Update on NASA High End Computing (HEC) &
Survey of Federal HEC Capabilities

March 6, 2017

Tsengdar Lee
HEC Portfolio Manager
Science Mission Directorate

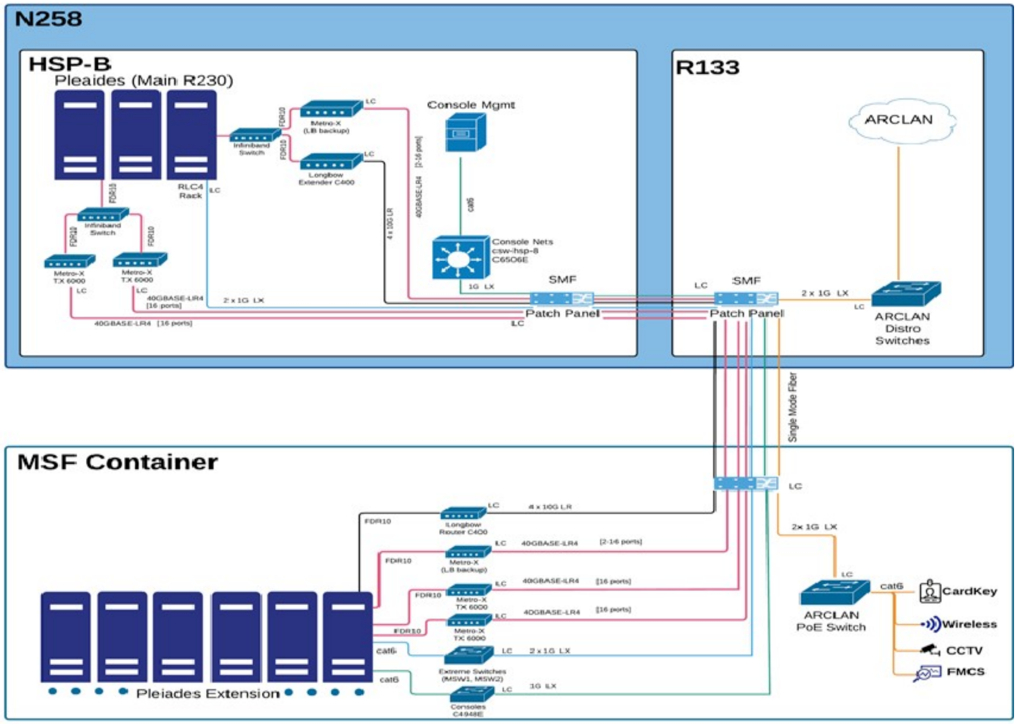
Modular Supercomputing Facility (MSF)

- Status
  - MSF is operational
    - Site is monitored by security 24x7 over cctv
    - Site is secured with 9’ fence with card controlled gate access
    - Module status is monitored by control room 24x7 and inspected each shift
    - Electra is operational as of 1 January 2017
    - Congress has just approved the 2^{nd} module be installed in 2017.
  - Electra
    - 16 SGI ICE-X Racks with Intel Xeon processors E5-2680v4 (Broadwell processors) (1.24 PF**; 147 TB^{+}; 4,654 SBUs^{++}/hr)
    - 1,152 nodes (dual-socket blades)
    - 2,304 processors (32,256 cores)
    - Dual-plane fully populated 7D hypercube InfiniBand FDR^ Network with Metro-X IB extenders

* TF = Teraflops = one million million (10^{12}) floating-point operations per second; ** PF = 10^{3} TF;
+ TB = 10^{12} Bytes; ++ SBU = Standard Billing Unit for tracking computing usage (https://hec.nasa.gov/user/policies/sbus.html); ^ FDR = 56Gb/s serial high bandwidth links

MSF Initial Test Results

- Benchmark Tests
  - LINPACK[+] – 1.096 petaflops (PF) – 96th on November 2016 TOP500 List
  - HPCG[++] – 25.188 teraflops (TF) – 46th on November 2016 HPCG List
- Application Tests
  - Extensive testing was conducted in November and December identifying performance issues focused on connectivity with the remote I/O infrastructure.
  - After system modifications, there is minimal to no impact on job run times.
- Operational Facility Early Results
  - Numerous facility tests were conducted in November and December with modifications made to improve the efficiency of the module.
  - PUE numbers are consistently below 1.03, greatly exceeding our 1.06 target.



+ LINPACK = linear algebra benchmark suite to measure computational speed; ++ HPCG = high performance conjugate gradient benchmark to measure computational speed; * PUE = power usage effectiveness

HECC Growth - Last Calendar Year

Systems	Racks		Cores		TF*		SBU+/hr	
	Jan-16	Feb-17	Jan-16	Feb-17	Jan-16	Feb-17	Jan-16	Feb-17
Pleiades	163	160	211,872	245,400	5,340	7,232	26,020	32,230
Electra		16		32,256		1,239		4,654
Merope	36	56	13,824	21,504	162	252	1,152	1,792
Total	**199**	**232**	**225,696**	**299,160**	**5,502**	**8,723**	**27,172**	**38,676**
Growth		16.58%		32.55%		58.54%		42.34%

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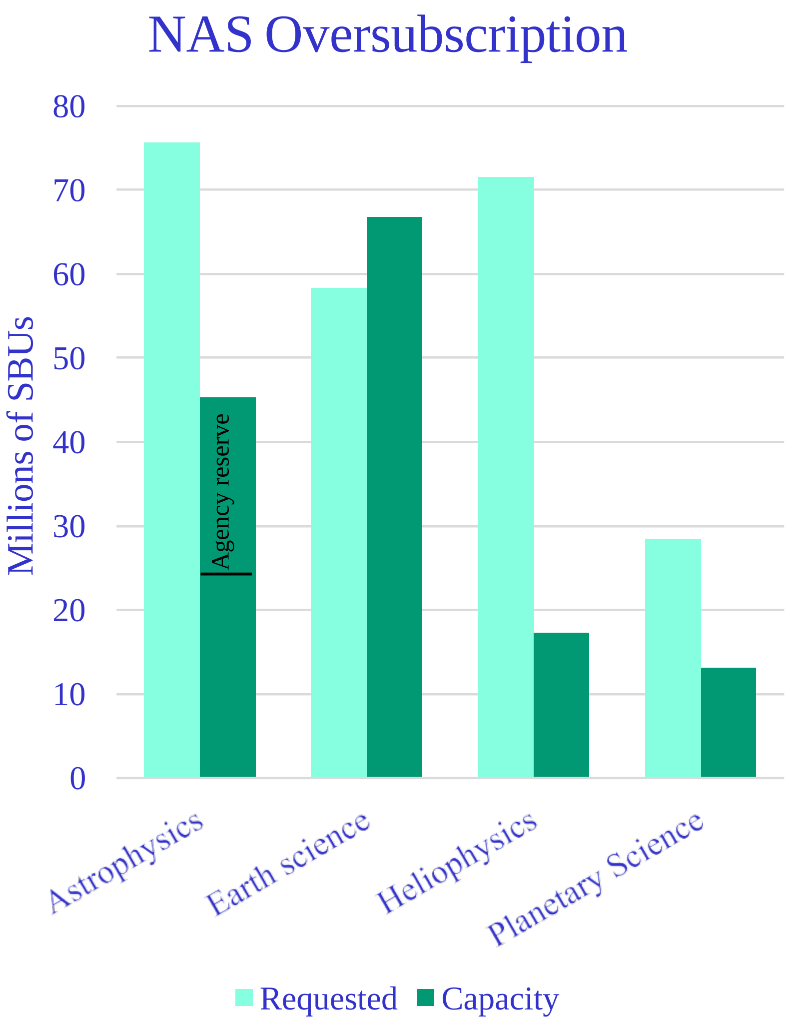
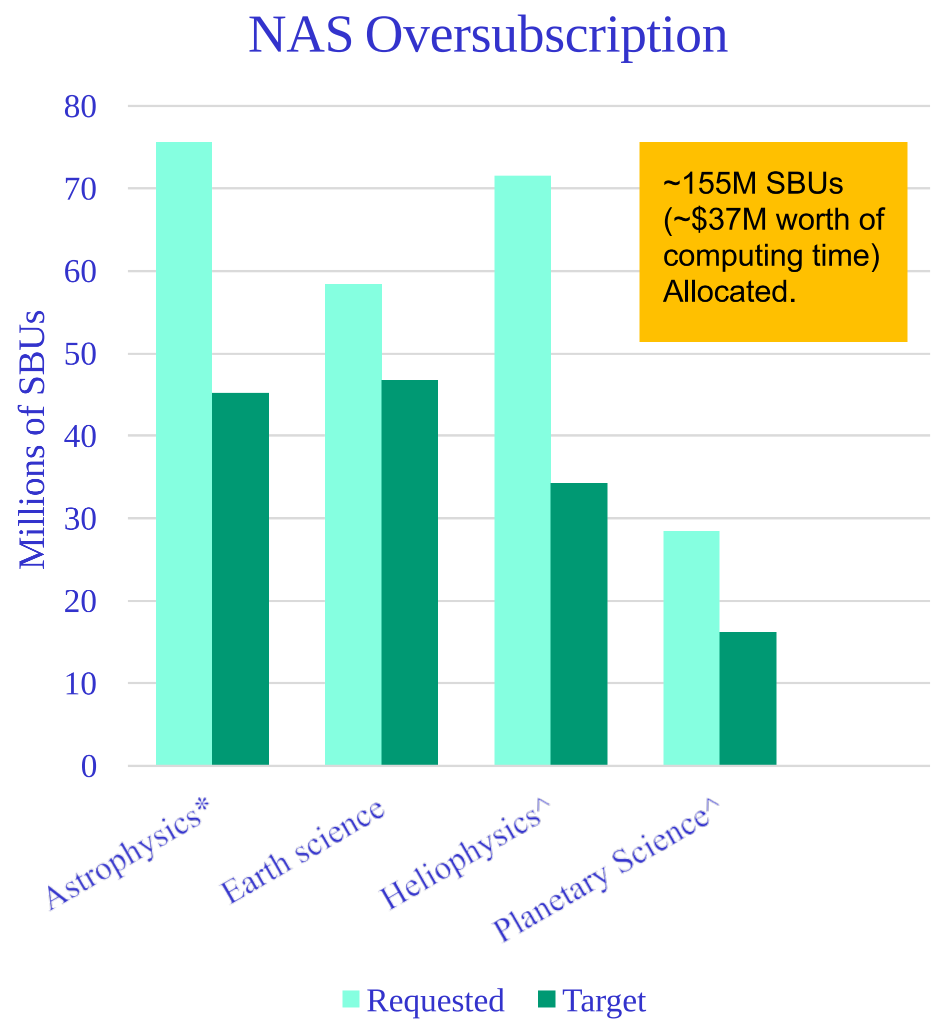
2017 Capacity Oversubscription



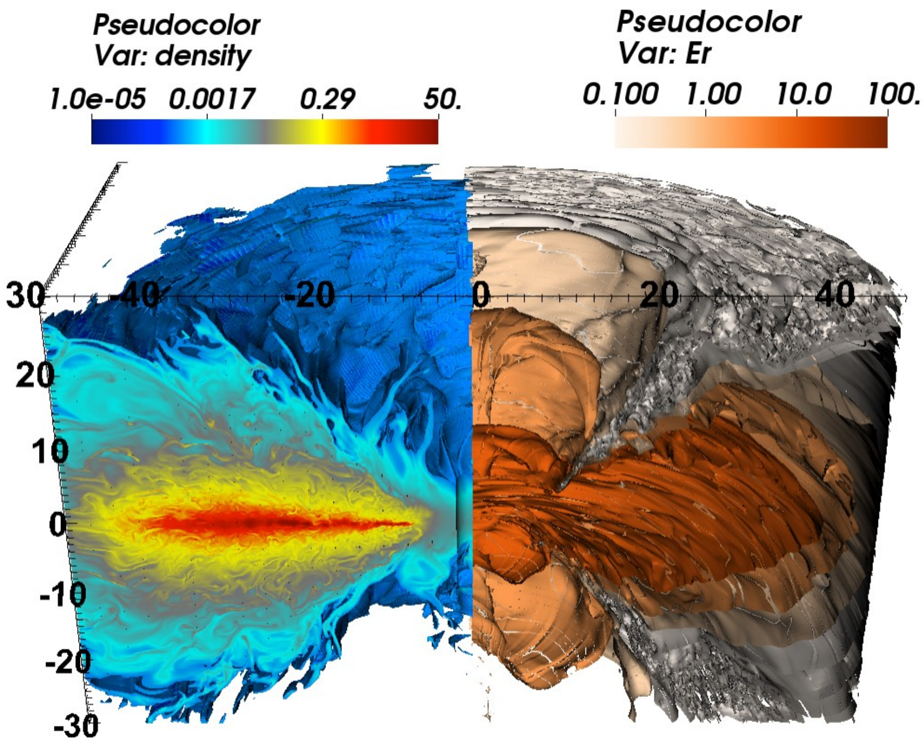


* Available capacity numbers are based on baseline resource distributions.

- NAS: Astro - 21.7%, Earth Science - 53.8%, Helio - 13.9%, Planetary - 10.6%
- Astrophysics allocation includes ~20M SBUs from the Agency reserve

Application Support: ATHENA

- Magnetohydrodynamics (MHD) code used to simulate black holes
- Previous I/O characterization
  - Identified bottleneck with IOT tool
  - Sped up I/O
    - 10x in 3264-rank case
    - 36x in 5968-rank case
- Current Performance Characterization
  - Developed set of kernels from full code
  - Using tools: Vector Advisor, Paraver, op_scope MPIprof
  - Transformations to reduce memory pressure yielded 12% improvement in a kernel
  - Investigating performance on Intel Xeon Phi cluster
- Next Steps
  - Conduct formal interview with PI
  - Investigate issues identified in interview
  - Write summary report



Snapshot of the global structure of a radiation-dominated black hole accretion disk with super-Eddington accretion rate from a global 3D radiation MHD simulation done in Pleiades. Left image shows the density, and the right shows the radiation energy density (both in units of the initial maximum value). Coordinate axes are labeled in units of Schwarzschild radius. Pleiades has been used for Athena/Athena++ code to perform simulations to study various astrophysical systems, including properties of black hole accretion disks, stability and structures of massive star envelopes as well as stream-stream collision in tidal disruption events.

Survey of Federal Agency HEC Capabilities

DoD, DoE, NSF

Response to Heliophysics Subcommittee, NASA Advisory Council

Survey Conducted by NASA HEC

NCCS, NASA Goddard Space Flight Center

February 27, 2017

L. Parnell, NCCS Consultant

Federal Agency HEC Sites Surveyed

- DoD HPCMP
  - AFRL, ARL, ERDC, Navy/SSC, MHPCC
- DoE
  - NNSA (LLNL)
  - SC (ALCF, OLCF, NERSC)
- NSF
  - Centers: NCSA, PSC, SDSC, TACC
  - XSEDE

DoD HPCMP HEC Systems Summary

Agency	Compute Nodes		Aggregated TFLOPS
	# Nodes	# Cores	
DoD HPCMP	30,406	843,318	20,076
DoE ASCR	87,232	6,644,623	78,650
DoE NNSA	28,932	516,370	8,817
NSF Centers	38,288	1,042,360	26,338
NSF XSEDE	?	220,548	16,556
NASA	11,472	246,048	7,250

Caveats:

- Not all systems are reported.
- Inconsistent reporting especially when accelerators are used.

Agency FY 2017 Budget Requests and Prior-Year HEC Funding ($M)

High-Capability Computing Systems Infrastructure & Applications

Agency \ PCA	2017 HCSIA	2016 HCSIA Estimates	2015 HCSIA Actuals	Enabling R&D (EHCS)	Software & Systems (HCSS)
NSF	183.2	180.4	189.0	131.0	86.5
DoD [b]	81.9	80.8	80.8	216.4	12.9
DOE [c]	393.6	374.4	378.8	208.3	17.5
NIH [d]	194.6	194.6	194.6	23.1	30.0
NIST	8.1	8.1	8.1	18.0	15.7
NASA	60.9	62.8	67.3	11.0	4.9
NOAA	36.0	29.7	23.0		
NNSA				30.0	
Total [a, d]	958.3	930.8	941.6	647.5	167.5

Headings Key: **PCA –** Program Component Area
EHCS – Enabling R&D for High-Capability Computing Systems
HCSIA – High-Capability Computing Systems Infrastructure & Applications
HCSS – High Confidence Software & Systems

Source: FY2017 NITRD Supplement to the President's Budget

Agency HEC Site Funding, Users & Allocations

<table>
<tr><th>Agency</th><th>Site</th><th>FY 16 Funding ($M)</th><th>Number of Projects</th><th>Number of Users</th><th>Allocations</th><th>Allocation Policy, Process (Methodology is very similar across all agencies and sites)</th></tr>
<tr><td>HPCMP</td><td>Various*</td><td>230</td><td></td><td>~1,800</td><td>Users: 95%
MPO: 5%</td><td rowspan="10">Policy: Allocate 90-95% of user-available machine resources. Retain 5-10% for discretionary use.

Process:
1.Projects submit proposals (quarterly to annually)
2.Requirements are validated
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Backup Information

List of Acronyms

- ALCF = Argonne Leadership Computing Facility
- DoD = Department of Defence
- DoE = Department of Energy
- FDR = 56Gb/s serial high bandwidth links
- HPCMP = High Performance Computing Modernization Program
- LLNL = Los Alamos National Laboratory
- NERSC = National Energy Research Scientific Computing Cente
- NCSA = National Center for Supercomputing Applications
- NNSA = National Nuclear Security Administration
- NSF = National Science Foundation
- OLCF = Oak Ridge Leadership Computing Facility
- PF = Petaflops = 10^{15} floating-point operations per second
- PSC = Pittsburgh Supercomputing Center
- SBU = Standard Billing Unit for tracking computing usage (https://hec.nasa.gov/user/policies/sbus.html)
- SDSC = San Diego Supercomputing Center
- TACC = Texas Advanced Computing Center
- TB = 10^{12} Bytes
- TF = Teraflops = one million million (10^{12}) floating-point operations per second
- XSEDE = Extreme Science and Engineering Discovery Environment

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  - XSEDE

DoD HPCMP HEC Systems Summary

Number of users: ~1,800

Vendor / Model	Compute Nodes (Standard / Large + Phi, GPU)			Peak TFLOPS
	# Nodes	# Cores	GB Memory / Node	
Cray XC30	1,215 / 8 + 124	30,592	64 | 128	786
Cray XC30	2,370/ 0 + 32	57,200	64	1280
Cray XC30	1,183 / 8 + 156	30,144	64 | 128	822
Cray XC40	1,523 / 8 + 168	51,008	128 | 512	2000
Cray XC40	3,098/32+ 32	101,184	128 | 512	3770
Cray XC40	1,523 / 8 + 168	51,008	128 | 512	2000
Cray XE6	4,716	150,912	64	1500
Cray XE6m	460	14,720	64	135
IBM IDPx	1,220 / 4 + 12	19,776	32 | 256	411
IBM IDPx	756	12,096	32	252
SGI ICE X	4,590	73,440	32	1500
SGI ICE X	3,216 / 4 + 356	125,888	128 | 768	5620
SGI ICE X	3,456 / 4 + 32	125,440	128 | 1	4660

DoE ASCR HEC Systems Summary

Number of users: 7,166+

Site / System	Vendor / Model	Compute Nodes			Peak TFLOPS	Notes
		# Nodes	# Cores	GB Memory / Node		
ORNL - LCF						
Titan - Cray XK7		18,688	AMD: 4,784,128	32GB + 6GB	27,000	+GPUs: 18,688
Eos - Cray XC30			11,776	64		Titan Support
ANL LCF						
Mira - IBM / Blue Gene/Q		49,152	786,432	16	10,000	
Theta - Intel (Xeon Phi)/Cray		>2,500	231,935	208	9,650	
NERSC						
CORI - Cray XC40 (Xeon, Phi)		Xeon: 1,988 / Phi: 9,304	Haswell: 63,616 Phi: 632,672	Haswell: 203 TB Phi: 1 PB (aggregate)	30,000	+ PDSF & Genepool – dedicated sys
Edison - Cray XC30		5.600	134,064	64	2,000	

DoE NNSA HEC Systems Summary

Livermore Computing General Availability Compute Platforms

Number of Users: 3,000+

System	Nodes	Total Cores	Total Memory (GB)	**TFLOPS Peak**	**Vendor**	**Program(s)**
Ansel	324	3,888	7,776	43.5	Dell	M&IC
Cab	1,296	20,736	41,472	431.3	Appro	ASC, M&IC
Vulcan	24,576	393,216	393,216	5,033.2	IBM	ASC, M&IC, HPCIC
Quartz	2,688	96,768	344,064	3,251.4	Penguin	ASC, M&IC
Borax	48	1,762	6,144	58.1	Penguin	ASC

NSF Centers HEC Resources
NCSA, PSC, SDSC, TACC

Site	Vendor / Model	Compute Nodes (Regular / Large / Extreme Memory)			Peak TFLOPS	Notes
		# Nodes	# Cores	GB Memory/ Node		
NCSA: Blue Waters	Cray XE6 / XK7 hybrid	22,640 / 4,228	396,032	32 / 64	13,340	XK: +4,228 GPUs
PSC: Bridges*	Intel Xeon	800 / 42 / 4	27,040	128 / 3,000 / 12,000	895 / 895	
SDSC:						
Comet*	Dell Intel Xeon	1,944 / 4	47,776	128 **(+320 Flash)** /1,500	2,000	+ 144 GPUs
Gordon*	Appro/ Intel	1,024	16,384	64	341	300 TB flash
Triton shared cluster	Vars.			~4,000	100+	UCSD/UC "condo"
TACC:						
Stampede*	Dell Intel	6,400	522,080	40	9,600	Xeon + PHI
Lonestar 5	Cray XC40	1,252 /2 /8	30,048	64 /1,000 / 512		Academic
Wrangler*	Dell/ EMC (10PB DSSD)		3,000+		62	Data Analysis, IU,UC - Replicated

*Access and allocations provided through XSEDE

NSF XSEDE Compute Resources & Usage*

Number of Users: 3,500+

Name	Site	CPUs	Peak TFlops	Utilization	Running Jobs	Queued Jobs	Other Jobs
Stampede	UT Austin	102400	9600	86%	814	281	108
Comet	SDSC	47616	2000	91%	1734	2334	137
XStream	Stanford	1300	1012	52%	68	9	86
SuperMIC	LSU CCT	7200	925				
Bridges Reg. Mem	PSC	21056	895				
Bridges Large Mem	PSC	160	895				
Jetstream	Indiana	15360	516				
Gordon Cluster	SDSC	16384	341	20%	123	32	19
Beacon	NICS	768	210				
Red	UN Lincoln	6000	100				
Wrangler	UT Austin	2304	62				

XSEDE: a single, virtual cyberinfrastructure that scientists use to interactively share computing resources, data, and expertise.
*Usage provided real time. Sample shown obtained 2/13/17 at 3:00 EST.

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Detailed Agency HEC Resource Allocation Process Descriptions

A. Department of Defense HPCMP

1. Requirements Determination

- Each DoD Service/Agency defines a set of computational projects supporting RDT&E program
  - DoD Services: Army, Navy, Air Force
  - DoD Agencies: DTRA, DARPA, MDA
- Project requirements are captured in an annual survey of computational project leaders
  - Survey captures requirements for upcoming fiscal year and four years into the future
  - Extensive data collected on each project
    - Project description
    - Hardware requirements – core-hours per year per system
    - Applications software requirement
    - Individual job requirements
    - Training requirements
- Each Service/Agency validates its overall requirements through HPC Advisory Panel Principals of each Service and Agency Requirements tend to exceed available HPC cycles by 3X

Detailed Agency HEC Resource Allocation Process Descriptions

A. DoD HPCMP, continued

2. Allocation Management Process

- 100% of all available computational resources at DOD Supercomputing Resource Centers are allocated
  - Based on theoretical maximum of 8,760 hours per year
- 5% reserved for HPCMPO allocations
- 25% allocated to Frontier Projects
  - These are high-impact, computationally-intensive projects
  - Selections based on technical merit review as well as Service/Agency prioritization
- 70% allocated to Services/Agencies for distribution
  - 30/30/30/10 (Army/Navy/Air Force/Agencies) split
  - Mechanisms in place support Service/Agency allocations for high priority, advance reservations, and dedicated workloads
- Overall limit on high-priority work of 35%
  - Frontier and Service/Agency high priority projects

Detailed Agency HEC Resource Allocation Process Descriptions

B. Department of Energy's National Laboratories

- The Office of Science computers are dedicated to tackling the modeling, simulation, and big datasets behind ambitious research.
  - The projects that use these facilities range from needing 10 million to more than 100 million hours of computing time.
- The DoE-SC user facilities' dedication to the larger research community makes them particularly unique.
  - They allocate time to researchers based on the strength of competitive scientific proposals.
  - As with all DOE user facilities, they are free to use as long as the scientist makes their data available to the larger scientific community. Discretionary allocations consume 10% of resources.
- The DOE's INCITE program provides 60% of allocations to computationally intensive, large-scale research projects that aim to address "grand challenges" in science and engineering.
  - The program conducts a two-part review of all proposals: a peer review by an international panel of experts and a computational-readiness review.
  - The annual call for proposals is issued in April, and the allocations are awarded in millions of core-hours for one to three years.

Detailed Agency HEC Resource Allocation Process Descriptions

B. DoE National Laboratories, continued

- The DOE’s ALCC program allocates 30% of resources to projects directly related to the DOE’s energy mission, national emergencies, or for broadening the community of researchers capable of using leadership computing resources.
  - The DOE conducts a peer review of all proposals based on scientific and technical merit of the project; appropriateness of the proposed method or approach; competency and adequacy of personnel and proposed resources; and the reasonableness and appropriateness of the proposed allocation request.
  - The yearlong allocation cycle runs from July 1 to June 30.
- The NNSA unclassified Livermore Computing facilities are allocated in a manner similar to that of the DoD HPCMP.
  - Project leaders submit proposals for resources based on their requirements. Proposals are evaluated and available appropriate facility resources are allocated based on the requirements

Detailed Agency HEC Resource Allocation Process Descriptions

C. National Science Foundation

- Allocations are made through the Extreme Science and Engineering Discovery Environment (XSEDE), which is composed of multiple partner institutions known as Service Providers, each of which contributes one or more allocatable services.
  - Resources include High Performance Computing (HPC) machines, High Throughput Computing (HTC) machines, visualization, data storage, testbeds, and services.
- An XSEDE allocation is a grant that provides approved research projects with 12 months of access to the XSEDE cyberinfrastructure.
  - Allocations may include computing and visualization time, data storage space, and extended collaborative support services at one or more XSEDE service provider sites.
  - Allocations are awarded to researchers who serve as principal investigators (PIs) of approved projects.
  - After receiving an allocation, each project's PI can create XSEDE accounts for other researchers on the project team, giving them access to the project's allocated digital services.

Detailed Agency HEC Resource Allocation Process Descriptions

C. National Science Foundation, continued

XSEDE offers four types of allocations to accommodate various use cases:

- **Startup allocations** -intended primarily for researchers who are new to the XSEDE environment, enabling them to quickly gain access to XSEDE digital services.
  - They are well suited for researchers who need to develop their codes, test their applications, or experiment with XSEDE systems.
  - Faculty members and postdoctoral researchers at US academic research institutions, as well as K-12 teachers, are welcome submit requests for Startup allocations at any time
  - Startup allocations provide each project with a maximum of 200,000 service units to be used within the 12-month time limit, on either a single computational system or a combination of systems.
- **Education allocations -** specifically designed for academic instruction or training activities, and are intended for faculty who want to incorporate XSEDE digital services into to their courses about the use of advanced cyberinfrastructure technologies.
  - PIs on Education allocations must be faculty at a US academic institution. You are welcome to submit a request for an Education allocation at any time through the XSEDE User Portal.
  - Education allocations provide each project with a maximum of 200,000 service units to be used within the 12-month time limit.
  - You may request time on either a single computational system or a combination of systems.

Detailed Agency HEC Resource Allocation Process Descriptions

C. National Science Foundation, continued

- **Research allocations -** reserved for projects with requirements that Startup allocations cannot accommodate.
  - With a Research allocation, an approved project can make extensive use of XSEDE's high-performance and high-throughput compute systems, scientific visualization systems, and data storage systems, and receive expert consulting and support from Extended Collaborative Support Service (ECSS) staff.
  - Requests for Research allocations are reviewed four times a year by the XSEDE Resource Allocations Committee (XRAC).
  - Research allocation requests may be submitted using the XSEDE User Portal, but each request must include a detailed document that describes the work the project plans to accomplish and justifies the need for the requested resources.
- **Campus Champions allocations** - reserved for the Campus Champions program which establishes representatives at US educational institutions who distribute knowledge of XSEDE's advanced cyberinfrastructure technologies to the researchers, educators, and students on their campuses.
  - Campus Champions help users on their campuses set up Startup allocations and provide them with the XSEDE contacts they need to resolve any problems.
  - Campus Champions are also responsible for hosting training and information sharing sessions on their campuses to make researchers, faculty, and students aware of XSEDE's resources and services, and how XSEDE can help them achieve their research goals.

Additional/Backup Information

DoE ASCR Computing Upgrades At a Glance

System attributes	NERSC Now	OLCF Now	ALCF Now		NERSC Upgrade	OLCF Upgrade	ALCF Upgrades
Name Planned Installation	**Edison**	**TITAN**	**MIRA**	**Theta** **2016**	**Cori** **2016**	**Summit** **2017-2018**	**Aurora** **2018-2019**
System peak (PF)	2.6	27	10	>8.5	> 30	200	180
Peak Power (MW)	2	9	4.8	1.7	< 3.7	13.3	13
Total system memory	357 TB	710TB	768TB	>480 TB DDR4 + High Bandwidth Memory (HBM)	~1 PB DDR4 + High Bandwidth Memory (HBM)+1.5PB persistent memory	> 2.4 PB DDR4 + HBM + 3.7 PB persistent memory	> 7 PB High Bandwidth On-Package Memory Local Memory and Persistent Memory
Node performance (TF)	0.460	1.452	0.204	> 3	> 3	> 40	> 17 times Mira
Node processors	Intel Ivy Bridge	AMD Opteron Nvidia Kepler	64-bit PowerPC A2	Intel Knights Landing Xeon Phi many core CPUs	Intel Knights Landing many core CPUs Intel Haswell CPU in data partition	Multiple IBM Power9 CPUs & multiple Nvidia Voltas GPUS	Knights Hill Xeon Phi many core CPUs
System size (nodes)	5,600 nodes	18,688 nodes	49,152	>2,500 nodes	9,300 nodes 1,900 nodes in data partition	~4,600 nodes	>50,000 nodes
System Interconnect	Aries	Gemini	5D Torus	Aries	Aries	Dual Rail EDR-IB	2nd Generation Intel Omni-Path Architecture
File System	7.6 PB 168 GB/s, Lustre®	32 PB 1 TB/s, Lustre®	26 PB 300 GB/s GPFS™	10PB, 210 GB/s Lustre initial	28 PB 744 GB/s Lustre®	120 PB 1 TB/s GPFS™	150 PB 1 TB/s Lustre®

Livermore Computing Systems Summary

System	Top500 Rank TFLOP/s	Program	Manufacture/ Model	Processor Architecture	OS	Inter- connect	Avg Power Demand (KW)	Nodes	Cores	Memory (GB)	Peak
Unclassified Network (OCF)											
Vulcan	**21**	ASC+M&IC+HPCIC	IBM BGQ	IBM PowerPCA2	RHEL/CNK	5D Torus	TBD	24,576	393,216	393,216	**5,033.2**
Cab (TLCC2)		ASC+M&IC+HPCIC	Appro	Intel Xeon E5-2670	TOSS	IB QDR	564	1,296	20,736	41,472	**426.0**
Quartz (CTS-1)	**41**	ASC+M&IC	Penguin	Intel Xeon E5-2695v4	TOSS	Omni-Path	TBD	2,688	96,768	344,064	**3251.4**
Ansel		M&IC	Dell	Intel Xeon EP X5660	TOSS	IB QDR	TBD	324	3,888	7,776	**43.5**
RZMerl (TLCC2)		ASC+ICF	Appro	Intel Xeon E5-2670	TOSS	IB QDR	TBD	162	2,592	5,184	**53.9**
RZZeus		M&IC	Appro	Intel Xeon E5530	TOSS	IB DDR	143	267	2,144	6,408	**20.6**
RZManta		ASC	IBM	IBM Power8+	RHEL	IB EDR	TBD	36	720	11,520	**597.6**
Ray		ASC+M&IC	IBM	IBM Power8+	RHEL	IB EDR	TBD	54	1,080	17,280	**896.4**
Catalyst		ASC+M&IC	Cray	Intel Xeon E5-2695v2	TOSS	IB QDR	TBD	324	7,776	41,472	**149.3**
Syrah		ASC+M&IC	Cray	Inetl Xeon E5-2670	TOSS	IB QDR	TBD	324	5,184	20,736	**107.8**
Surface		ASC+M&IC	Cray	Intel Xeon E5-2670	TOSS	IB FDR	TBD	162	2,592	41,500	**451.9**
Borax (CTS-1)		ASC+M&IC	Penguin	Intel Xeon E5-2695v4	TOSS	N/A	TBD	48	1,728	6,144	**58.1**
RZTrona (CTS-1)		ASC	Penguin	Intel Xeon E5-2695v4	TOSS	N/A	TBD	48	1,728	6,144	**58.1**
Herd		M&IC	Appro	AMD Opteron 8356, 6128 Intel EX E7-4850	TOSS	IB DDR	7	9	256	1,088	**1.6**
OCF Totals	**Systems**	14									**11,149.4**
Classified Network (SCF)											
Pinot(TLCC2,SNSI)		M&IC	Appro	Intel Xeon E5-2670	TOSS	IB QDR	TBD	162	2,592	10,368	**53.9**
Sequoia	**4**	ASC	IBM BGQ	IBM PowerPCA2	RHEL/CNK	5D Torus	TBD	98,304	1,572,864	1,572,864	**20132.7**
Zin (TLCC2)	**164**	ASC	Appro	Intel Xeon E5-2670	TOSS	IB QDR	TBD	2,916	46,656	93,312	**961.1**
Jade (CTS-1)	**42**	ASC	Penguin	Intel Xeon E5-2695v4	TOSS	Omni-Path	TBD	2,688	96,768	344,064	**3251.4**
Shark		ASC	IBM	IBM Power8+	RHEL	IB EDR	TBD	36	720	11,520	**597.6**
Max		ASC	Appro	Intel Xeon E5-2670	TOSS	IB FDR	TBD	324	5,184	82,944	**107.8**
Agate (CTS-1)		ASC	Penguin	Intel Xeon E5-2695v4	TOSS	N/A	TBD	48	1,728	6,144	**58.1**
SCF Totals	**Systems**	7									**25,162.6**
Combined Totals		21									**36,312.0**

System Category	TFLOP/s	% of Total

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