DoD High Performance Computing

Addressing the Supercomputing Challenge for DoD Research, Development, and Test & Evaluation Projects

2023 DoD SAP and IT Cybersecurity Summit Presentation

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AFRL-2022-2461 & AFRL-2023-5252

Outline

- Background
- DoD supercomputing resources available
  - No charge for computation time
  - Available for use by government, contractors, and academia on DoD contract
- Efforts to support “above secret” requirements

Goal: Increase awareness of DoD supercomputing capabilities available to support programs/projects

Navy Success Story (Susceptibility/Survivability Studies)

- Navy utilized shared DoD HPMCP "above secret" systems for electromagnetic and platform maneuvering/stability evaluations (AI/ML related work)
- "Above Secret" systems made it possible to increase fidelity (spatial, temporal, and spectral) of the susceptibilities community's analytical products
- Without the "above secret" HPCMP capabilities, model runs would not have been completed due to the cost and ability of multiple, independent programs to finance and obtain a comparable HPC capability
- Work substantially furthered Navy efforts to transition advanced technologies to the warfighter in a timely manner

6-month effort completed in 3 weeks

USAF Success Story (Weapons Effects / Survivability)

- **Acquisition Program conducted parametric model runs to quantify weapon attributes and munition effects on engagement/mission survivability**
  - Generated authoritative data for senior leader Decision Support Tool
  - Data will impact programmatic & funding decisions for developmental weapons
- **1,740,000 model runs**
  - Program faced “watering down” study to make programmatic schedule
- **Use of “above secret” systems reduced simulation run time by 88%**
  - Workload optimized
  - Enabled program to run cases at higher fidelity
  - Allowed more testing; ensured analytical confidence without compromising schedule
  - No cost to end user

Completed in 200 days versus 5 years

✓ Cost ✓ Schedule ✓ Performance

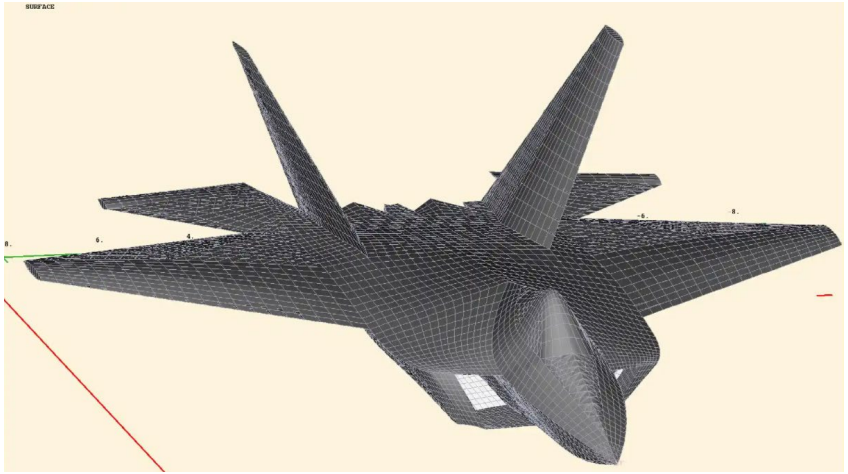
Supercomputing (High Performance Computing)

- Enables problem solving and data analysis that is impossible, too time-consuming or costly with standard computers
- Relies on specialized hardware to orchestrate high-speed, parallel computation at maximum performance

Use of Supercomputing:

Solving Complex Problems via High Speed Parallel Processing

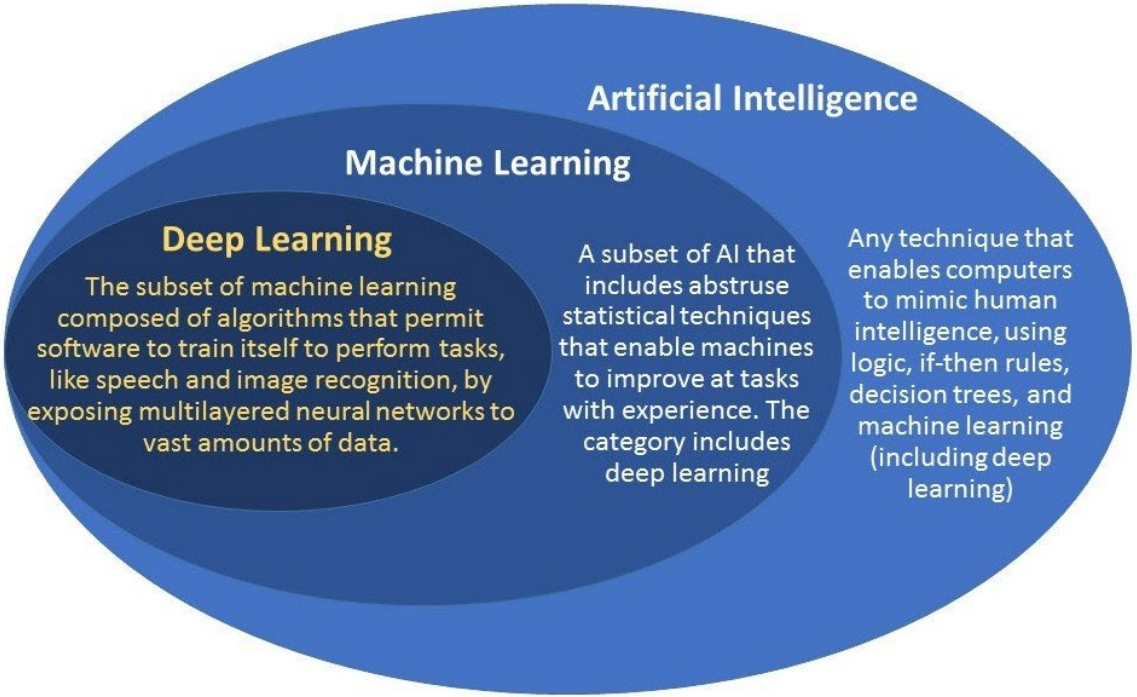
Large problems divided into smaller problems, then solved at the same time in parallel.



Examples: Computational Fluid Dynamics (CFD) & Finite Element Analysis

Use of High Performance Computing:
Artificial Intelligence, Machine Learning (ML), and Deep Learning

- **GPU Intensive**
- **Growing Demand**
- **Evolving Software**
- **Evolving Hardware**



Source: https://www.ibm.com/blogs/systems/ai-machine-learning-and-deep-learning-whats-the-difference/

Use of Supercomputing:
Solve Problems at Higher Fidelity in Less time

Example: ACAT I Program Milestone Decision
Operational Effectiveness Study to Support Down select

2 Future aircraft design concepts
4 Flight Profiles (Low, Med, High, Standoff)
5 Weapon Configurations
3 Environments (Forest, Desert, Mountainous)
2 Times of Day (Day, Night)
10 Weather conditions
5 Electronic Jamming states
2 Target Conditions (Moving, Stationary)
3 Target Types (Early Warning RADAR site, missile launcher, RADAR van)

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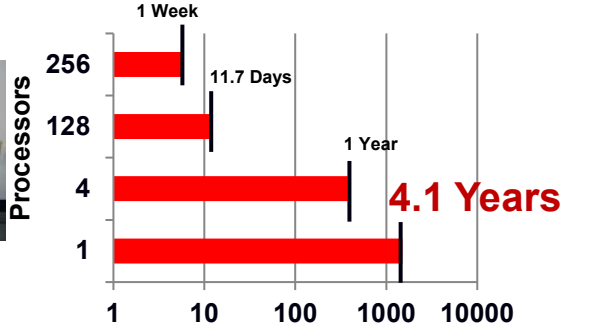
2 x 4 x 5 x 3 x 2 x 10 x 5 x 2 x 3 = **72,000 cases**

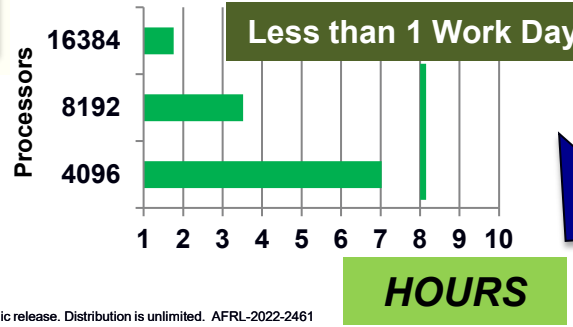
Assume a single model run takes 30 minutes on 1 processor

MUSTANG Supercomputer:
56,448 processors

Performing Model Runs on Workstations or Small Cluster



Using Supercomputer

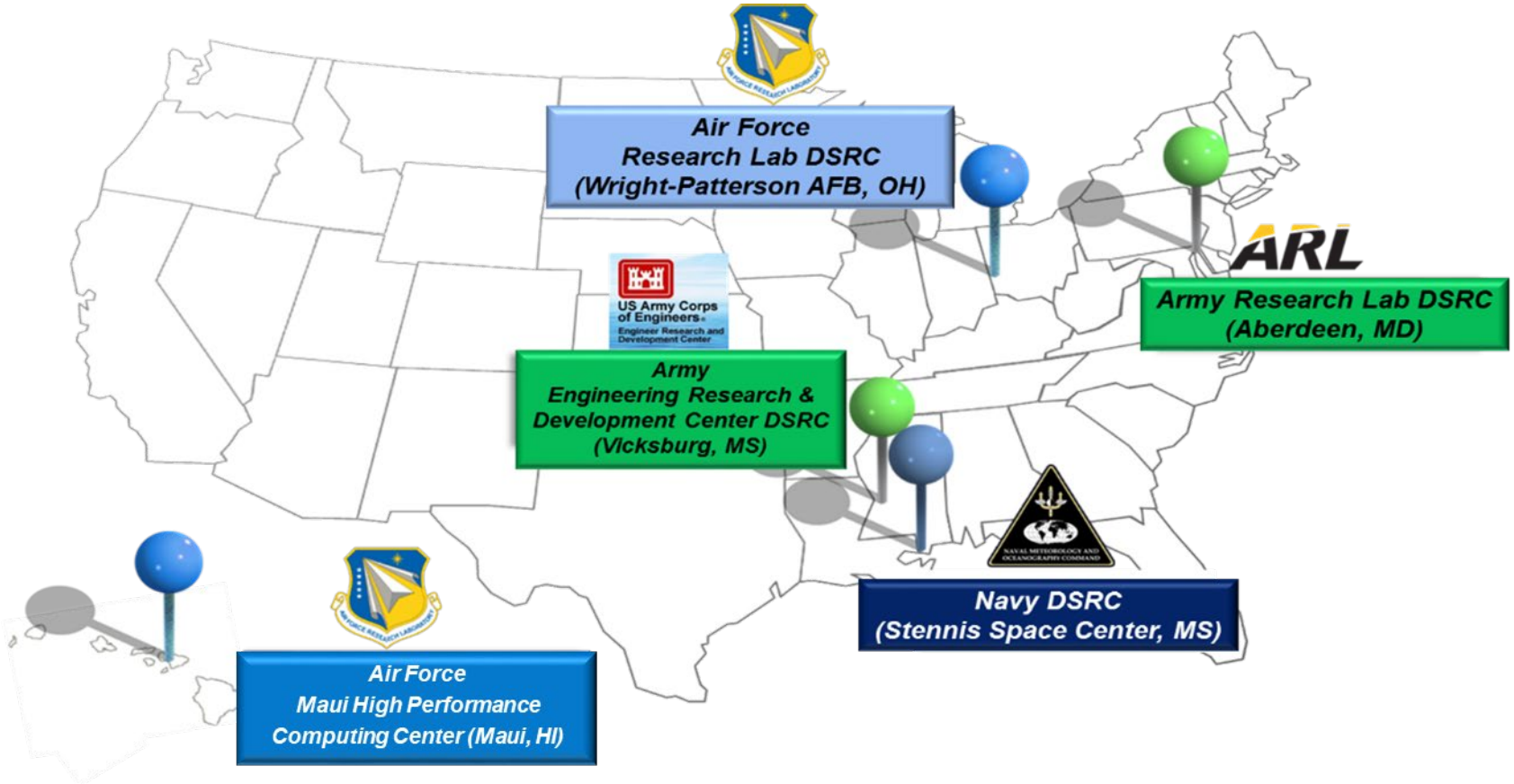


DoD High Performance Computing Modernization Program

- The DoD High Performance Computing Modernization Program (HPCMP) initiated in 1993 in response to Congressional direction
- The Mandate - advance the supercomputing capability for the DoD, provide a national research network, provide software and computational science expertise and support to better enable DoD RDT&E activities
- DoD program administered by Engineering Research & Development Center (Vicksburg, MS) on behalf of Army ASLT
  - Joint Service execution
  - Substantial "in kind" funding from services

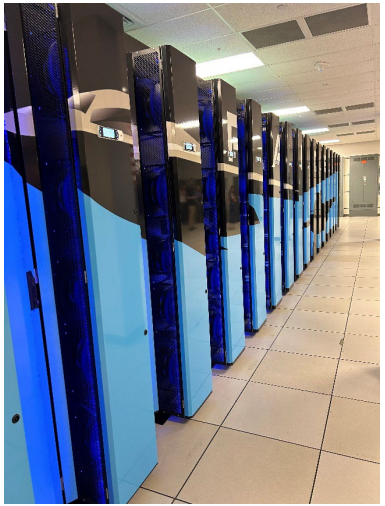
DoD HPC Modernization Program Supports Air Force, Army, Navy, and DoD Agencies

DoD Supercomputing Resource Centers (DSRCs)



Newest System
AFRL Raider

- Penguin Computing
- 189,440 Compute Cores 6.11 PetaFLOPS
- 354 Compute Nodes
  - 8 Large Memory Nodes
  - 32 Quad Machine Learning Nodes
  - 24 Visualization Nodes
  - 64 High Core Performance Compute Nodes
  - 1400 Standard Nodes
- 10 Login Nodes
- 2 Data Transfer Nodes
- 2.0-3.6 GHz AMD ‘Milan” 7713 Processor
  - 64 cores/CPU
- 152 NVIDIA Ampere A100 GPGPUs
- InfiniBand HDR-200 Dragonfly
- 414 TB of Memory, 20 PB Storage



DoD HPCMP Supercomputing Systems

- **Unclassified System Specifications found:**
  - https://centers.hpc.mil/systems/unclassified.html
- **Recurring tech refresh on systems**
- **No charge for compute time**

Defense Research and Engineering Network (DREN)

- Robust, high-capacity, low-latency network
- Connects DoD Supercomputing Resource Centers and user sites
- Supports the DoD Research, Development, and Test & Evaluation missions
- DREN IV provides 1 Gbps to 400 Gbps service to DoD sites
- Supports Multicast, IPv6, and IPv4
- Complies with all DoD Security Regulations and provides secure transport for data between Service Delivery Points (SDPs) at each connected location
- Secret-level network overlay (SDREN)

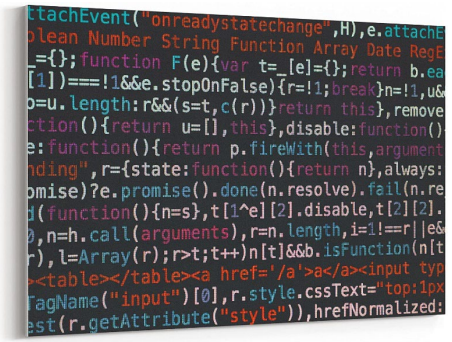
Source: https://www.hpc.mil/program-areas/networking-overview/dren-sdren

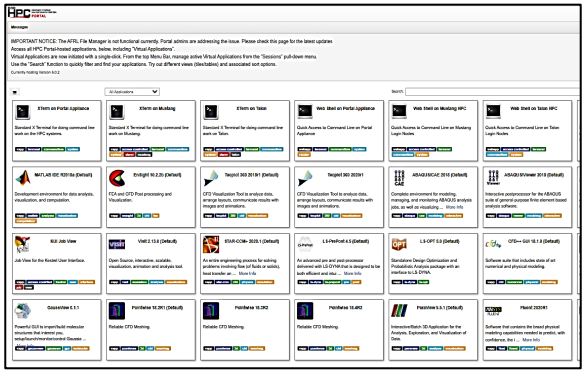
Who can use DoD Supercomputers?

- All users must have a National Agency Check with Inquiries (NACI) or a Security Clearance
- DoD RDT&E entities and support contractors can use DoD HPC systems
- No Charge to Using Organizations for Computation Time

Software On HPC Systems

- **Bring Your Own Code**
  - Stored in your ***/home*** space or in a separate project space
  - We can assist with the build process for our systems
  - We can assist with run scripts to maximize productivity
- **Use Our Existing Portfolio***
  - Over 200 installed libraries, utilities, compilers and analysis codes
  - https://centers.hpc.mil/software for listing of software
- **HPC Portal Environment**
  - A web based user friendly Interface for beginning users
  - Permits jobs to be run on applications served through the Portal
  - No software installation required



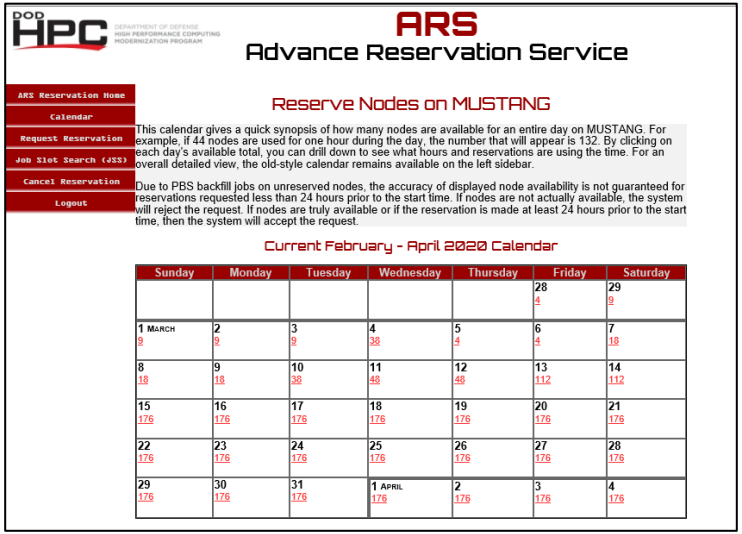


Sample of the HPC Portal Environment

* Unclassified Systems listed on website, Classified systems software not necessarily provided by HPCMP

Running Jobs: Priority Service Provided to Users

- **Allocation process**
  - Processing hours dedicated to DoD High Priority and Urgent Projects
- **Advance Reservation Service (ARS)**
  - State-of-the-art job scheduling/queuing system
  - HPCMP customers guaranteed, quick access to portions of allocated systems for dedicated use
- **Dedicated Support Partitions (DSPs)**
  - Processing nodes specifically reserved for large computational efforts
    - Projects that cannot be addressed with advance reservation service
    - Long-term reoccurring work (30–360 days)
    - Developmental testing



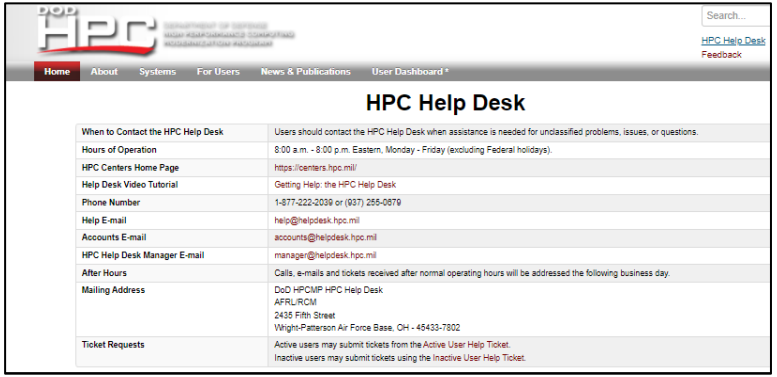
https://reservation.hpc.mil/reserve/

Assistance and Training

DoD HPC Help Desk

Help: help@helpdesk.hpc.mil
Toll Free: 877-222-2039
Local: 937-255-0679
Manager: manager@helpdesk.hpc.mil
Hours: 8:00 AM – 8:00 PM ET

https://centers.hpc.mil



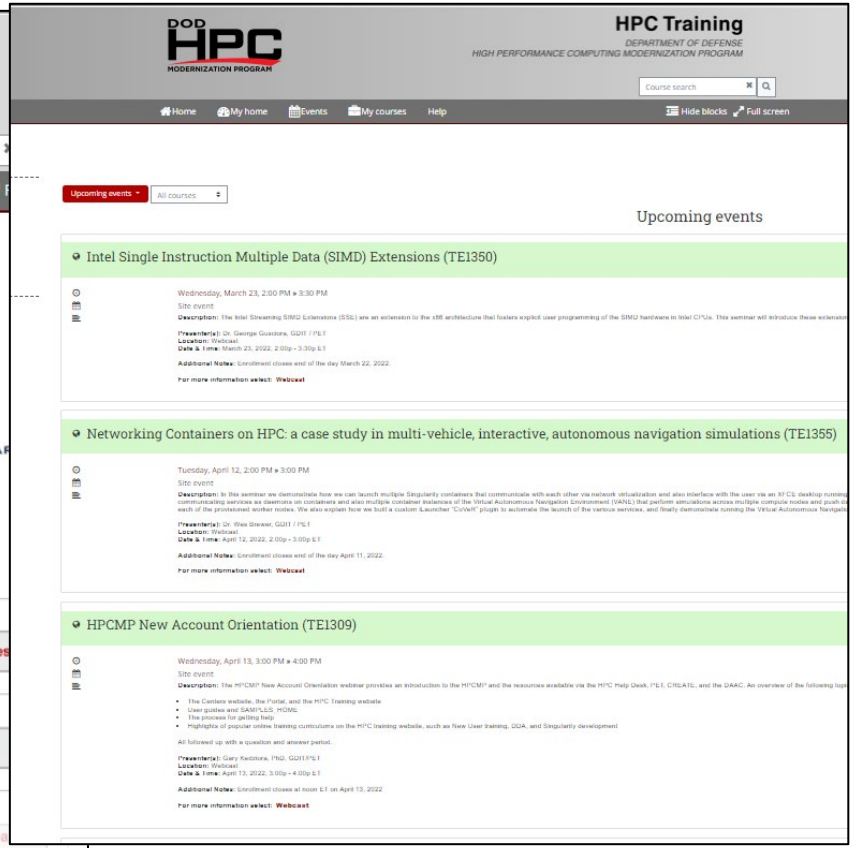
HPC Help Desk Video Series

Welcome to the HPC Help Desk Video Series. This series answers some of the most common questions asked by our users, helping them make the most of their HPC accounts. Topics covered include the following:

Title	Captions	Job Aid	Length
Getting an Account	Show with Captions	Job Aid	14:40
Getting Help: the HPC Help Desk	Show with Captions	Job Aid	13:46
Introduction to Baseline Configuration	Show with Captions	Job Aid	4:39
Introduction to HPCMP SCAMPI	Show with Captions	Job Aid	8:15
Introduction to Modules	Show with Captions	Job Aid	12:38
Introduction to PBS	Show with Captions	Job Aid	14:36
Using Lustre	Show with Captions	Job Aid	10:34
Using SLB	Show with Captions	Job Aid	10:53
Using a YubiKey	Show with Captions	Job Aid	08:54
Installing Kerberos for Linux *	Show with Captions *	Job Aid *	10:16
Installing Kerberos for Mac *	Show with Captions *	Job Aid *	12:40
Installing Kerberos for Windows *	Show with Captions *	Job Aid *	11:12
Logging into an HPC System *	Show with Captions *	Job Aid *	05:16
Using FileZilla *	Show with Captions *	Job Aid *	12:39
Getting Started with the HPCMP GitLab Service on Mac and Linux *	Show with Captions *	Job Aid *	13:26
Getting Started with the HPCMP GitLab Service on Windows *	Show with Captions *	Job Aid *	19:10

** login required*

Supercomputing Training https://training.hpc.mil



Advanced User Support

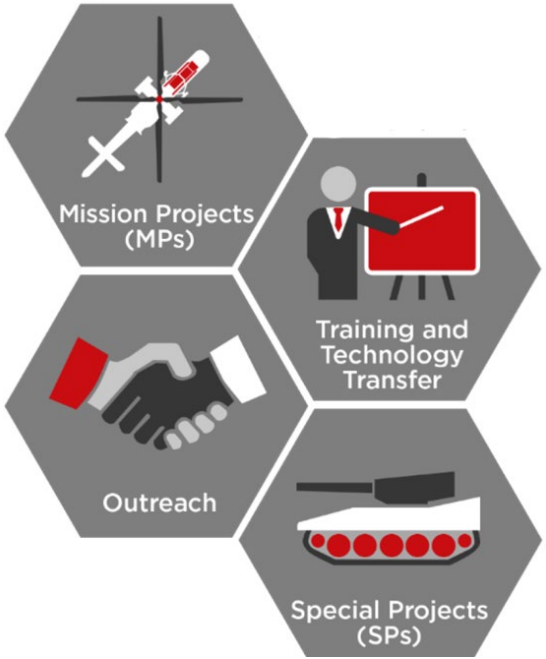
PhD level assistance is provided through the Productivity Enhancement and Training Element of the DoD HPC Program

Mission Projects

DoD HPCMP PhD support staff funded by DoD HPCMP to work with users to solve mission-critical problems of interest across the DoD

Outreach

Increase awareness of DoD Supercomputing Resources and support available to the DoD RDT&E community



PET
USER PRODUCTIVITY ENHANCEMENT AND TRAINING

Training

Provide recurring live and recorded training for new and advanced supercomputing users as well as training/reference material

Special Projects

DoD HPCMP PhD support staff funded by user's organization to help the user's organization solve unique mission-critical problems

DoD Supercomputing Resources Available for "Above Secret" Programs/Projects

“Supercomputing capability is not only a key indicator for a country’s core competitiveness in science and technology, but also for it’s comprehensive national strength”

- Chinese Communist Party State Media, 2023

"Supercomputing capability is not only a key indicator for a country's core competitiveness in science and technology, but also for it's comprehensive national strength"

National Supercomputing Center in Zhengzhou.

National Supercomputing Center in Wuxi

Aerospace Supercomputing Center under construction in Hainan

AI Supercomputing Center in Chengdu

Supercomputing Center under construction in Qingdao

National Supercomputing Center in Tianjin

Erosion of U.S. Technological Advantage

Russia cobbles together supercomputing platform to wean off foreign suppliers

New RSK Tornado system will help Russia port HPC apps to homegrown CPUs

The New York Times

China Extends Lead as Most Prolific Supercomputer Maker

REUTERS

Theft of F-35 design data is helping U.S. adversaries -Pentagon

Shenyang J-21

Chinese People Liberation Army cyber troops. PLA Photo

Tech / Policy

China plans multibillion-dollar investment to knock US from top spot in fastest supercomputer ranking

Newsweek

U.S. World Business Tech & Science Culture Newsgeek Sports Health The Debate

TECH & SCIENCE

RUSSIA PLANNING TO BUILD POWERFUL NEW SUPERCOMPUTERS AFTER SEEING ITS TECHNOLOGY LAG BEHIND U.S. AND CHINA

BUSINESS INSIDER

FBI: A Chinese Hacker Stole Massive Amounts Of Intel On 32 US Military Projects

USNI News

China Has Stolen Vast Amounts of Navy Submarine, Missile Data in Multiple Breaches from Contractor's Servers

By: Sam LaGrone

June 8, 2018 4:26 PM • Updated: June 8, 2018 7:09 PM

The Register

US fears China may have ten exascale systems by 2025

China refuses to share benchmarks, US sharpens focus on developing optimized software

Dan Robinson Fri 20 May 2022 // 16:04 UTC

The Washington Post

China builds advanced weapons systems using American chip technology

Secure Supercomputing is Necessary to Preserve U.S. Technological Advantage

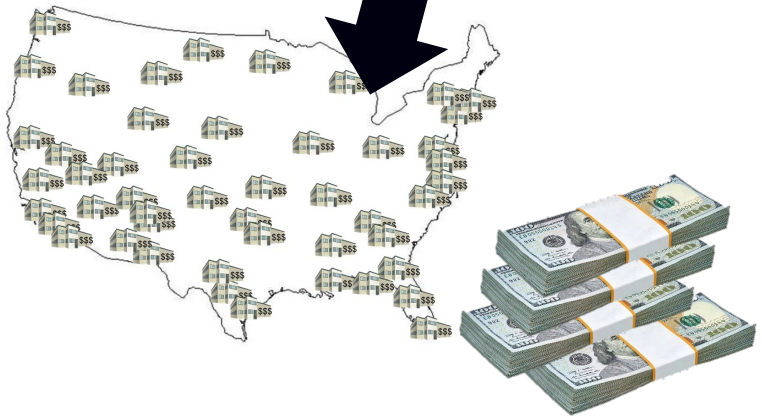
Background: DoD HPCMP "Above Secret" Supercomputing

- **Substantial portion of DoD RDT&E mission were not being supported**
- **Missions required ability to process data at higher levels with data caveats**
- **"Above Secret" projects are high priority or highly valued projects for the Department**
- **Programs are moving into higher classification levels**

How Programs Currently Obtain Supercomputing Support
(Why DoD Leadership is Interested in this Effort)

- Find a government or contractor site with ample power & cooling
  - *If it doesn't exist, build it*
  - *If it doesn't have enough power and cooling, add enough (hopefully)*
- Design a computer that project can afford (not what you really want)
- Procure the computer after a lengthy acquisition process
- Hire security staff to get the facility accredited and to operate site
- Hire an IA staff to get the system accredited
- Hire system administrators (or misuse engineers)
- Maintain the facility
- Maintain/update/patch software
- Maintain/update hardware
- Maintain accreditation
- Perform the project (finally)
- Pay for tech refresh (if you can) or mothball the site
- Dispose of system when program/project ends (maybe)

This process repeated for a multitude of programs In every Service and Agency

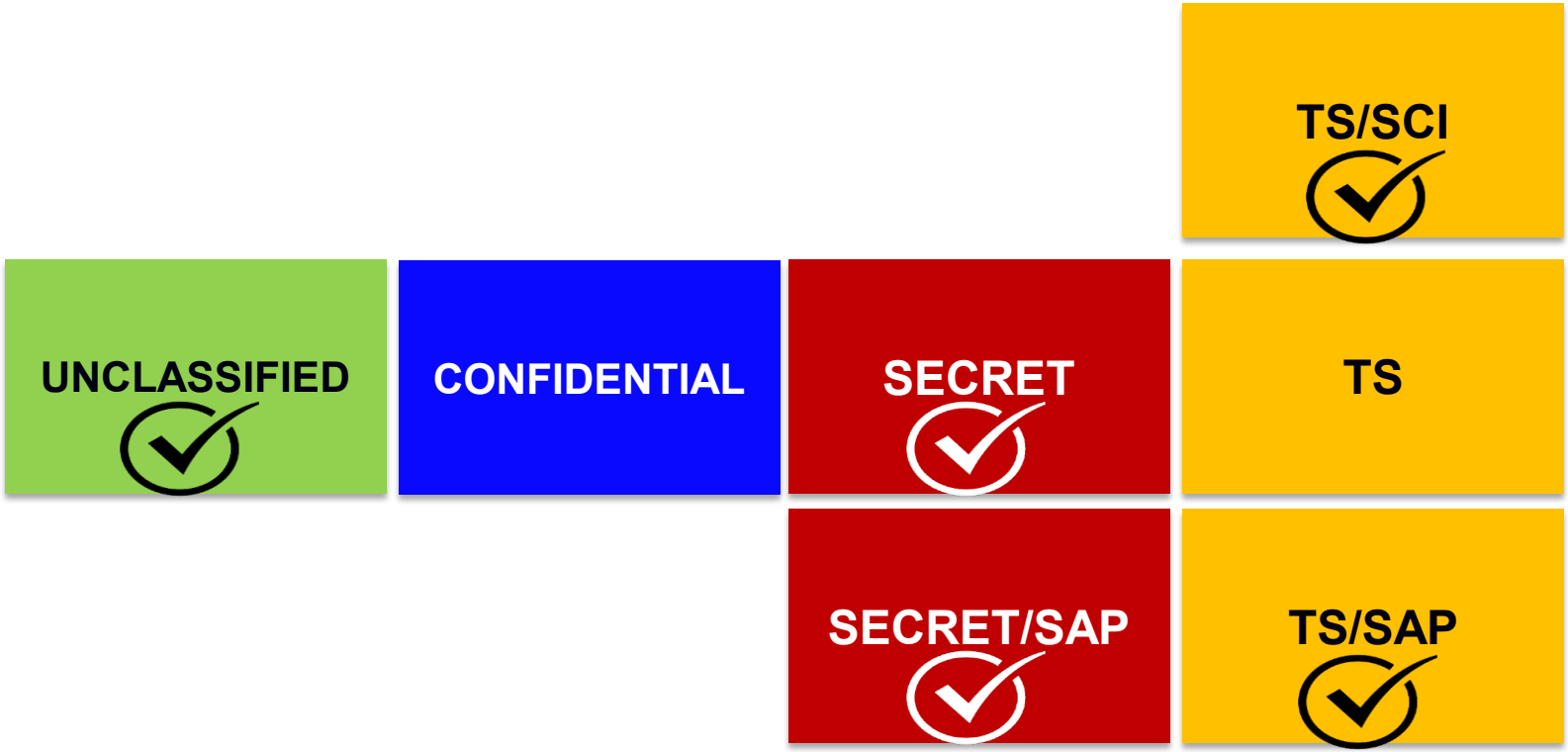


Benefits of a Shared, Secure Supercomputing Capability

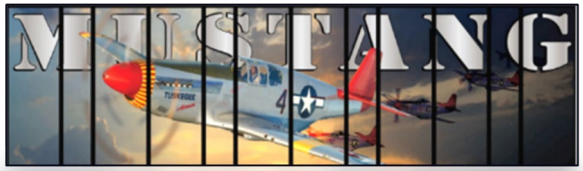
- Protects U.S. technologies and weapon systems development
- Encourages use of DoD HPCs to sustain U.S. technical advantage
  - Access to larger scale supercomputers
  - Built in technical refresh
  - Agile
    - Fast setup time for projects
    - Facility and system accreditation in-place
    - System administration provided
    - Ability to utilize systems on-site and via remote site
- Improves cost-effectiveness for Department
  - Help DoD reduce redundancy and sustainment tail
  - Accelerates high value, high priority DoD programs

✓ Cost ✓ Schedule ✓ Performance

Scope of DoD HPCMP Resources



DoD “Above Secret” - Pathfinder Systems



“Mustang”

- UNCLASSIFIED
- 56,448 compute cores
- 4.87 PetaFLOPS
- 1128 Standard Compute Nodes
  - 24 large memory nodes
  - 24 visualization nodes
- 8 E-Racks, 6 Cool/CDU, 11 D-Racks
- 2.7 GHz Intel Xeon 8168 “Skylake”
- 24 cores/CPU
- 244 terabytes of memory
- 9.281 petabytes of storage

“Voodoo”

- 13,824 compute cores
- 1.194 PetaFLOPS
- 284 Standard Compute Nodes
- 4 large memory nodes
- 2 E-Rack, 2 Cool/CDU, 3 D-Racks
- 2.7 GHz Intel Xeon 8168 “Skylake”
- 24 cores/CPU
- 58 terabytes of memory
- 1.584 petabytes of storage

“Shadow” & “Spectre”

- 6,912 compute cores (each)
- 0.59 PetaFLOPS
- 140 Standard Compute Nodes
- 4 large memory nodes
- 1 E-Rack, 2 Cool/CDU, 2 D-Racks
- 2.7 GHz Intel Xeon 8168 “Skylake”
- 24 cores/CPU
- 29.9 terabytes of memory;
- 1.046 petabytes of storage

Support Now Available

ATO

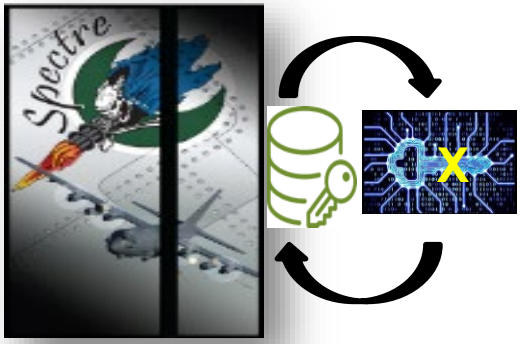
56,448 core
"Mustang"

Shared
24/7

ATO

13,824 core
"Voodoo"

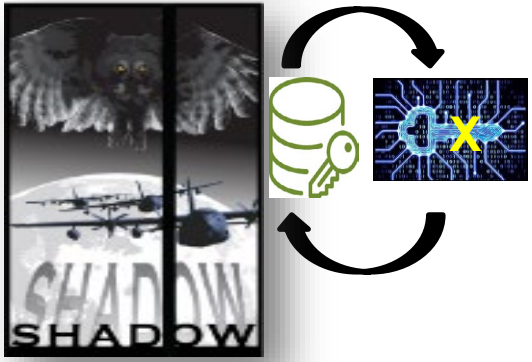
Shared
24/7



6,912 core
"Spectre"

One Program/Project
on System

ATO



6,912 core
"Shadow"

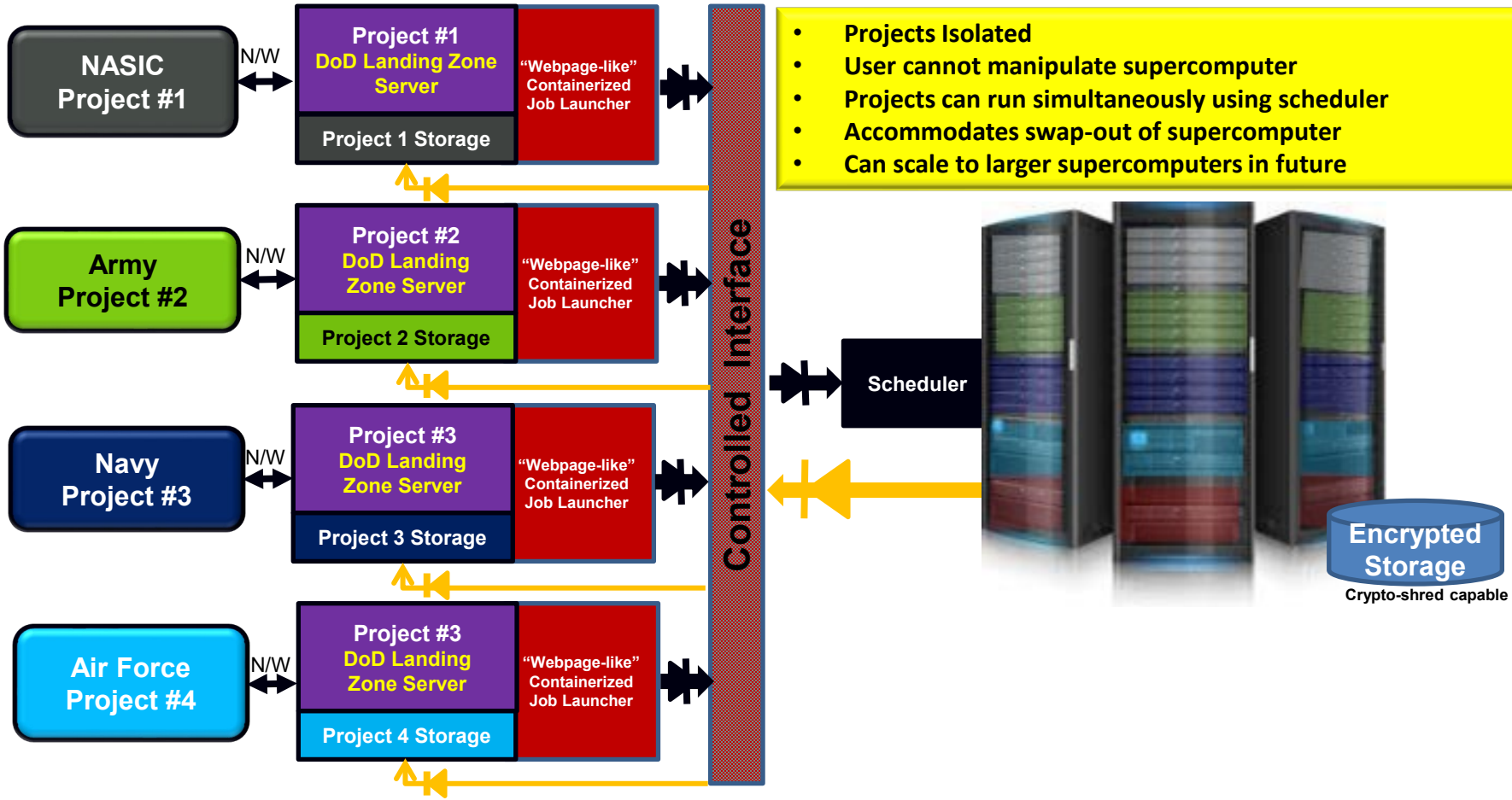
One Program/Project
on System

ATO

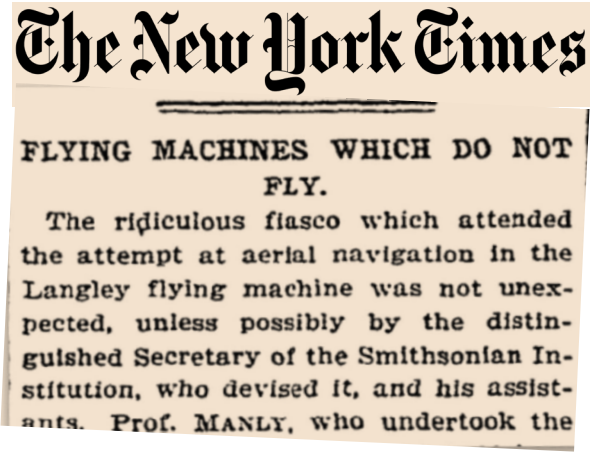
Strategy for “Above Secret” Supercomputing

- For DoD to exploit large-scale systems, we must have ability to share a supercomputer across programs/projects
  - Traditional periods processing approach inefficient and impractical
  - Enables high utilization
- Must support timely technical refresh and accreditation
  - U.S. technological advantage at risk
- AFRL DSRC pursuing technical solution to securely isolate projects/programs and users on shared supercomputing system
  - Collaboration with AF Test Community and DoD SAP CIO office
  - Support from vendors and other domain experts

Shared, Multi-Caveat, Secure Supercomputing (Notional Design)



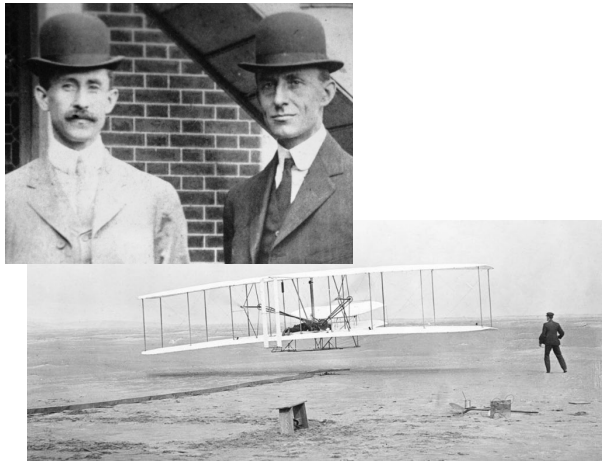
- Projects Isolated
- User cannot manipulate supercomputer
- Projects can run simultaneously using scheduler
- Accommodates swap-out of supercomputer
- Can scale to larger supercomputers in future



The New York Times

FLYING MACHINES WHICH DO NOT FLY.

The ridiculous fiasco which attended the attempt at aerial navigation in the Langley flying machine was not unexpected, unless possibly by the distinguished Secretary of the Smithsonian Institution, who devised it, and his assistants. Prof. MANLY, who undertook the



October 9, 1903:

"The flying machine which might really fly might be evolved … in 1 to 10 million years."

- New York Times

December 17, 1903:

"Success 4 flights Thursday morning all against 21-mile wind. Started from level with engine power alone. Average speed through air 31 miles. Longest 57 seconds."

- Orville Wright, Telegram to Father

Reference: https://www.nytimes.com/1903/10/09/archives/flying-machines-which-do-not-fly.html

Summary: DoD HPC Modernization Program Provides Invaluable HPC Resources to Scientists & Engineers

- **DoD government and contractors can access all DoD HPC systems**
  - **No cost to using organization for compute time on systems**
- **Connectivity to DSRCs, labs, academia, and test activities via a capable wide-area network – the Defense Research and Engineering Network (DREN)**
- **Access to expert help with accounts, coding, domain expertise, and training**
  - DoD HPC Helpdesk assistance
  - Readily available training
  - Advanced user support
- **DoD HPC Modernization Program supports "above secret" supercomputing**

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