MISSISSIPPI STATE UNIVERSITY™

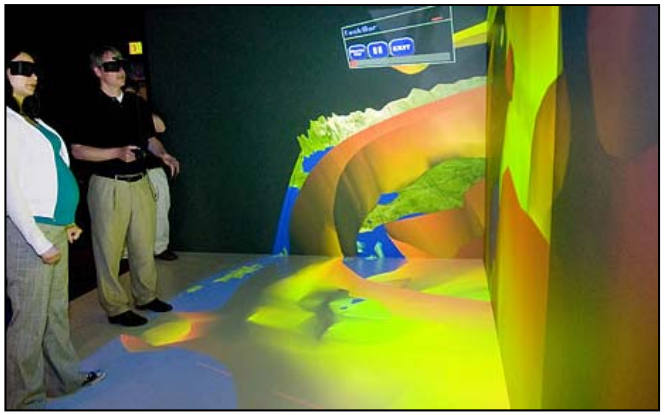
Mississippi State University High Performance Computing Collaboratory Brief Overview

Trey Breckenridge
Director, HPC

HPC² High Performance Computing COLLABORATORY

Mississippi State University

- Public university (Land Grant) founded in 1878
  - Traditional strengths are agriculture and engineering
- Student enrollment exceeds 20,000
  - 20% are graduate students
- Carnegie classification (US only) is now RU/VH
  - One of 108 cited for “very high research activity”
  - One of 40 public universities with RU/VH and “Community Engagement” classifications
- MSU ranks 60th among public US universities for R&D expenditures
  - 6th in agricultural sciences
  - 31st in computer sciences
  - 35th in engineering research
  - 39th in social sciences



MISSISSIPPI STATE UNIVERSITY

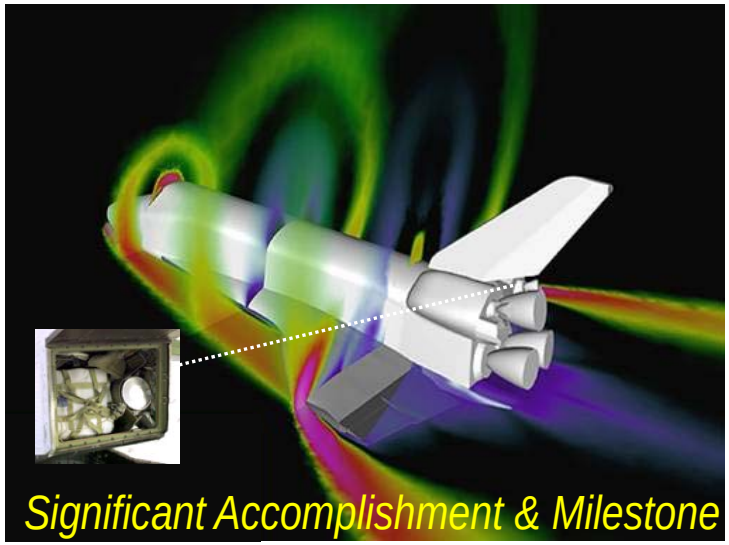
HPC2

History of the High Performance Computing Collaboratory (HPC²)

- Evolution of the National Science Foundation Engineering Research Center *for Computational Field Simulation (1990-2001)*
  - Mission: To reduce the time and cost of complex field simulations for engineering analysis and design

1998 NASA STS-95 (John Glenn)
Mission: the drag chute door fell off at launch.

A Shuttle simulation was completed by the ERC during the Mission. This demonstrated that the ERC had reduced the CAD to solution time from 2 months to 2 days.



Significant Accomplishment & Milestone

MISSISSIPPI STATE UNIVERSITY

HPC²

History of the HPC^2

- Over the 11-year life cycle as NSF ERC, annual funding increased by an order of magnitude
- Graduated from the ERC program in 2001
- Life after NSF ERC
  - Maintain same philosophies: HPC and multi-disciplinary research
  - Broaden scope beyond CFS
  - Become fiscally self-sufficient
- Renamed as the High Performance Computing Collaboratory

The HPC^2 Today

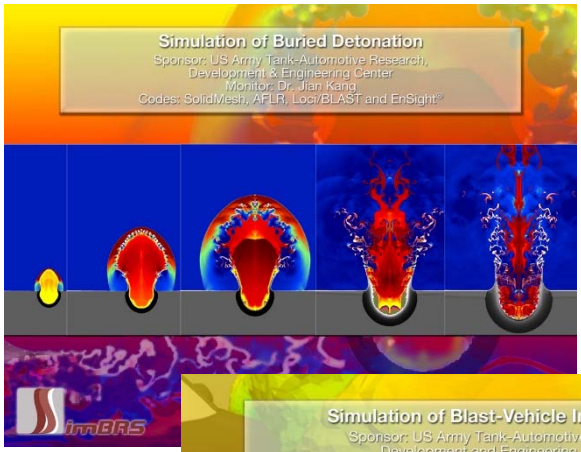
- A coalition of centers and institutes that share a common focus on
  - ✓ Advancing the state-of-the-art in **computational science and engineering** through the utilization of **high performance computing**
  - ✓ **Multi-disciplinary** research
  - ✓ **Education, research and service**
- HPC^2 provides computing, operational, and administrative (business) functions for a group of affiliated centers/institutes
  - ➢ More than just a supercomputing center

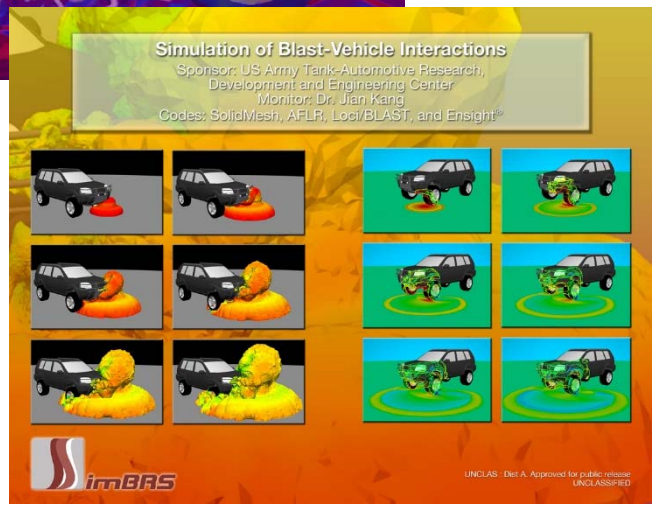
The Centers/Institutes of the HPC^2

- Currently comprised of 7 independent centers and institutes:
  - Center for Advanced Vehicular Systems (CAVS)
  - Center for Battlefield Innovation (CBI)
  - Center for Computational Sciences (CCS)
  - Distributed Analytics and Security Institute (DASI)
  - Geosystems Research Institute (GRI)
  - Institute for Genomics, Biocomputing and Biotechnology (IGBB)
  - Northern Gulf Institute (NGI)

HPC² Research Focus Areas

- Astrophysics
- Computational Fluid Dynamics
- Data Analytics
- Computational Manufacturing
- Cyber Security and Forensics
- Geographic Information Systems
- Genomics and Proteomics
- Human Factors
- Materials Modeling
- Molecular Modeling
- Scientific Visualization
- Transportation Modeling and Planning
- Unmanned Aerial Systems and Remote Sensing
- Weather and Ocean Modeling





MISSISSIPPI STATE UNIVERSITY

HPC²

HPC² Facilities: Buildings

Thad Cochran Research, Technology & Economic Development Park
Starkville, MS

- HPC Building
  - 71,000 square feet
- CAVS Building
  - 57,000 square feet

NASA Stennis Space Center
MS Gulf Coast

- Science and Technology Building
  - 38,000 square feet

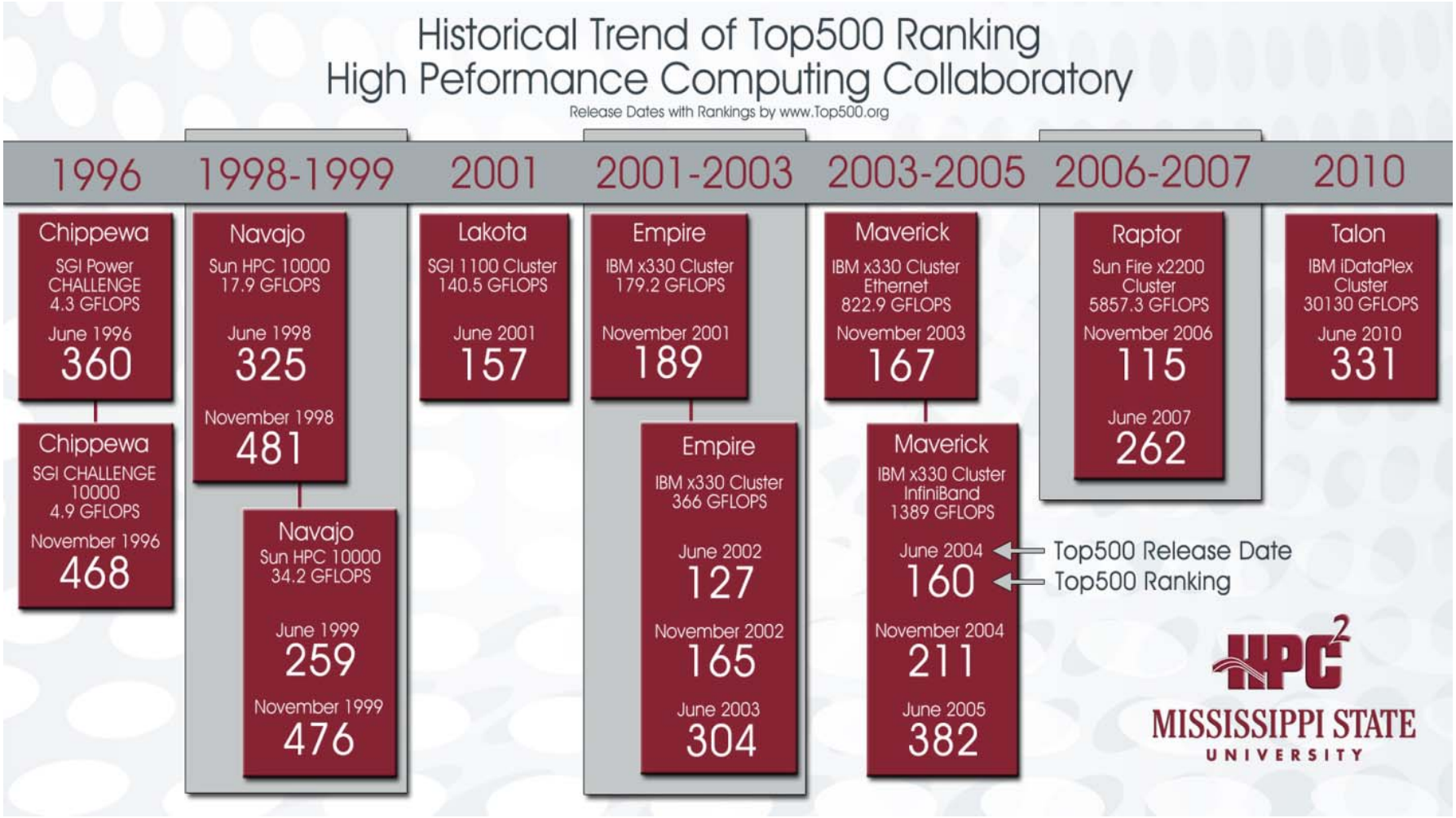
MISSISSIPPI STATE UNIVERSITY

HPC²

Technology Innovations at MSU HPC^2

- Myrinet
  - One of the first Myricom customers
  - Wrote Myrinet drivers for several platforms
- MPI
  - MPICH-1 – the MSU/ANL Implementation
  - MPI implementations for Sun and SGI
- InfiniBand
  - One of first large-scale, production IB HPC clusters
- Warm-water cooling
  - First to implement WWC on Xeon Phi
  - First to use WWC in sub-tropical environment

TOP500 History at MSU



HPC² Computational Resources

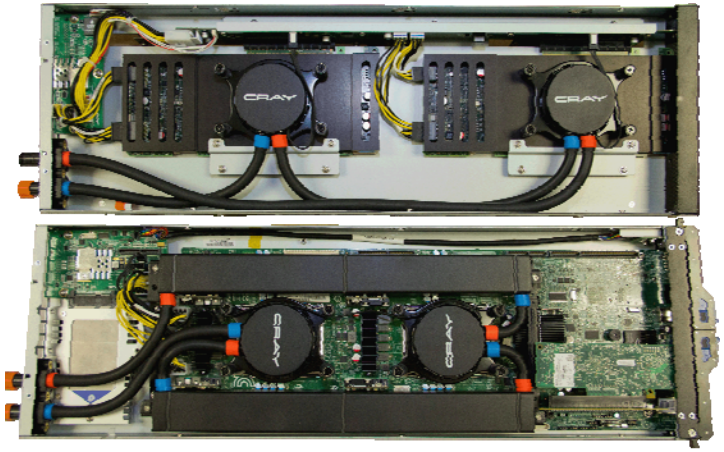
- High Performance Computing (HPC) systems
  - Shadow: Cray CS300-LC
    - ✓ 316 TeraFLOPS
    - ✓ 18,240 cores (2640 traditional/15,600 Xeon Phi)
    - ✓ 8 TB of main RAM; 2TB of co-processor RAM
    - ✓ FDR Infiniband (56 Gbps)
    - ✓ Direct warm water cooling
  - Talon: IBM iDataPlex
    - ✓ 34.4 TeraFLOPS
    - ✓ 3072 cores; 6 TB of RAM
    - ✓ QDR Infiniband (40 Gbps)
    - ✓ Chilled rear-door cooling
  - Raptor: Sun X2200m2 Cluster
    - ✓ 10.6 TeraFLOPS
    - ✓ 2048 cores; 4 TB of RAM
    - ✓ 10Gig/1Gig Ethernet
  - C: Cray XT5
    - ✓ 8 TeraFLOPS
    - ✓ 1440 cores; 360 GB of RAM

Shadow (CS300-LC) configuration

- 128 compute nodes
  - Two Intel E5-2680 v2 “Ivy Bridge” processors,
    - ✓ 10 cores (2.8 GHz)
  - 64 GB memory (DDR3-1866)
  - 80GB SSD drive
  - Mellanox ConnectX-3 FDR InfiniBand (56Gb/s)
  - Two Intel Xeon Phi 5110P coprocessors
    - ✓ 60 cores (1.053 GHz)
    - ✓ 8 GB GDDR5 memory
- Two redundant management nodes
- Three login/development nodes
- Fully non-blocking Mellanox FDR InfiniBand network
- Compute node peak performance: 316 TFLOPS
  - Achieved 80.45% efficiency on Linpack (254.328 TFLOPS)

Cray CS300-LC

- Direct, warm-water cooled
  - Input water temperature up to 40C (104F)
  - Only system on the market that could water cool the processor, memory, and Intel Xeon Phi (or NVIDIA GPU)
  - Secondary water loop with low pressure and low flow into each node
  - Each CPU (and each Xeon Phi) has its own water pump, so built in redundancy.
  - Lots of water sensors with a nice monitoring and alert capability



HPC² Computational Resources (continued)

- Storage
  - ~1 Petabyte (PB) of disk storage
  - 9 Petabytes (PB) of near-line tape storage

- Desktops/Laptops
  - 210 Faculty/Staff desktops and laptops
  - 165 Student desktops
  - 120 Lab, meeting room, and other systems

- Networking
  - LAN: 10 Gigabit Ethernet Backbone
    - ✓ 10 Gigabit connected servers
    - ✓ 1 Gigabit Ethernet to every other device
  - WAN: 20 Gigabit connectivity via two geographically diverse routes

Questions?

MISSISSIPPI STATE UNIVERSITY

HPC²