State of NASA High End Computing Capability Project and its Support of Astrophysics

October 3, 2016

Tsengdar Lee
HEC Program Executive
Science Mission Directorate

Partially Prepared by Elsa Yoseph

History of NASA's High End Computing Capability

- In 1998, NASA consolidated supercomputing capabilities to ARC and formulated a consolidated supercomputing management office CoSMO.
- After a reorganization of agency programs, CoSMO ceased operation in 2006. High-End Computing Capability (HECC) project, managed by SMD, became the agency's supercomputing capability which supports all the Mission Directorates. Most of the high-end computational scientific and technical workloads in the agency are being completed using HECC resources.
- HECC is tasked to maintain a stable core high-end computing capability (facility, technology, and human capital) to provide baseline computational resources, protect a core agency capability from program content fluctuations and to allow missions to invest in (on an as needed and just-in-time basis) additional capability at marginal cost.
- As a "build-to-budget" project, approximately 1/3 of the HECC budget is focused on technologies refresh leading to a continuously increasing capability.
- Status in 2016:
  - HECC has maxed-out the current facility. There is no capacity to address the ever increasing programmatic requirements – even if additional programmatic funding is provided.
  - The rise in HECC needs continues and is accelerating in all disciplines.

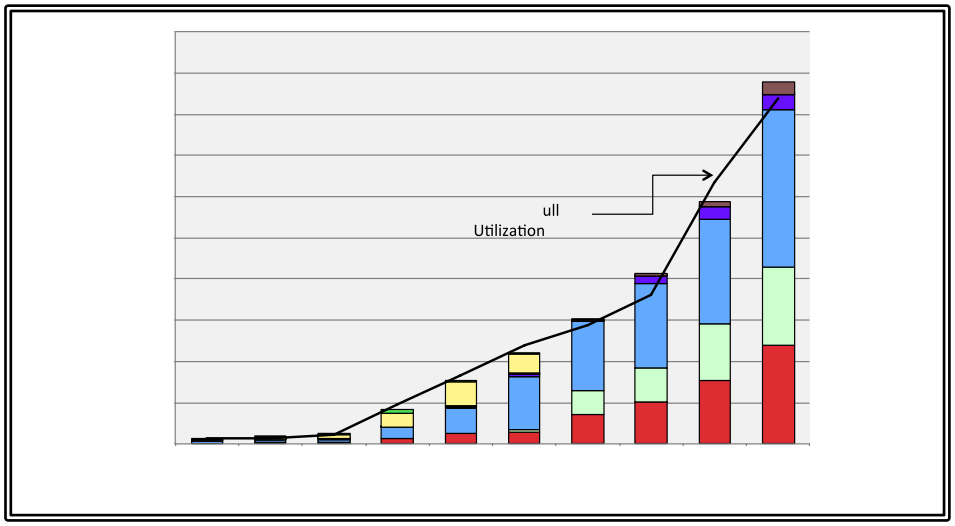
Available HEC Resources

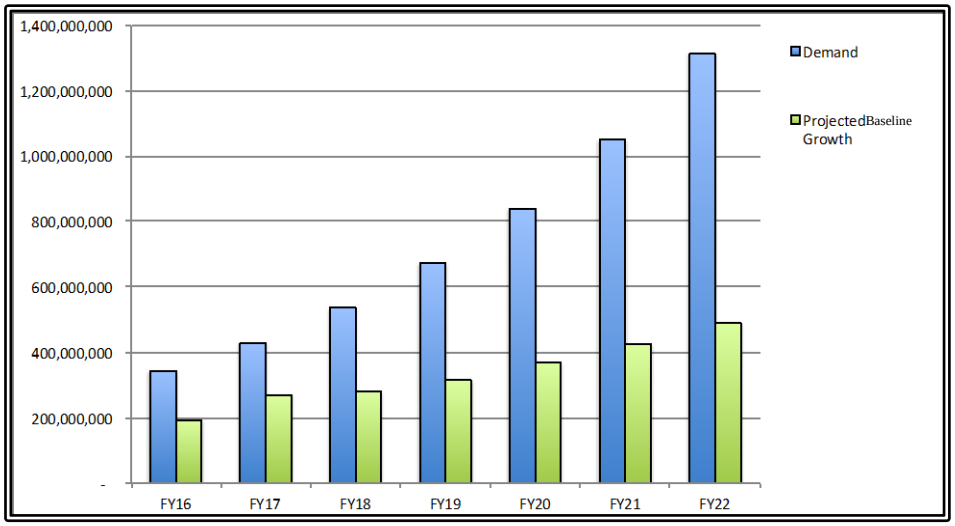
- SMD science Divisions' current baseline HEC budget and computing shares in the High-End Computing Capability (HECC) Project at Ames Research Center were first established in FY2006 when the HECC project was formulated.

  The below table shows the original HEC resource distributions based on the budget contributions from the four science Divisions:

SMD Division	High-End Computing Capability (Ames Research Center)
Astrophysics	21.7%
Earth Science	53.8%
Heliophysics	13.9%
Planetary Science	10.6%

Past Utilization and Projected Yearly Demand and Growth





- The year-to-year growth of HECC utilization has exceeded 50% since 2006.
- Each year demand far exceeds capacity.
- Standard Billing Units represent work completed normalized over different computer architectures.

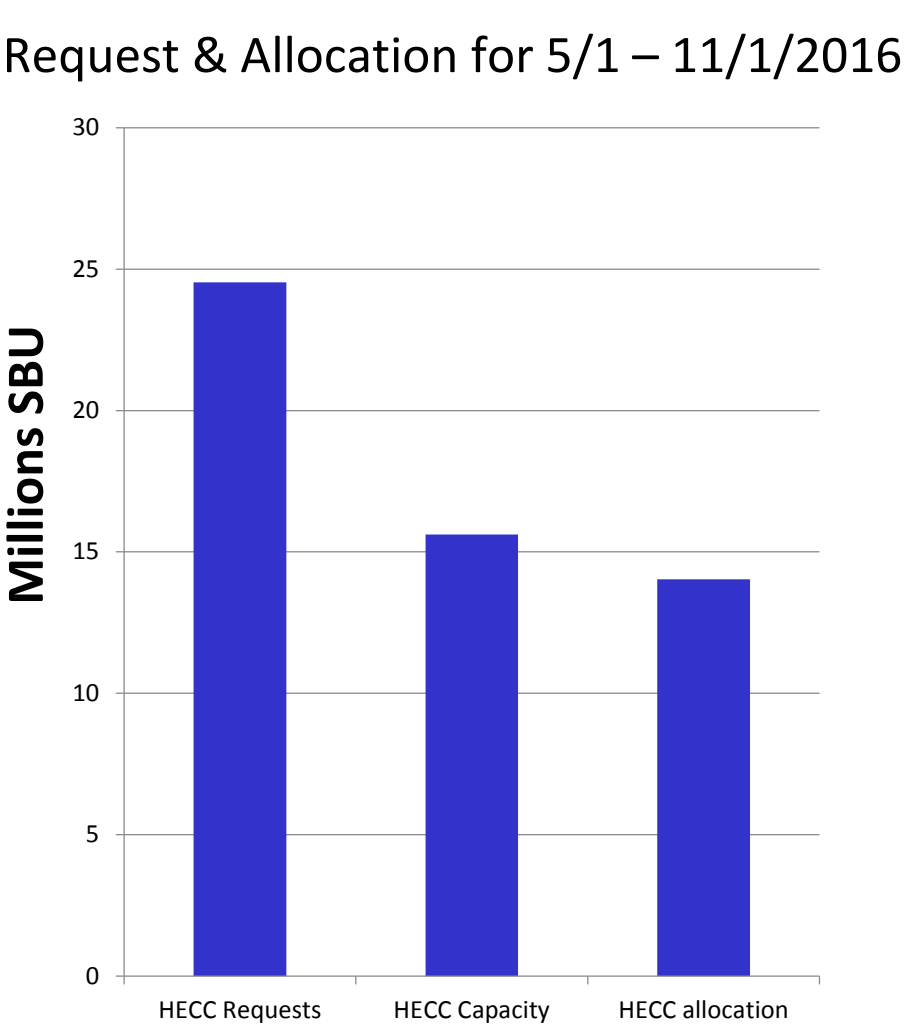
- Demand is based on request for computing resources in FY16 with 25% year-to-year growth.
- Demand in FY16 is almost twice the available capacity.
- The demand will not be met with this expansion project. However, the facility expansion will allow augmentation in computing capability.

Facing the HEC Resource Challenge

Current HEC Resource Allocation and Access Challenge

- Demand for HEC resources has increased significantly in the past couple of years in all disciplines.
- Compute capacity has not kept up with demand.
- As a result, there is an oversubscription of resources.
- Time critical engineering and data processing projects have caused further delays to research projects.
- As a reference, 1 SBU* = $0.26 in FY16

*A Standard Billing Unit (SBU) is a common unit of measurement employed by the HEC program for allocating and tracking computing usage across its various architectures. SBUs charged = number of Minimum Allocatable Units x number of wall clock hours x SBU Conversion Factor.

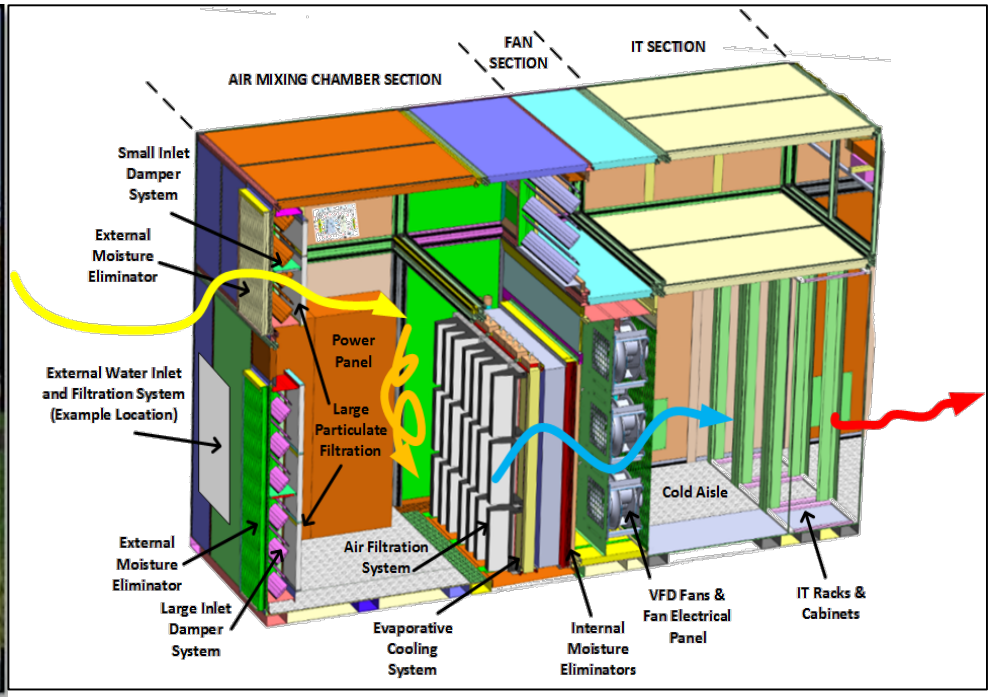


Mitigation Strategy

- Build HECC facility to allow future expansion.
  - The Agency has just approved a major HECC facility expansion proposal on 9/19/2016. Planned construction will start in 2018.
- Tie HEC resource needs to the budget planning process.
  - Allocate **planned** HEC resource during the proposal evaluation and award process (consider all the resource needs).
- When needed, SMD's Science Divisions have the flexibility to buy more resources (Caveat: only when facility is available)
- Work with the scientific community through the normal strategic planning process to understand the relative priority of HEC.

Modular Supercomputing Facility (MSF) Prototype

Artist's rendering of the proposed pilot MSF



Air Flow through ½ of pilot MSF

- The prototype MSF has industry leading energy efficiency projections
  - Projected power used for cooling 16 racks in 1 year would drop from 947,482 kWh to 145,766 kWh, an 84% savings.
  - Annual water evaporated for cooling 16 racks would drop from 1,460,000 gallons to 8,820 gallons, a 99.4% reduction.
- Future modules can be deployed on an as-needed basis and can utilize emerging technologies unavailable today that can further increase the effectiveness of the compute environment.
  - Cost per module is 15% of the cost of the fully populated compute and module deployment
- A fully deployed site of 16 modules would cost under $40M with site preparation

Artist's Rendering of Full MSF Concept

(Build HECC facility to allow future expansion)

This artist rendition shows a possible full deployment of a Modular Supercomputing Facility. Capable of housing 256 compute racks or 18,432 nodes this would have almost 100 more racks than Pleiades and use just over 6MW of power. The cost estimate which is being refined would be under $40M for the site preparation and all of the modules.

Tie HEC Resource Needs to the Budget Planning Process

A bottom-up requirements gathering, top-down allocation model will now be employed to instill planning discipline and ensure continued delivery of HEC resources.

Governing Principles:

1. HEC resources will be treated as a limited resource. Proper planning is needed for managing the resource.
2. HEC requires significant budgetary investment. SMD will plan for HEC resources similar to and in coordination with the Planning, Programming, Budgeting, and Execution (PPBE) process.
3. HEC resource demands will be gathered and adjudicated during the PPBE process. Once approved and funded, they become a requirement for implementation by the HEC program.

Resource Allocation:

– Allocate **planned** HEC resource during the proposal evaluation and award process

Mitigation Strategy

- Build HECC facility to allow future expansion.
- Tie HEC resource needs to the budget planning process.
  - Allocate **planned** HEC resource during the proposal evaluation and award process (consider all the resource needs).
- When needed, SMD's Science Divisions have the flexibility to buy more resources (Caveat: this is assuming facility is already available).
- Work with the scientific community through the normal strategic planning process to understand the relative priority of HEC.

Questions?