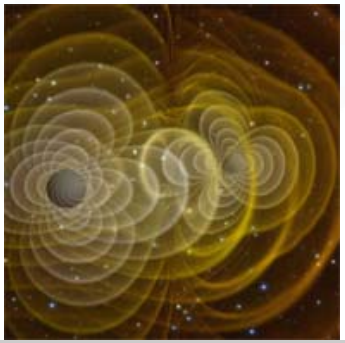


External tank redesign

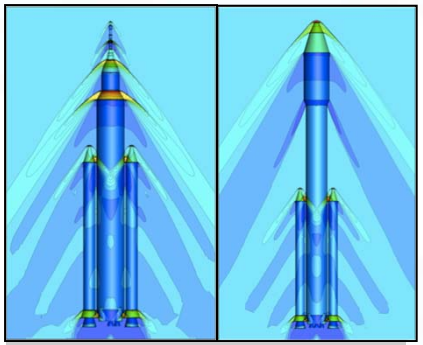




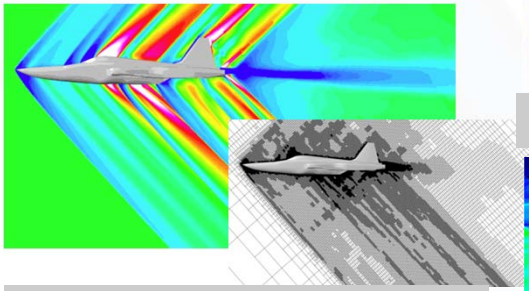
Launch abort system



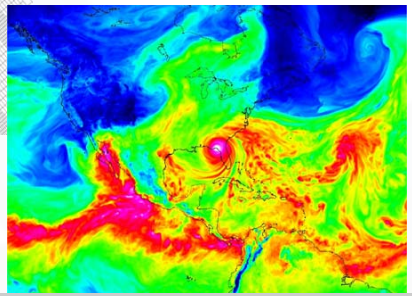
Merging black holes



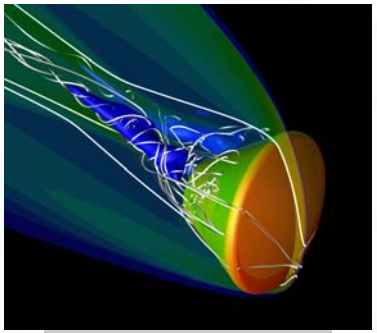
SLS vehicle designs



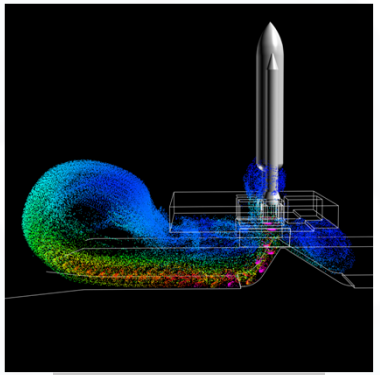
Sonic boom optimization



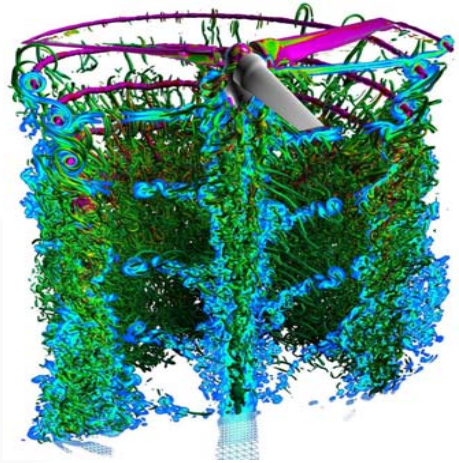
Hurricane prediction



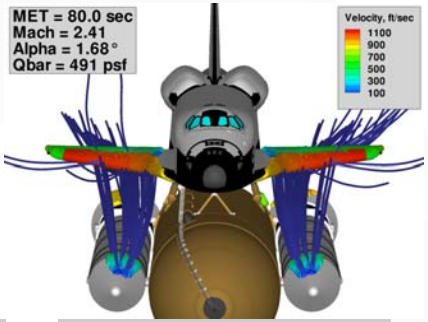
Orion reentry



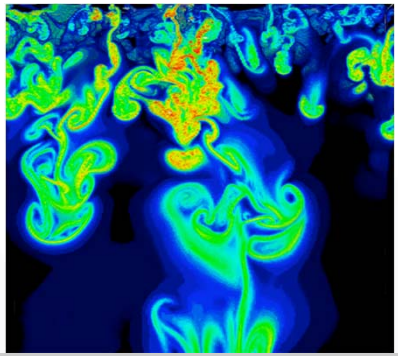
Flame trench



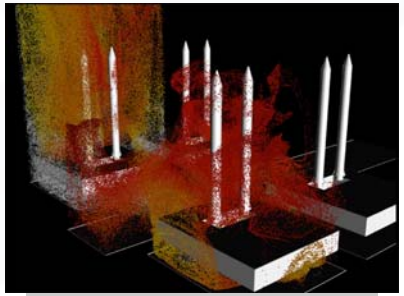
Rotary wing aerodynamics



Debris transport



Solar magnetodynamics



SRB burn in VAB

How to get NAS Resources/Services

Allocation from NASA Mission Directorate

- 95+% of NASA resources allocated this way; no cost to users
- NASA internal work, grants, contracts
- Examples: Earth Science RFPs, NASA Earth Exchange (NEX)

Space Act Agreement

- Specified contributions of NASA and collaborator to common project
- No funds transfer
- NASA staff do computational work

Reimbursable Space Act Agreement

- Non-NASA collaborator pays marginal cost for supercomputing
- Examples: NOAA, SpaceX

NAS will work with USGS to arrange appropriate mechanism for supercomputer access