HPC in MS
John E. West
DoD HPC Modernization Program
• Provide the best commercially available high end computing capability

• Acquire and develop joint-need HPC applications, software tools, and programming environments

• Educate and train users

• Link users and computer sites via high-capacity networks

• Promote collaborative relationships
…with users supporting missions worldwide
Health care in Mississippi.

It is by no means back-woods or antiquated, as is often Hollywood’s interpretation.

In fact, Mississippi was home to the first-ever heart transplant ... and the first-ever lung transplant ... and the first-ever kidney autotransplant. All performed by Mississippian Dr. James Hardy, a surgeon at Mississippi’s University Medical Center.

Yes, Mississippi. We were the first in the world to have a change of heart. Now isn’t it time the rest of the world had a change of heart about Mississippi?
1. California
2. New York
3. New Mexico
4. Tennessee
5. Maryland
6. Illinois
7. Mississippi
8. Ohio
9. Texas
10. Washington

Late 2006
“A supercomputer is a computer that led the world (or was close to doing so) in terms of processing capacity, particularly speed of calculation, at the time of its introduction.”

The Wikipedia
They’re big
1,100 ft² incl. disks
60 ft
14 ft
They're big
Sapphire - Cray XT3

- 8,192 processors
- 16,500 GB memory
- 375,000 GB of disk
Sapphire - Cray XT3
• 8,192 processors
• 16,500 GB memory
• 375,000 GB of disk

Your Laptop
• 2 processors
• 1 Gigabytes memory
• 160 Gigabytes of disk

...solving the hard problems
They’re big
• Consumes 7,000,000 kW-hours per year of power

• Cooled by 1,000 ton chiller
• Consumes 7,000,000 kW-hours per year of power
• Cooled by 1,000 ton chiller

• Consumes 10,656 kW-hours per year of power
• Cooled by a 5 ton chiller
They’re big
(this is the one that matters)
The aggregate computational capability of the ERDC MSRC is 42 TFLOPS.

It would take 1,000 scientists working with calculators around the clock over 640 years to do the work our computers can do in 1 second.
These machines tell us about the world around us
**THE GRAND CHALLENGE EQUATIONS**

\[ B_i A_i = E_i A_i + \rho_i \sum_j B_j A_j F_{ji} \]

\[ \nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t} \]

\[ \vec{F} = m \vec{a} + \frac{dm}{dt} \vec{v} \]

\[ dU = \left( \frac{\partial U}{\partial S} \right)_V dS + \left( \frac{\partial U}{\partial V} \right)_S dV \]

\[ \nabla \cdot \vec{D} = \rho \]

\[ Z = \sum_j g_j e^{E_j/kT} \]

\[ F_j = \sum_{k=0}^{N-1} f_k e^{2\pi ijk/N} \]

\[ \nabla^2 u = \frac{\partial u}{\partial t} \]

\[ \nabla \times \vec{H} = \frac{\partial \vec{D}}{\partial t} + \vec{j} \]

\[ \nabla \cdot \vec{B} = 0 \]

\[ P(t) = \sum_i W_i B_i(t) \]

\[ \rho_{n+1} = \rho_n (1 - \rho_i) \]

\[ -\left( \frac{\hbar}{8\pi^2 m} \right) \nabla^2 \Psi(x,t) + V \Psi(x,t) = -\left( \frac{\hbar}{2\pi i} \right) \frac{\partial \Psi(x,t)}{\partial t} \]

\[ -\nabla^2 u + \lambda u = f \]

\[ \frac{\partial \vec{v}}{\partial t} + (\vec{u} \cdot \nabla) \vec{u} = -\frac{1}{\rho} \nabla p + \nabla \Psi \frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} + \frac{\partial^2 u}{\partial z^2} = f \]

- Newton's Equations
- Schrödinger Equation (Time Dependent)
- Navier-Stokes Equation
- Poisson Equation
- Heat Equation
- Helmholtz Equation
- Discrete Fourier Transform
- Maxwell's Equations
- Partition Function
- Population Dynamics
- Combined 1st and 2nd Laws of Thermodynamics
- Radiosity
- Rational B-Spline

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High Performance Computing Modernization Program

...solving the hard problems
• ERDC 42 TFLOPS  
  (+80 TFLOPS in Nov)  
• NAVO 69 TFLOPS  
• MSU 14 TFLOPS  
• …
The aggregate computational capability of the state of MS is over 130 TFLOPS.

It would take 1,000 scientists working with calculators around the clock 2,000 years to do the work our computers can do in 1 second.
That’s a lot of science
The Numerical Flow Analysis (NFA) code provides key capabilities to model breaking waves around a ship, including both plunging and spilling breaking waves, the formation of spray, and the entrainment of air. NFA uses a Cartesian-grid formulation with immersed-body and volume-of-fluid methods. The governing equations are formulated on a Cartesian grid, thereby eliminating complications associated with body-fitted grids. The sole geometric input into NFA is a surface parameterization of the ship hull. The ease of input in combination with a parallel flow solver permits the rapid turnaround of numerical simulations of complex interactions between free surfaces and ships. Inset 1 shows a volume rendering of the flow. Insets 2 and 3 show the isosurface colored by velocity.
Dr. Wieslaw Maslowski
Coupled Environmental Model Prediction

Long-term environment modeling in pan-Arctic region utilizing coupled ice/ocean simulations for military operations planning.
Isosurface of energy from non-ideal air blast in urban terrain. Surrounding buildings are modeled as non-responding structures. The underlying computational mesh is partially exposed at the top and right-hand side of the energy isosurface (2.1 x 10^10 ergs/gm). Insets show conceptual view of Times Square (1), top view of the energy isosurface (2) and the building surfaces colored by peak overpressure (3).
On August 29, 2005, Hurricane Katrina struck a glancing blow to New Orleans, undermining the levees and flooding New Orleans. Inset 1 shows the Hurricane Katrina surge and wind impact on the Louisiana and Mississippi Gulf Coast, as performed under the auspices of the Interagency Performance Evaluation Task Force. The Hurricane Katrina satellite image in inset 2 is courtesy of NASA/Jeff Schmalz, MODIS Land Rapid Response Team.
At about 2:30 p.m. Saturday, December 14, 1996, the Bright Field freighter ran into the Riverwalk Mall on Poydras Street Wharf in New Orleans. This event was the impetus for the above computational windfield simulation of contaminant dispersal. Using supercomputers to analyze similar scenarios plays an important role in improving homeland security and defense planning. Insets show conceptual view of Riverwalk Mall with streamlines (1) the building surfaces colored by wind-field momentum (2), and the region of New Orleans under investigation (3).
Why do you care?
Telescope
1608
...solving the hard problems

High Performance Computing Modernization Program
The breadth of these examples highlights a unique aspect of high-performance computing that distinguishes it from other scientific instrument—its universality as an intellectual amplifier.
Why do you *personally* care?
High Performance Computing Modernization Program

...solving the hard problems