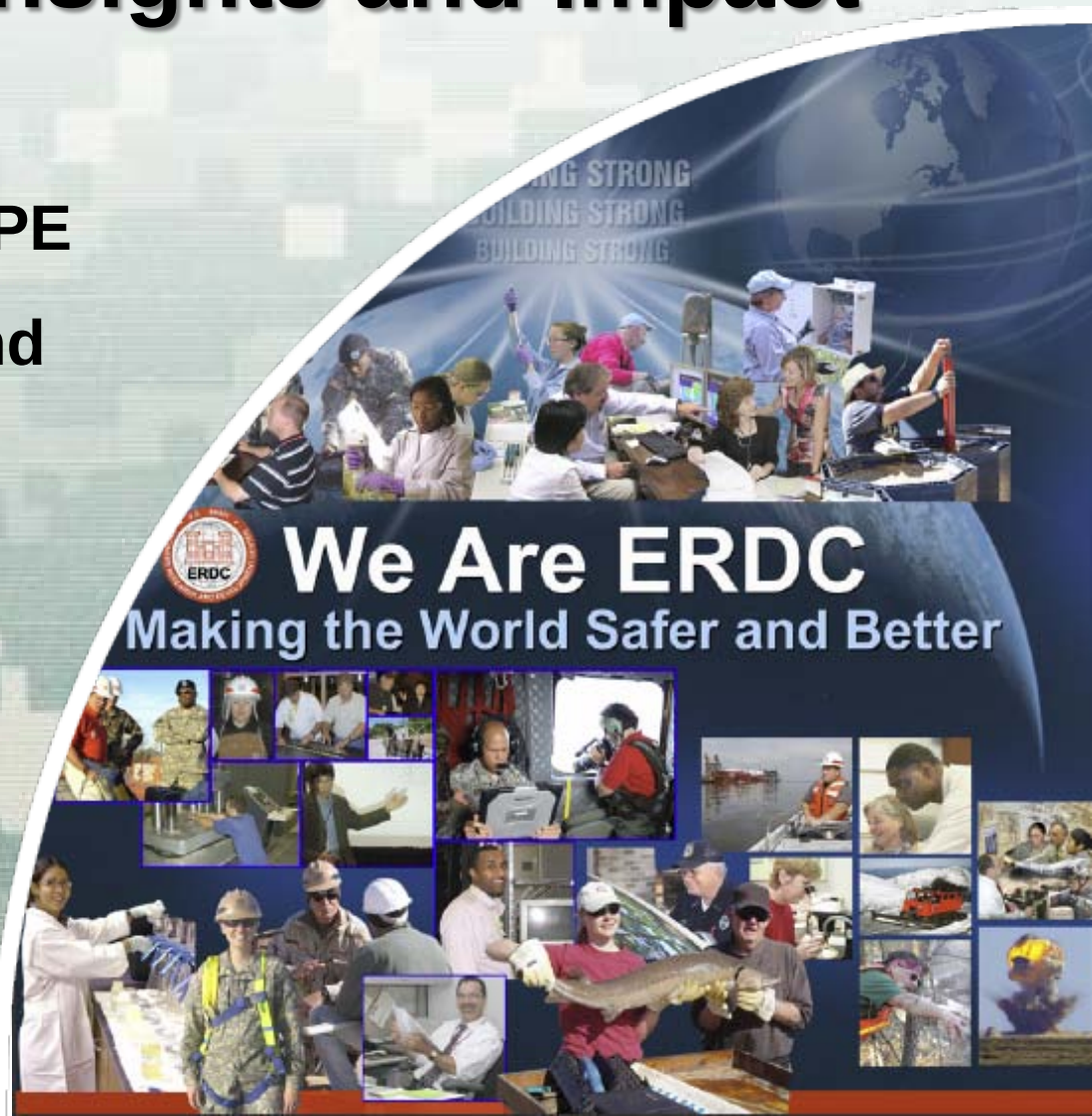
DoD Science and Engineering Computations: Insights and Impact

Jeffery P. Holland, PhD, PE

Director, USACE R&D and Engineer Research and Development Center

15 November 2011



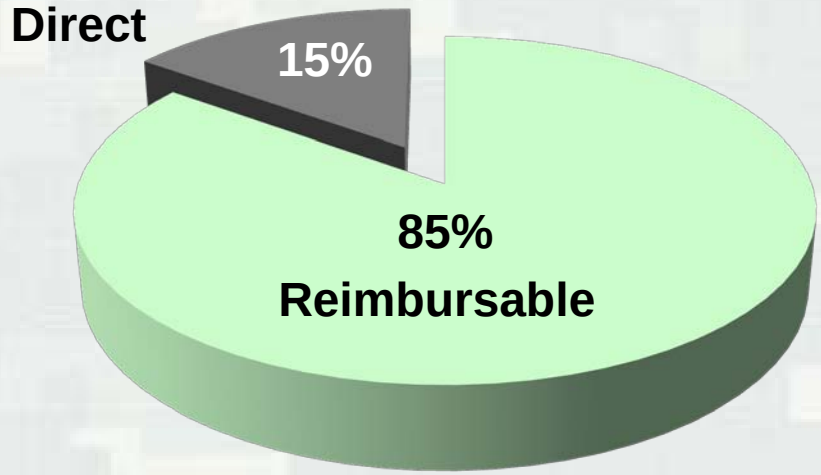
US Army Corps of Engineers
BUILDING STRONG®

Engineer Research and Development Center (ERDC)

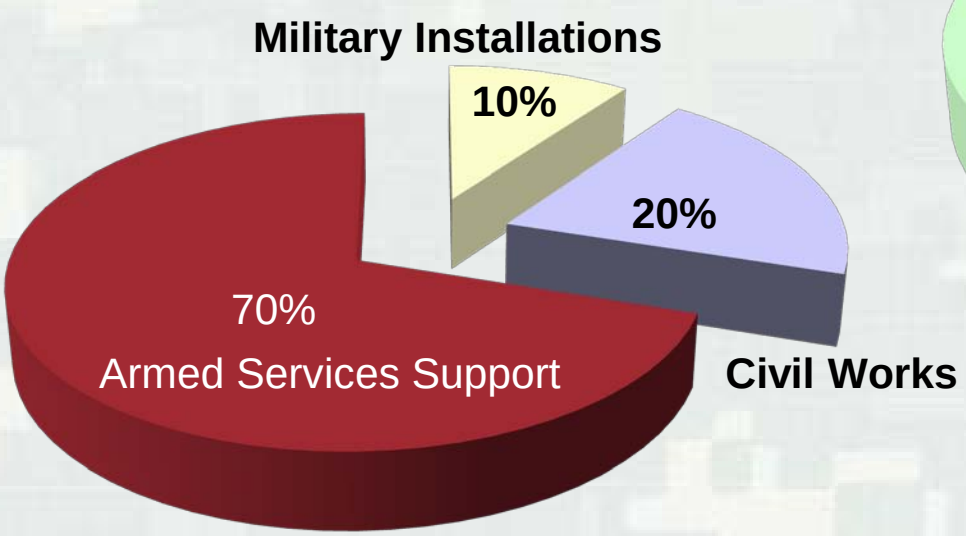
2500 Employees

ERDC Program

Research Funding Type



Research Areas

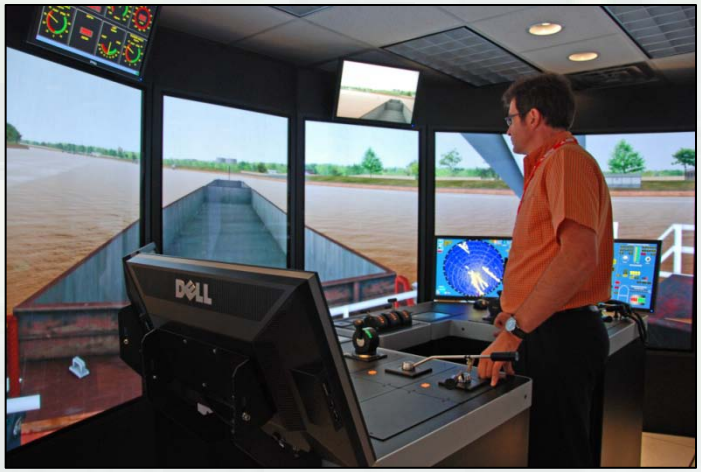


$1.6 Billion Total FY 11 Funding

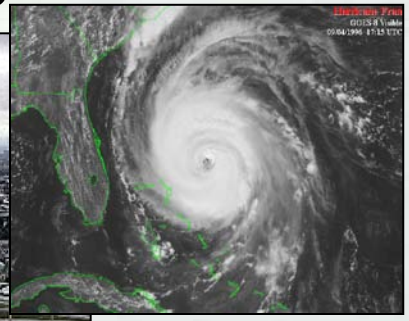
Support to Combat, Stability and Disaster Operations

BUILDING STRONG®

Providing Enduring and Essential Water Resource Solutions

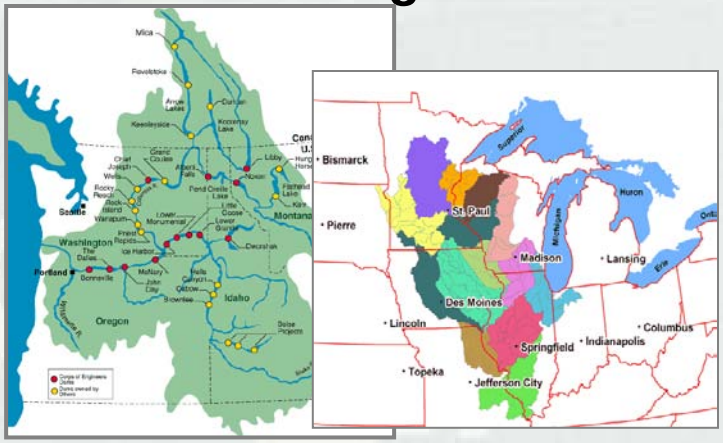


Navigation



Flood and Coastal Storm Damage Reduction

Environment



Regional/Watershed Solutions

BUILDING STRONG®

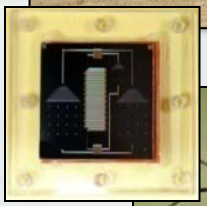
Operationalizing Sustainability

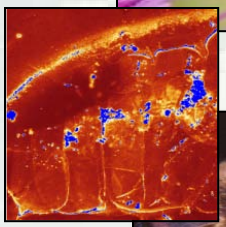
Sustainable Ranges and Lands

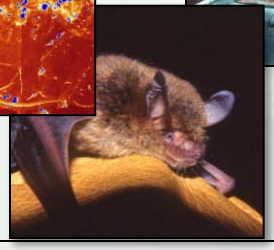




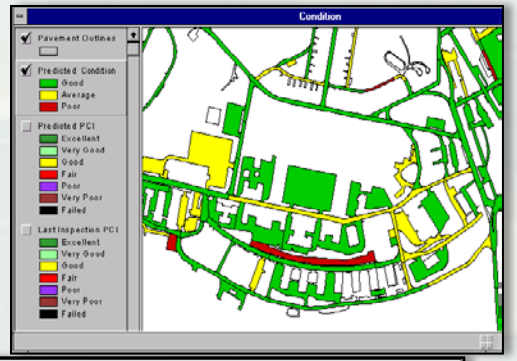
Materials in the Environment

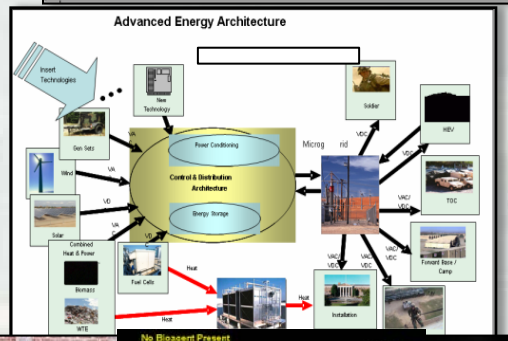





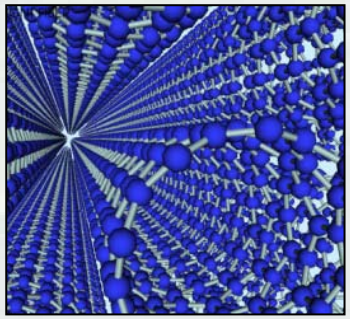


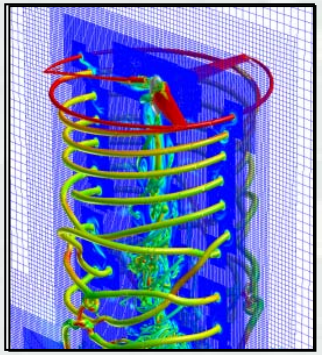
Adaptive, Resilient Installations and Systems

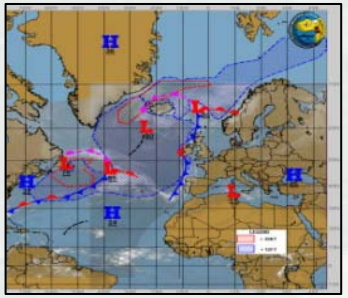




High Performance Computing (HPC) is key to addressing the DoD's most significant challenges:







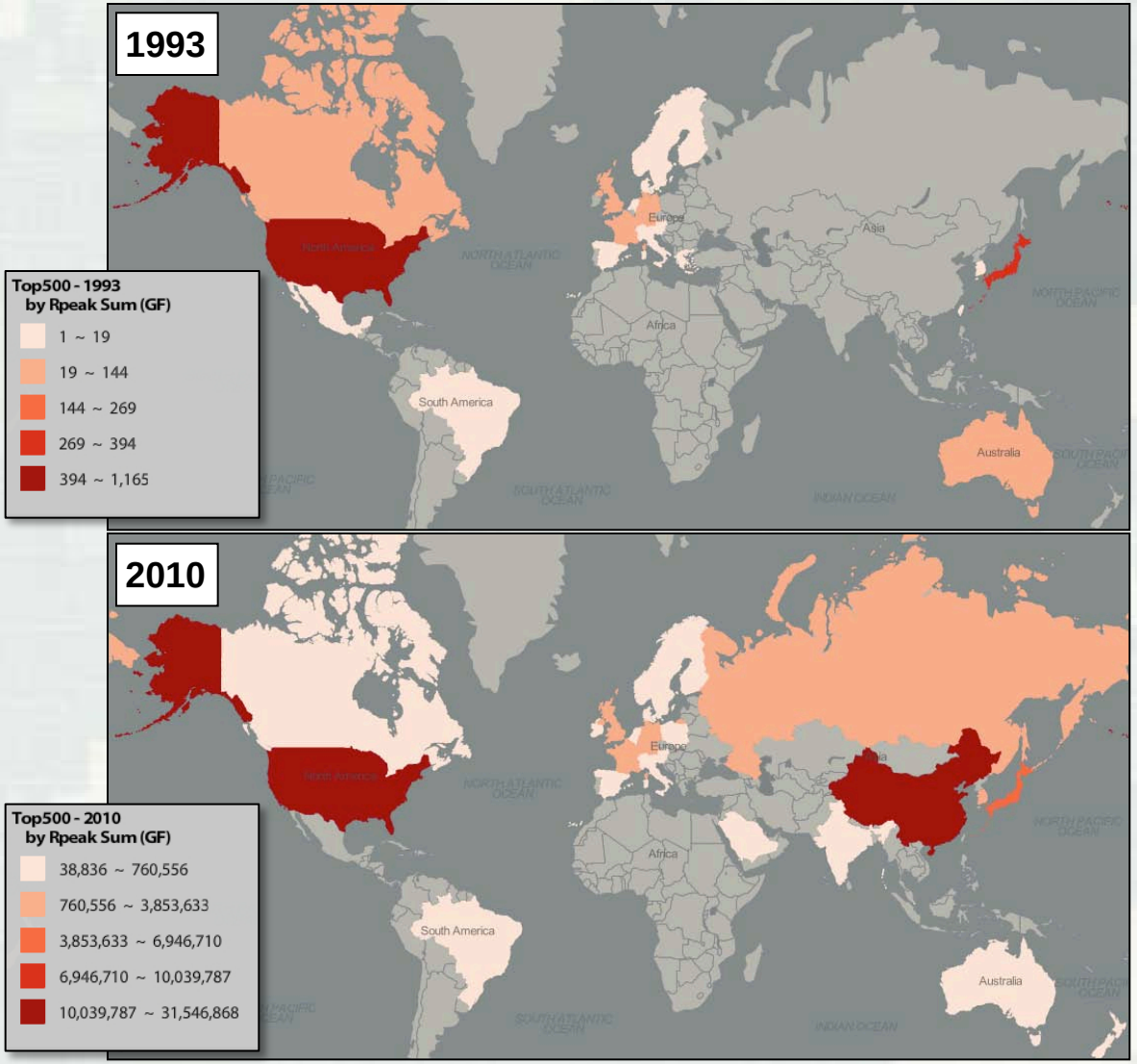
- In ***research***, HPC enables exploration and evaluation of new theories well beyond what is financially possible using experiments alone.
- In ***acquisition***, HPC facilitates the use of validated applications in design and testing.
- In ***operations***, HPC allows for real-time calculations to produce just-in-time information for decision makers on the battlefield.

HPC is transforming and revolutionizing DoD's ability to accomplish its present and future mission.

HPC – A Strategic Asset

Worldwide Peak Computational Capability

Over the past two decades, countries worldwide have recognized the strategic advantage realized by the US investment in HPC and are now racing to catch up.

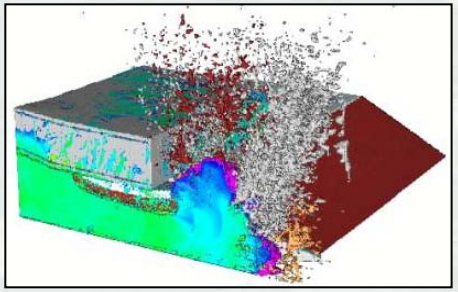


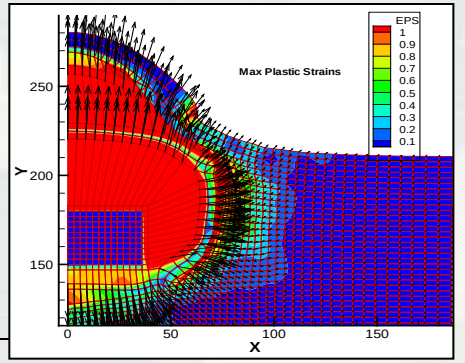
- **ERDC has a long history of using modeling to expand the understanding of real world phenomena since its founding in 1931.**
- **Today, this capability is supported by some of the world's largest computers running validated numerical models.**

ERDC HPC Success Stories

Solutions for IED Detection and Deterrence

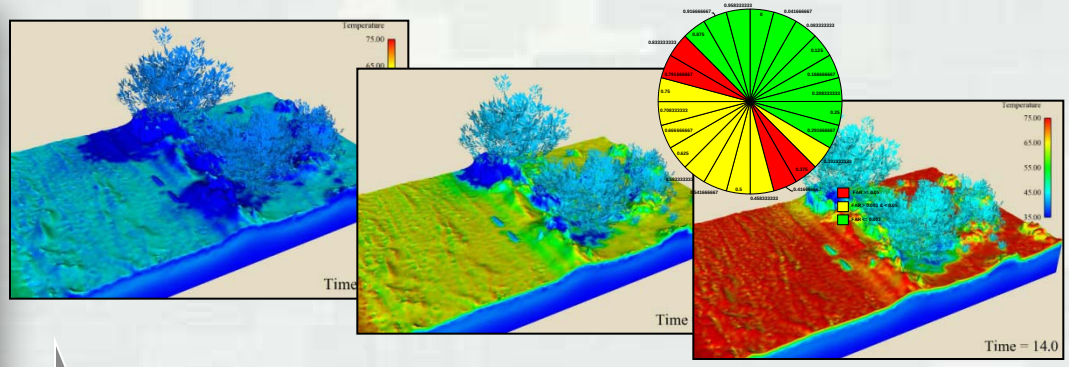
"Hard Impact" anti-blast technology protecting MRAPs from culvert IEDs



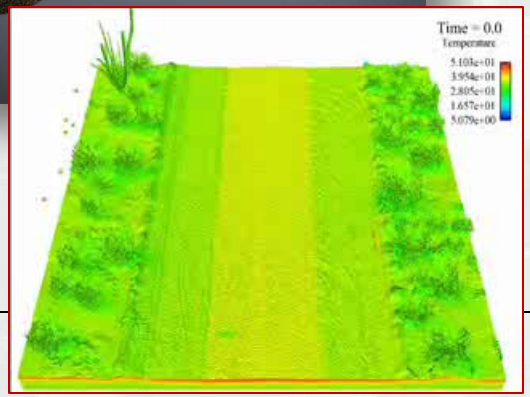


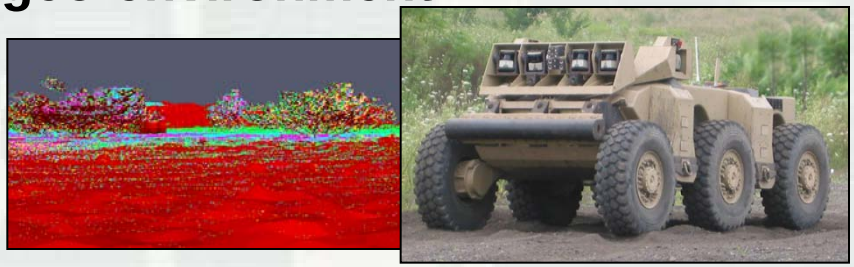
ERDC HPC Success Stories
Sensor Development Support

High-fidelity models to predict and improve performance of Current and Future Force sensor systems for surface and near-surface target detection within complex geo-environments



Geometric representations of vegetation indigenous to a specific geo-environment

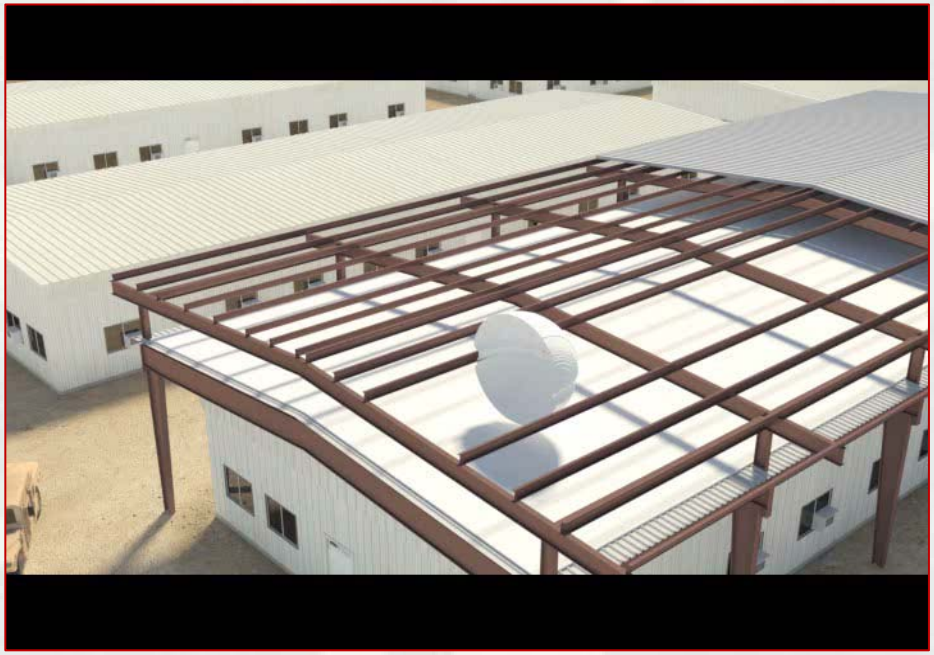


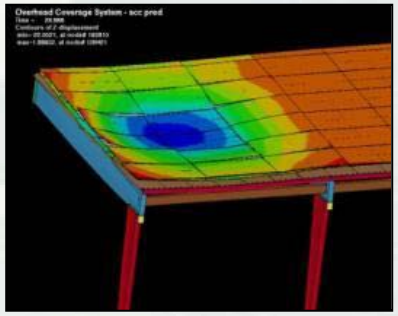


Simulated LADAR Sensors

ERDC HPC Success Stories

Overhead Cover Analysis for Emerging Threats





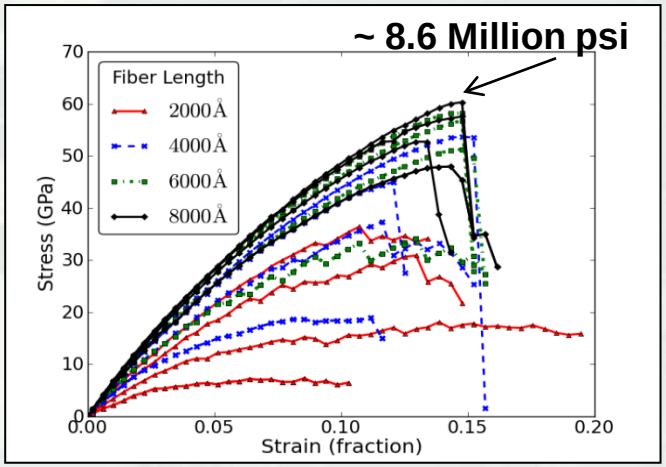
- Computational Fluid Dynamics (CFD) to understand complex blast loads
- Finite Element Method (FEM) for dynamic structural response
- Field evaluation to validate structural response and protection

ERDC HPC Success Stories

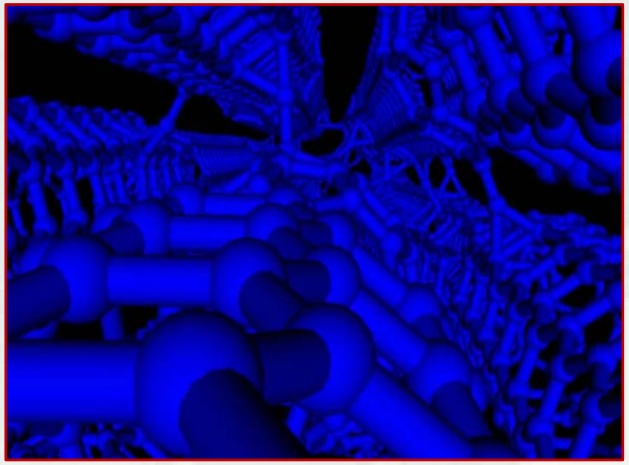
Lifecycle of New Materials

Design first, then build at the molecular level

- **Molecular design for scalable carbon nanotube fiber using MD simulations and verifying experimental data**
- **Max tensile strength >8 million psi, 10 million+ cpu hours, simulations of 1 million+ atoms**
- **Provided new insights into fiber response, identified unsuccessful design approaches, and saved many man-years of research**
- **8X tensile strength of the strongest carbon fiber and up to 16X strength of Kevlar at significantly lower weight**



Predicted fiber response for varied cross-link densities and CNT lengths



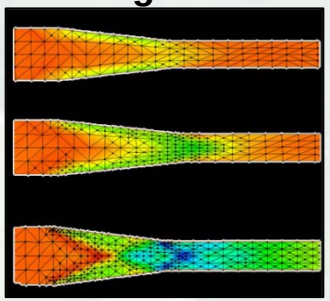
MD simulation of cross-linked CNT fiber(Cornwell et al., 2010)

Plasma system being readied for CNT fiber irradiation experiments

ERDC HPC Success Stories

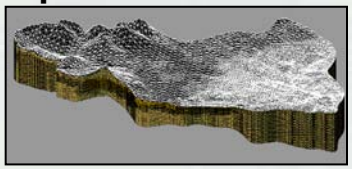
Adaptive Hydraulics/Hydrology Model

Adaptive and Moving Meshes



Tetrahedra, triangles

a posteriori error indicators

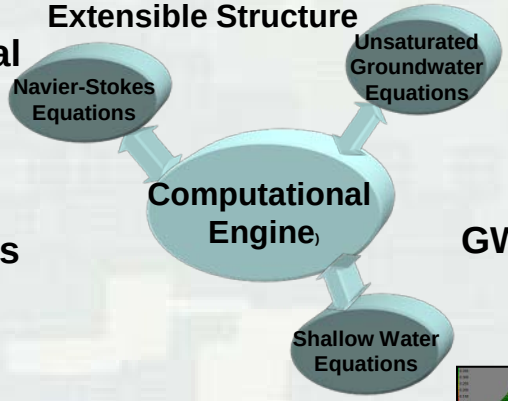


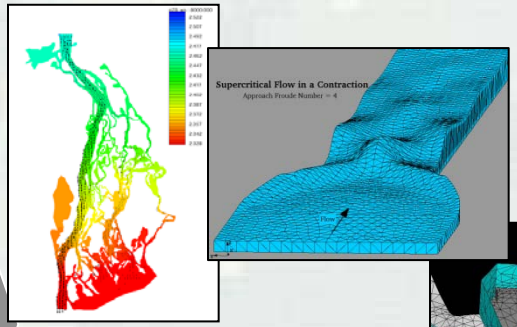
Computational Engine

Utilities

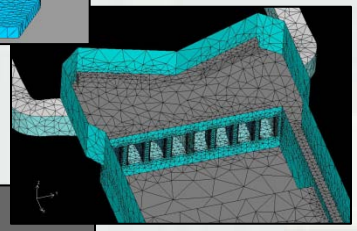
Multiple equations sets

Extensible Structure

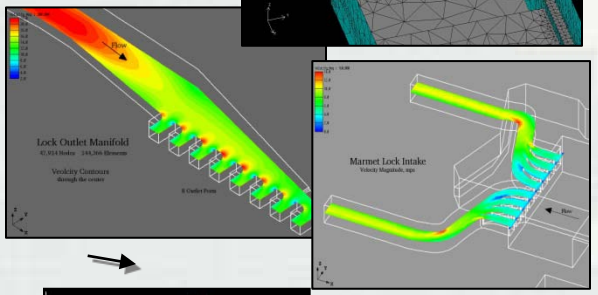




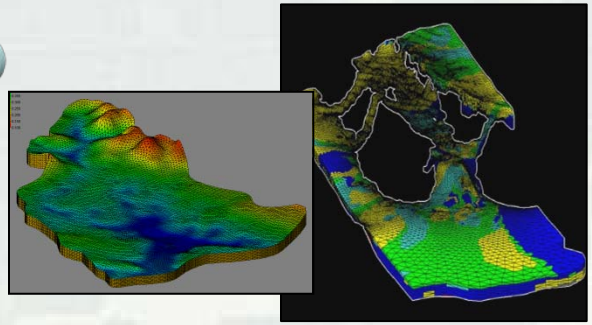
Riverine and Overland Flow

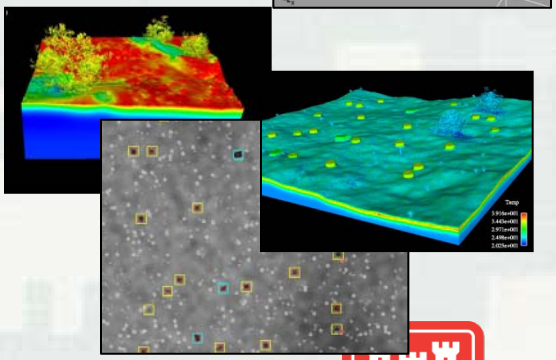


Internal Flows



Groundwater and GW/Surface Water Interaction





Near Surface Fluid Flow and Heat Transport

High Performance Computing

2-D and 3-D hydrodynamic, hydrologic, thermal, and constituent transport simulation

BUILDING STRONG®

DoD HPC Modernization Program

DoD Supercomputing Resource Centers

JOINT COMMUNITY

Army HPCMP Participation

- ARL & ERDC DSRCs
- 1,377 Users/22 Organizations/101 Projects
- 49 DREN Sites
- 12 Challenge Projects/4 DHPIs
- 5 Institutes

Navy HPCMP Participation

- NAVY DSRC
- 1,365 Users/17 Organizations/199 Projects
- 38 DREN Sites
- 12 Challenge Projects/6 DHPIs

Air Force HPCMP Participation

- AFRL & MHPCC DSRCs
- 1,367 Users/24 Organizations/193 Projects
- 25 DREN Sites
- 13 Challenge Projects/4 DHPIs
- 1 Institute

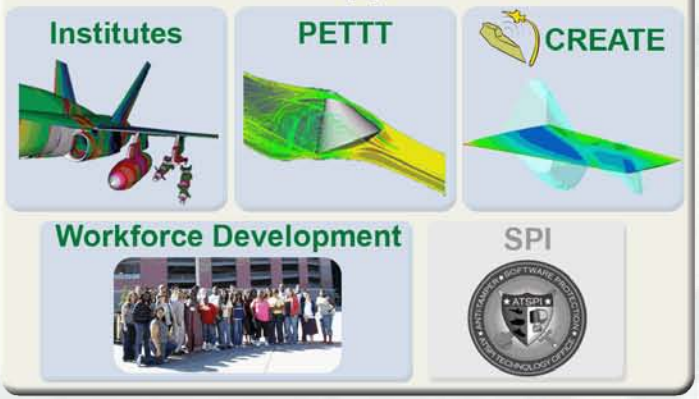
Defense Agencies Participation

- DARPA, DTRA, JFCOM, MDA, PA&E & OTE
- 552 Users/3 Organizations/22 Projects
- 60 DREN Sites
- 3 Challenge Projects

Other

- 52 DREN Sites
- 1 DHPI

Software Applications Support

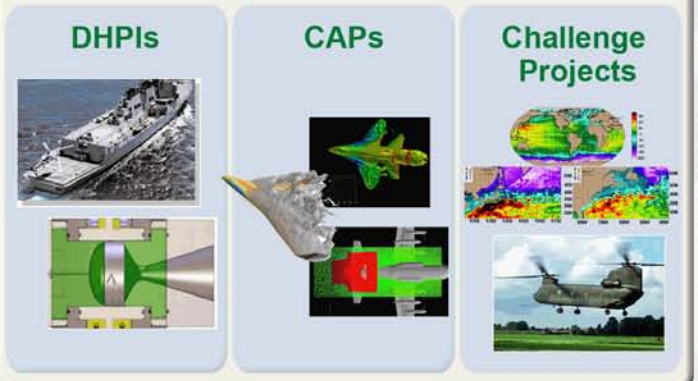


Networking & Security

Defense Research & Engineering Network

Resource Management

Requirements & Allocations



DoD HPC Modernization Program

Vision

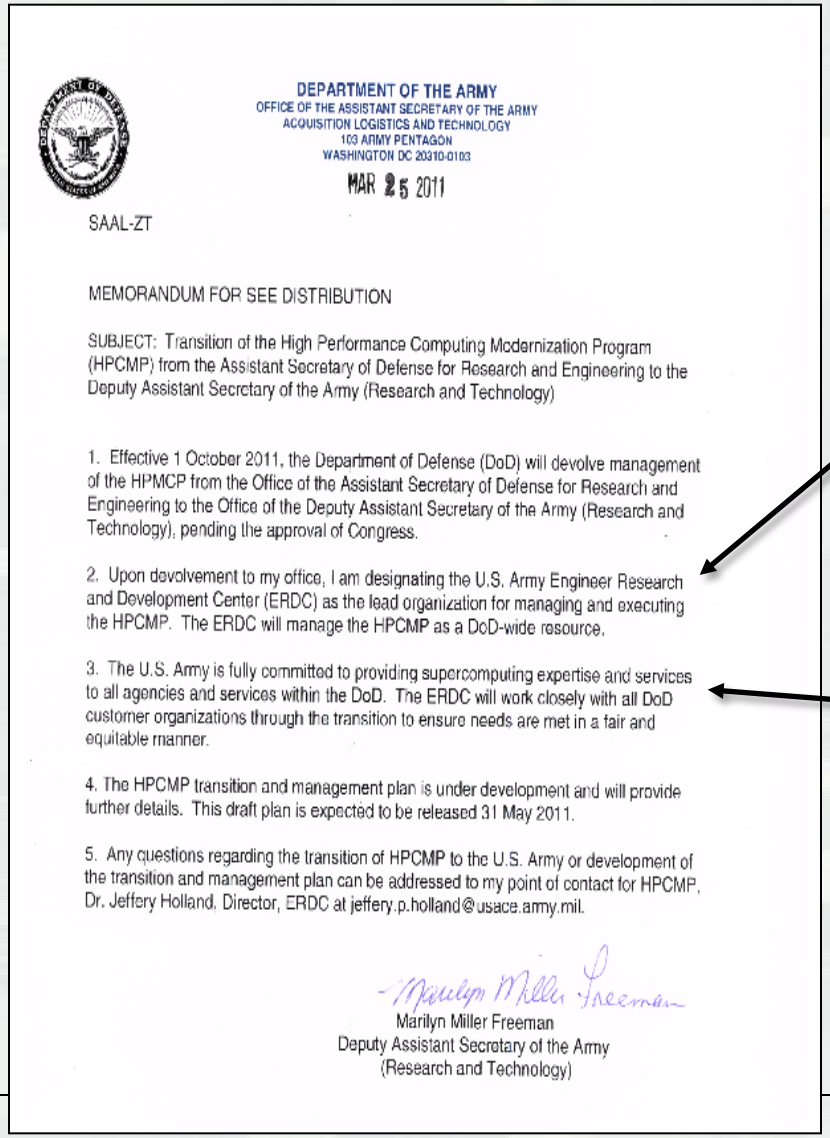
Create a pervasive culture among DoD's scientists and engineers where they routinely use advanced computational environments to solve the most demanding problems transforming the way DoD does business and finding better solutions faster

Mission

Accelerate development and transition of advanced defense technologies into superior warfighting capabilities by exploiting and strengthening US leadership in supercomputing, communications, and computational modeling

DoD HPC Modernization Program

ERDC-Managed in FY12



DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY OF THE ARMY
ACQUISITION LOGISTICS AND TECHNOLOGY
103 ARMY PENTAGON
WASHINGTON DC 20310-0103

MAR 25 2011

SAAL-ZT

MEMORANDUM FOR SEE DISTRIBUTION

SUBJECT: Transition of the High Performance Computing Modernization Program (HPCMP) from the Assistant Secretary of Defense for Research and Engineering to the Deputy Assistant Secretary of the Army (Research and Technology)

1. Effective 1 October 2011, the Department of Defense (DoD) will devolve management of the HPMCP from the Office of the Assistant Secretary of Defense for Research and Engineering to the Office of the Deputy Assistant Secretary of the Army (Research and Technology), pending the approval of Congress.

2. Upon devolvement to my office, I am designating the U.S. Army Engineer Research and Development Center (ERDC) as the lead organization for managing and executing the HPCMP. The ERDC will manage the HPCMP as a DoD-wide resource.

3. The U.S. Army is fully committed to providing supercomputing expertise and services to all agencies and services within the DoD. The ERDC will work closely with all DoD customer organizations through the transition to ensure needs are met in a fair and equitable manner.

4. The HPCMP transition and management plan is under development and will provide further details. This draft plan is expected to be released 31 May 2011.

5. Any questions regarding the transition of HPCMP to the U.S. Army or development of the transition and management plan can be addressed to my point of contact for HPCMP, Dr. Jeffery Holland, Director, ERDC at jeffery.p.holland@usace.army.mil.

Marilyn Miller Freeman
Deputy Assistant Secretary of the Army
(Research and Technology)

"…The ERDC will manage the HPCMP as a DOD-wide resource."

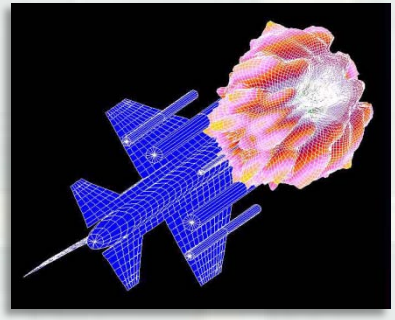
"The U.S. Army is fully committed to continuing to provide supercomputing expertise and services to all agencies and services within the DoD. The ERDC will work closely with all DoD customer organizations through the transition to ensure needs are met in a fair and equitable manner."

DoD HPCMP User Community

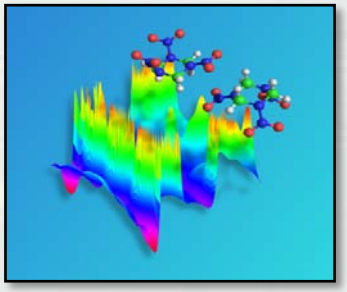
FY12 Requirements

- 515 active projects
- 4,661 users
- 250 sites

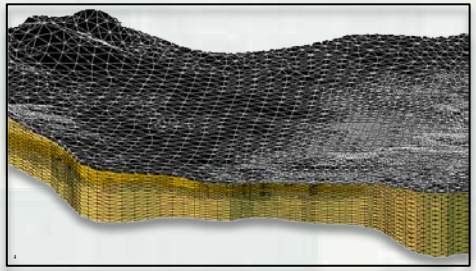
Computational Electromagnetics & Acoustics



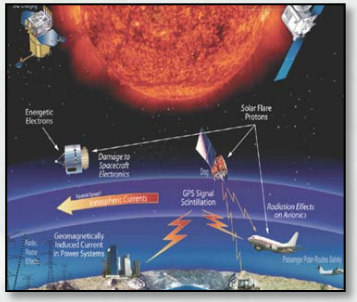
Computational Chemistry, Biology & Materials Science



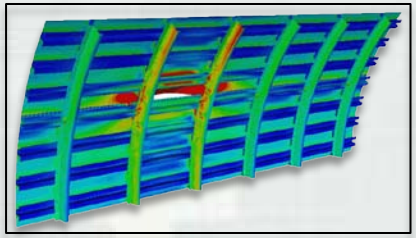
Environmental Quality Modeling & Simulation



Space and Astrophysical Science

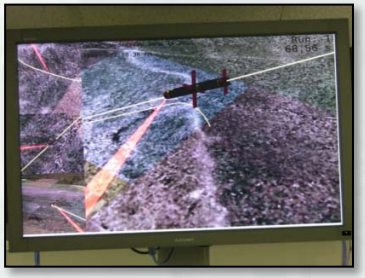


Computational Structural Mechanics



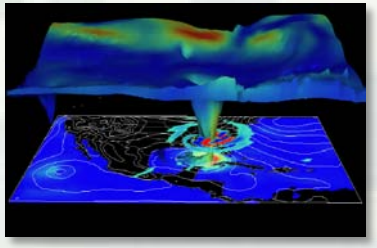
Electronics, Networking, and Systems/C4I

Integrated Modeling & Test Environments

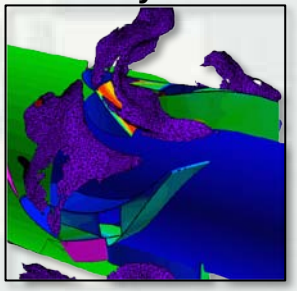


Forces Modeling &Simulation

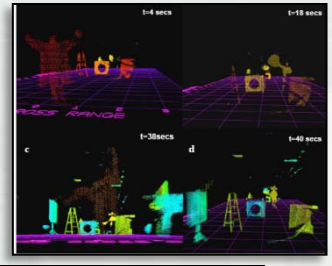
Climate/Weather/Ocean Modeling & Simulation



Computational Fluid Dynamics



Signal/Image Processing



- **DoD has a significant opportunity to do more with less as it supplements, designs, and in some cases replaces physical testing with physics-based modeling.**

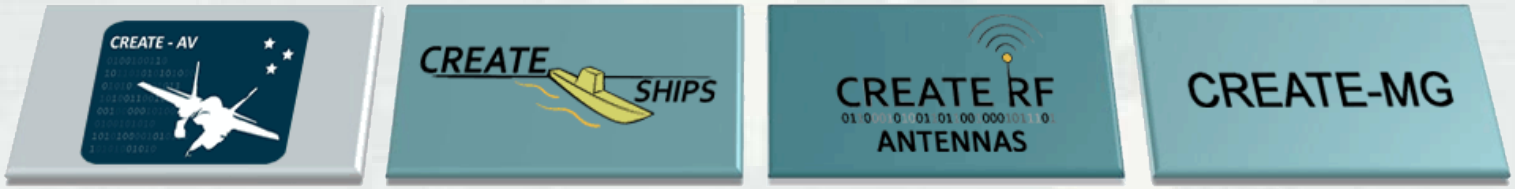
- **This is the fundamental concept behind CREATE as part of the software portfolio of the HPCMP.**

Computational Research and Engineering Acquisition Tools and Environments

CREATE
Computational Research and Engineering Acquisition Tools and Environments

CREATE is a multi-phased program designed to develop and deploy computational engineering tool sets for acquisition engineers.

- **Aircraft (AV) design tools -** Fixed-wing aircraft, rotorcraft, conceptual design, and operational testing & transition
- **Ship design tools -** Shock/damage, hydrodynamics and early-stage design, and operational testing & transition
- **Radio frequency (RF) Antenna design and integration tools -** Conceptual design and detailed analysis tools for a myriad of DoD platforms
- **Meshing and Geometry (MG) support -** Improves the ease, speed, flexibility, and quality of geometry and mesh generation



Increased innovation & reduced development time for DoD weapons systems

The High Performance Computing Modernization Program has been on all of the past 35 Top 500 Supercomputer sites lists since June 1993

Leadership past and present…

19th most powerful computer in the world in June 2011 for AFRL DSRC's Raptor (Cray XE6 8-core) with 8 others in the Top100

28th most energy-efficient supercomputer in the world on Green500 list for November 2007 for MHPCC DSRC's Dell PowerEdge 1955

7th most powerful computer in the world in June 2001 for NAVY DSRC's IBM SP Power3

5th most powerful computer in the world in June 2000 for NAVY DSRC's IBM SP Power3

Total Deployed Capability in GFLOPS

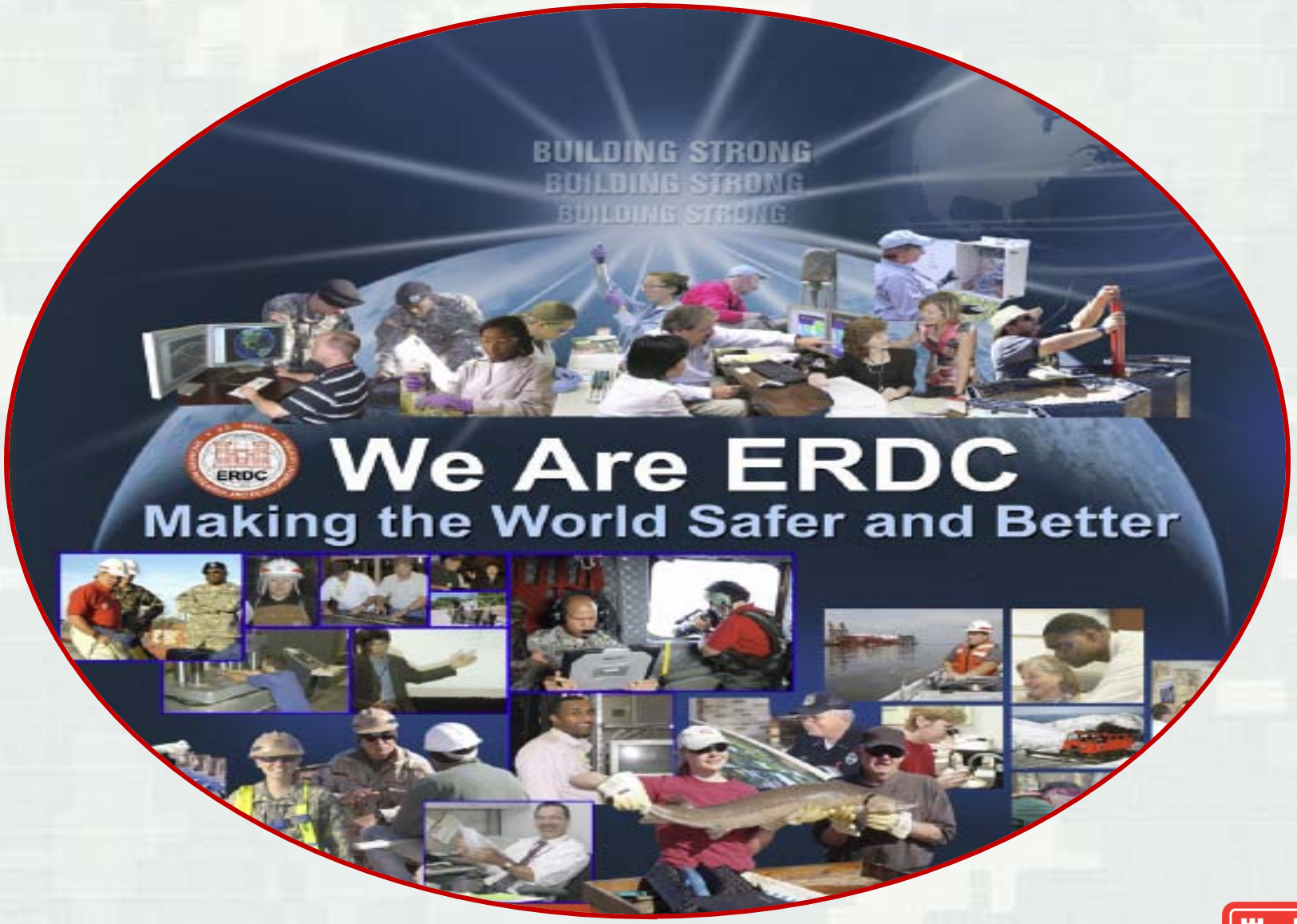
Year	GFLOPS
1996	360
2011	1,790,935

Total Core Count

Year	Cores
1996	1,006
2011	177,592

Total Machine Count

Year	Machines
1996	19
2011	14



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