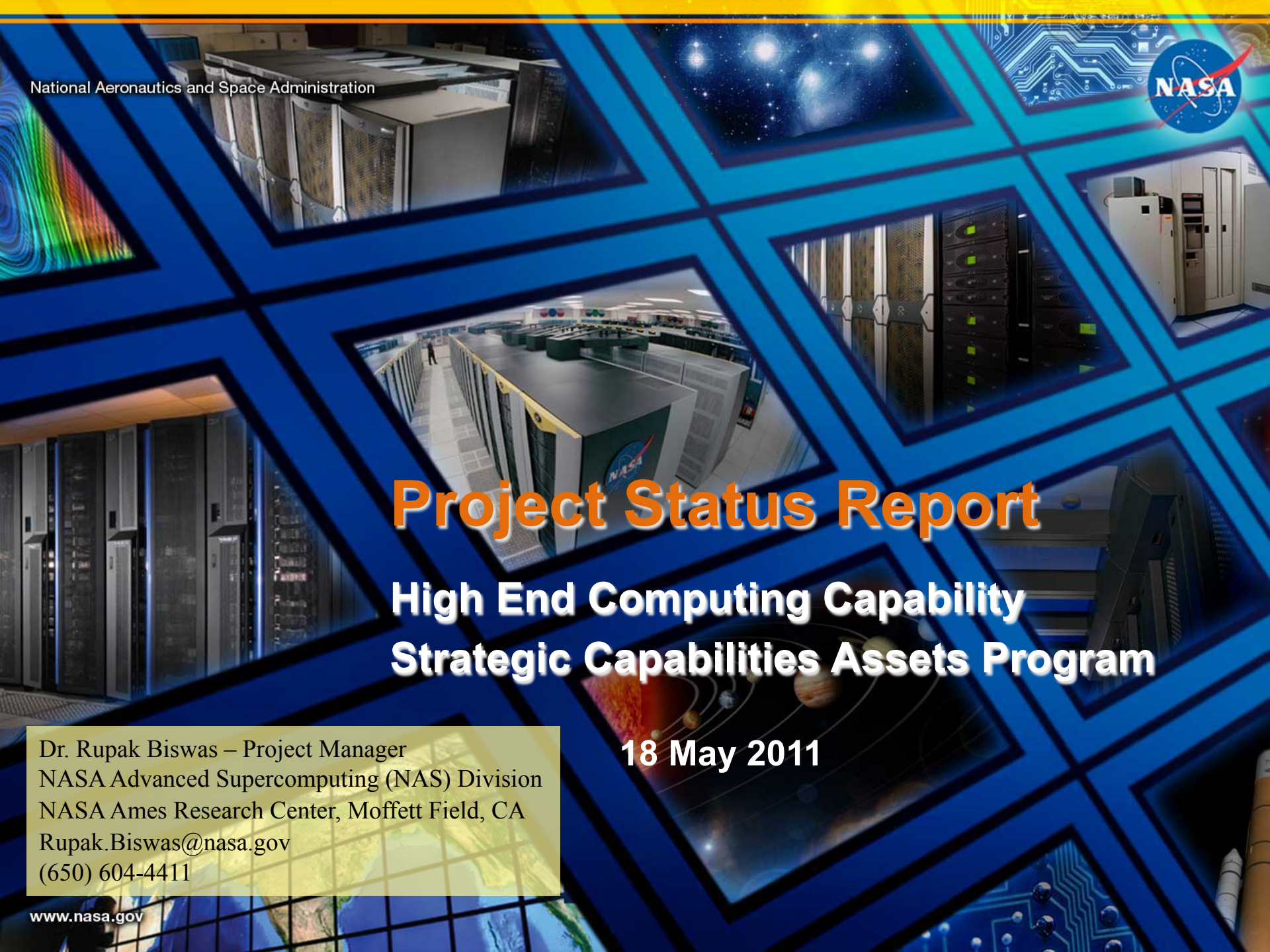


Project Status Report

High End Computing Capability
Strategic Capabilities Assets Program

18 May 2011

Dr. Rupak Biswas – Project Manager
NASA Advanced Supercomputing (NAS) Division
NASA Ames Research Center, Moffett Field, CA
Rupak.Biswas@nasa.gov
(650) 604-4411

High-End Ocean State Estimates for Real-World Challenges

- Under the Estimating the Climate and Circulation of the Ocean 2 (ECCO2) project, scientists at NASA JPL and MIT are reconstructing the state of Earth's ocean and sea-ice system during the last 20 years.
- These fully 3D, time-evolving reconstructions are produced by massive computations that combine mathematical models with satellite and in-situ measurements; results provide detailed data about variations in quantities such as ocean current patterns, temperature, and sea level.
- The numerical methods used to combine the models and data require thousands of computer cores, hundreds of terabytes of storage, and multiple terabytes of RAM — HECC supercomputers are among the few available platforms able to handle the required scale of computation, data processing, and analysis.
- HECC experts also provide extensive data analysis and visualization support to the ECCO2 team.

Mission Impact: HECC resources and visualization services help NASA scientists to develop scientific insights into how (and why) the global earth system is changing and improve understanding of life supporting planetary cycles.

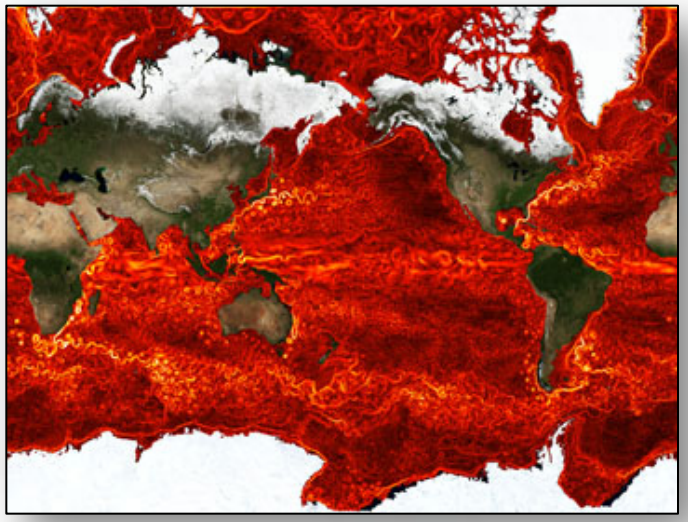


Figure: Surface current speeds from a simulation with 1/16-degree-horizonatal grid spacing. The currents and associated 3D full ocean state can be used to drive applications such as improved estimates of carbon uptake by the oceans and improved melt-rate estimates for the Antarctic and Greenland ice sheets.

POC: *Chris Hill, cnh@mit.edu, (617) 253-6430, Massachusetts Institute of Technology; Chris Henze, christopher.e.henze@nasa.gov, (650) 604-3959, NASA Advanced Supercomputing Division*

Pleiades Enables Turbulent Flow Predictions for Aeronautics Research

- Using the Pleiades supercomputer, researchers at Stanford University and at NASA Ames Research Center are running simulations to accurately predict turbulent flow characteristics and interactions in high-Mach boundary layers.
- Boundary layer turbulence has first-order impact on aerodynamic heating, drag, and control of hypersonic vehicles; and affects engine performance and operability, as well as vehicle structure and weight.
- This research is helping develop fundamental understanding of these flow interactions, which is critical to the design of future aircraft and aerospace reentry vehicles.
- Turbulent flows are inherently unsteady, and require large amounts of computing resources to resolve space and time scales; about 1 million SBUs have been used to investigate the basic physics of turbulence, making Pleiades the ideal production system for this work.

Mission Impact: Use of HECC resources enables researchers to improve the fundamental understanding of turbulent boundary layer characteristics and associated surface heat fluxes, which are critical to designing next-generation high-speed aircraft and reentry vehicles.

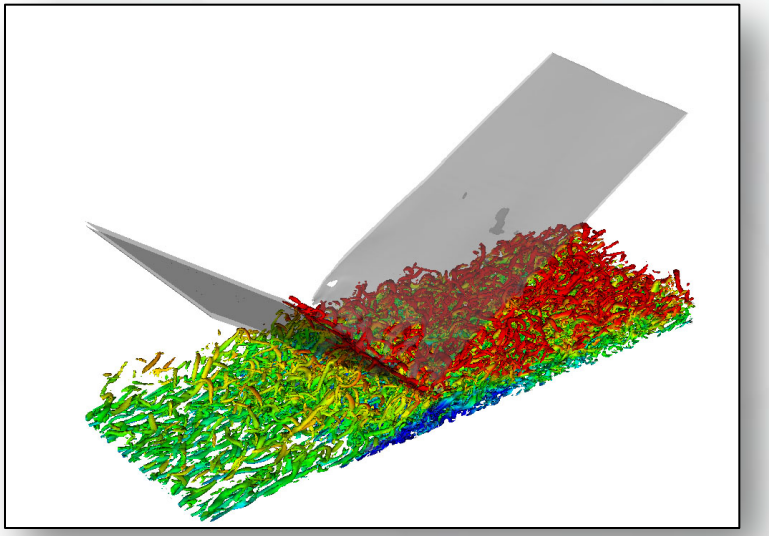


Figure: Oblique shock impinging on a hypersonic turbulent boundary layer for a Mach 2.05 flow over an 8-degree wedge angle. (Sanjiva Lele, Parviz Moin, Stanford University)

POC: *Seokkwan Yoon, s.yoon@nasa.gov, (650) 604-4482, NASA Advanced Supercomputing Division*

HECC Code Optimization Support Improves Kepler Mission Results

- As part of ongoing support for the Kepler Science Operations Center, HECC staff implemented code optimization techniques that improved both accuracy and performance of the BLENDER tool used to confirm planet candidates.
- Implemented code routines that normalize results and produce contour plots in terms of confidence intervals (sigma), which quantify the "goodness of fit" between the synthetic light curves generated by BLENDER and the Kepler observations.
  - Results from this method have revealed new features in the chi-square landscapes that the Blender team is working to understand.
- Discovered and corrected bug in the BLENDER light curve generator, and eliminated significant communication, which resulted in a several-fold speed increase.
- Processed "urgent" targets with BLENDER for modeling Kepler light curves for a pending Kepler data release.
- Kepler members at Ames and the Harvard-Smithsonian Center for Astrophysics are enthusiastic about results gained from HECC's improvements.

Mission Impact: HECC expertise has enabled the Kepler Mission to improve the accuracy of results and gain new understanding of the science data collected.

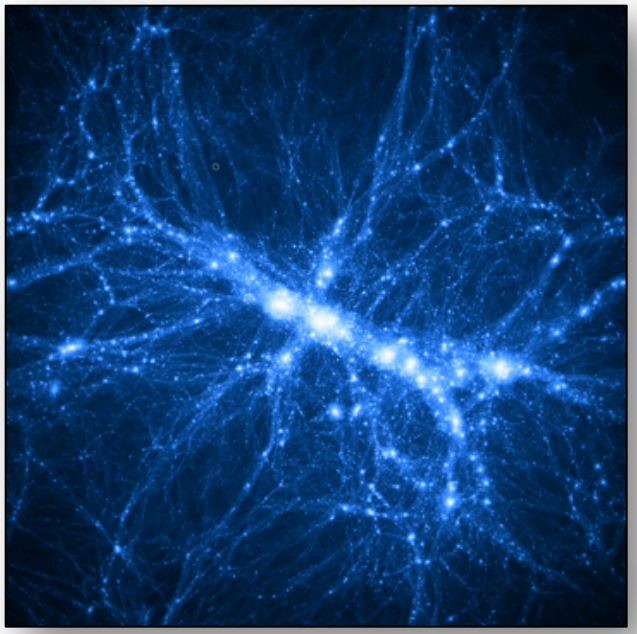


Figure: NASA's Kepler space telescope, designed to find Earth-size planets in the habitable zone of sun-like stars, has already discovered its first five new exoplanets, or planets beyond our solar system.

POC: *Chris Henze, christopher.e.henze@nasa.gov, (650) 604-3959, NASA Advanced Supercomputing Division*

Visualizing Simulations of Cosmology and Galaxy Formation

- A research team at the University of California, Santa Cruz, is addressing the challenge of explaining how the structures in today's universe formed within the Lambda Cold Dark Matter framework.
- Using the Pleiades and Columbia supercomputers, the team has produced simulations of large volumes of the universe at high resolution, in order to follow the formation and evolution of every dark matter halo that can host galaxies, including the merging of these halos.
- Pleiades has enabled the team to run dissipationless and hydrodynamic simulations—in particular, its Bolshoi Gigalight-year simulations.
- Collaboration with HECC visualization experts has been crucial for visualizing and interpreting the results of these simulations to understand the evolving cosmos.
- The Visualization team produced a high-redshift Bolshoi visualization featured in the show, "Life: A Cosmic Story," produced by the California Academy of Sciences and shown daily at Morrison Planetarium—the largest all-digital planetarium in the world.

Mission Impact: Visualizations produced within the HECC Project are helping astronomers and the wider public, including planetarium visitors, to understand the evolving cosmos.

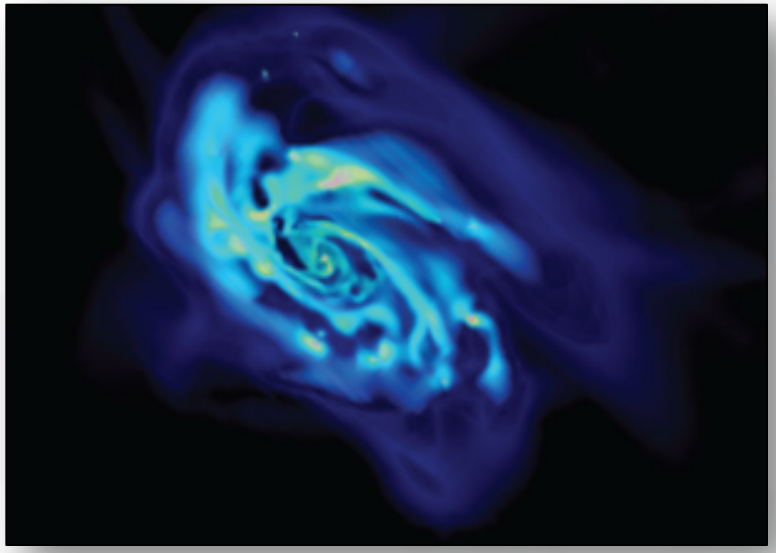


Figure: Visualization of the cosmic web: an image, one billion light years across, of the final snapshot from the 8-billion-particle Bolshoi simulation. (Anatoly Klypin, New Mexico State University; Stephan Gottloeber, AIP-Germany)

POC: *Joel Primack, joel@scipp.ucsc.edu, University of California, Santa Cruz, Chris Henze, christopher.e.henze@nasa.gov, (650) 604-3959, NASA Advanced Supercomputing Division*

Networks Team Develops Prototype InfiniBand Monitoring Web Tool

- A web-based InfiniBand (IB) monitoring tool, developed by the Networking team, allows staff to easily monitor and isolate problems across the entire HECC enclave IB fabric. The tool updates counters every second for real-time monitoring.
- Information is collected directly from the IB switches, inserted into a database, and displayed on an internal website. Output is grouped by IB switch, computer rack location, and fabric. Detailed information about each connection (ID, uptime, all error types, speed, hostname, etc.) is also displayed. Features include:
  - "Top 20 IB errors" display improves problem isolation for hosts and/or switchports.
  - Built-in ticketing/tracking system logs changes made to the IB fabric.
  - Implements an algorithm used by the Systems group that detects bad cables based on specific errors and displays them on the web.
  - Provides the ability to trace host-to-host through the fabric and view error counters for each switchport along the path.

Mission Impact: Having the ability to easily monitor and isolate problems across the HECC InfiniBand fabric using a centralized method allows engineers to more quickly and effectively identify and resolve interconnect issues and keep users' jobs running at optimal performance.

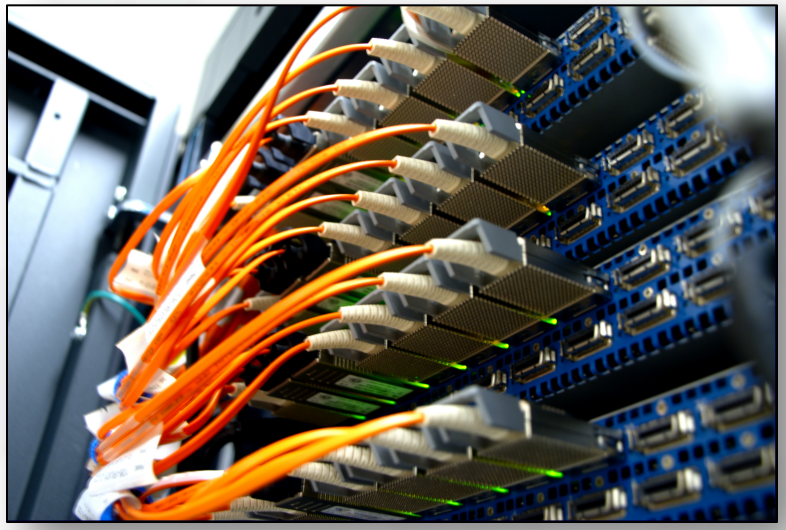


Figure: This photo shows a small portion of the 50-plus miles of cables and thousands of ports that comprise the HECC InfiniBand fabric—the largest InfiniBand fabric in the world.

POC: *Nichole Boscia, nichole.k.boscia@nasa.gov, (650) 604-0891, NASA Advanced Supercomputing Division, Computer Sciences Corp.*

HECC Pioneers New Scientific Desktop Computer Support Model

- An HECC team recently received final certification of "Seat 6," a new ODIN computer support model that offers a more robust, secure, and less expensive solution to desktop requirements than other standard seats.
- Seat 6 systems are purchased, configured, and managed by the user organization, with system configuration and IT security reviewed and approved by Ames' IT Security Division (Code IS) as compliant with agency Mission Focus Review (MFR) 137 requirements.
- The approved configuration, certified using the HECC-developed automated console check utility, contains needed scientific software, uses FileVault for data-at-rest encryption, allows only non-elevated user accounts, and uses an IP firewall as well as other security enhancements.
- Hardware procurement is completed through the SEWP contract at a cost lower than what can be obtained through ODIN.

Mission Impact: Innovative solutions provide systems that are more secure and better able to meet user needs at a lower cost while providing all the necessary tracking mechanisms to meet Agency and Federal requirements.

6. Certified Locally Managed Seat

Includes:
- Certification that locally managed operating system configuration is secure and suitable for connection to the trusted NASA intranet

CIO Responsibilities:
- Administration of security certification process

Organization Responsibilities:
- Maintain certification of native OS
- Install and maintain operating system and applications
- Manage privileges at the organization level with CIO providing policy and guidance
- Manage hardware repairs and replacement
- Install and maintain peripherals (printers, scanners, projectors, etc.)

Figure: Definition of Seat 6 proposed by NASA Workstation Tiger Team to meet user and MFR 137 requirements.

POC: *Cathy Parks, cathy.b.parks@nasa.gov, (650) 604-4314, NASA Advanced Supercomputing Division, Computer Sciences Corp.*

HECC Teams Respond to Facility Emergency, Restore Computing Within 24 Hours

- Quick response from HECC personnel averted a potential catastrophic disaster after a chiller plant failure on April 7 caused extreme overheating on the main computer floor.
- Control Room, Facility Engineering, Systems, and Network teams successfully stabilized and returned the HECC computing complex to production in 24 hours.
- Control Room personnel responded quickly with notifications and completed shutdown procedures in about 30 minutes.
- Facilities personnel shut down electrical systems, stopped a resulting water leak in a Pleiades rack (*see figure*), began repairs to the chiller system, and checked all water connections.
- Systems staff worked to recover the computing and storage systems, restarted Pleiades and returned it to production status.
- Network staff assured proper network functionality as the systems were brought back online.

Mission Impact: The HECC teams' quick recovery from a facility emergency saved hundreds of thousands of computer hours that would otherwise have been lost to NASA Mission Directorates for computation on important Agency projects.

Figure: At left, photo shows loosened hose (top) and brass connector fitting (lower left) in Pleiades rack 24. At right, water collected inside the rack caused damage, which has since been repaired.

POC: *Davin Chan, davin.chan@nasa.gov, (650) 604-3613,*
David Robertson, david.g.robertsonl@nasa.gov, (650) 604-6754,
NASA Advanced Supercomputing Division, Computer Sciences Corp.

Presentations and Papers

Presentations

- "Diagnostics and Prognostics for Stage Separation Failure" IEEE Aerospace conference, Big Sky, Montana, 2011, D. Luchinsky et al.*

  http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=5747595&tag=1

- "High-Fidelity Modeling for Health Monitoring in Honeycomb Sandwich Structures" IEEE Aerospace Conference, Big Sky, Montana, 2011, D. Luchinsky et al.*

  http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=5747569

Papers & Publications

- "Cavitation-Induced Ignition of Cryogenic Hydrogen-Oxygen Fluids," V. V. Osipov et al, Appl. Phys. Lett. 98, 134102 (2011); published 29 March 2011, doi:10.1063/1.3571445.* *http://apl.aip.org/resource/1/applab/v98/i13/p134102_s1*

- "Indirect cube: A power-efficient topology for compute clusters," J. Navaridas, José Miguel-Alonso, Optical Switching and Networking, Elsevier B.V., available online 9 April 2011, doi:10.1016/j.osn.2011.03.004.* http://apl.aip.org/resource/1/applab/v98/i13/p134102_s1

- Black Holes, edited by Mario Livio and and Anton M. Koekemoer, Cambridge University Press, 2011, ISBN: 9781107005532; article "Gravitational waves from black-hole mergers, by J. Baker, J.M. Centrella, et al.*

  http://www.cambridge.org/gb/knowledge/isbn/item5962644/?site_locale=en_GB

** HECC provided supercomputing resources and services in support of this work*

News and Events

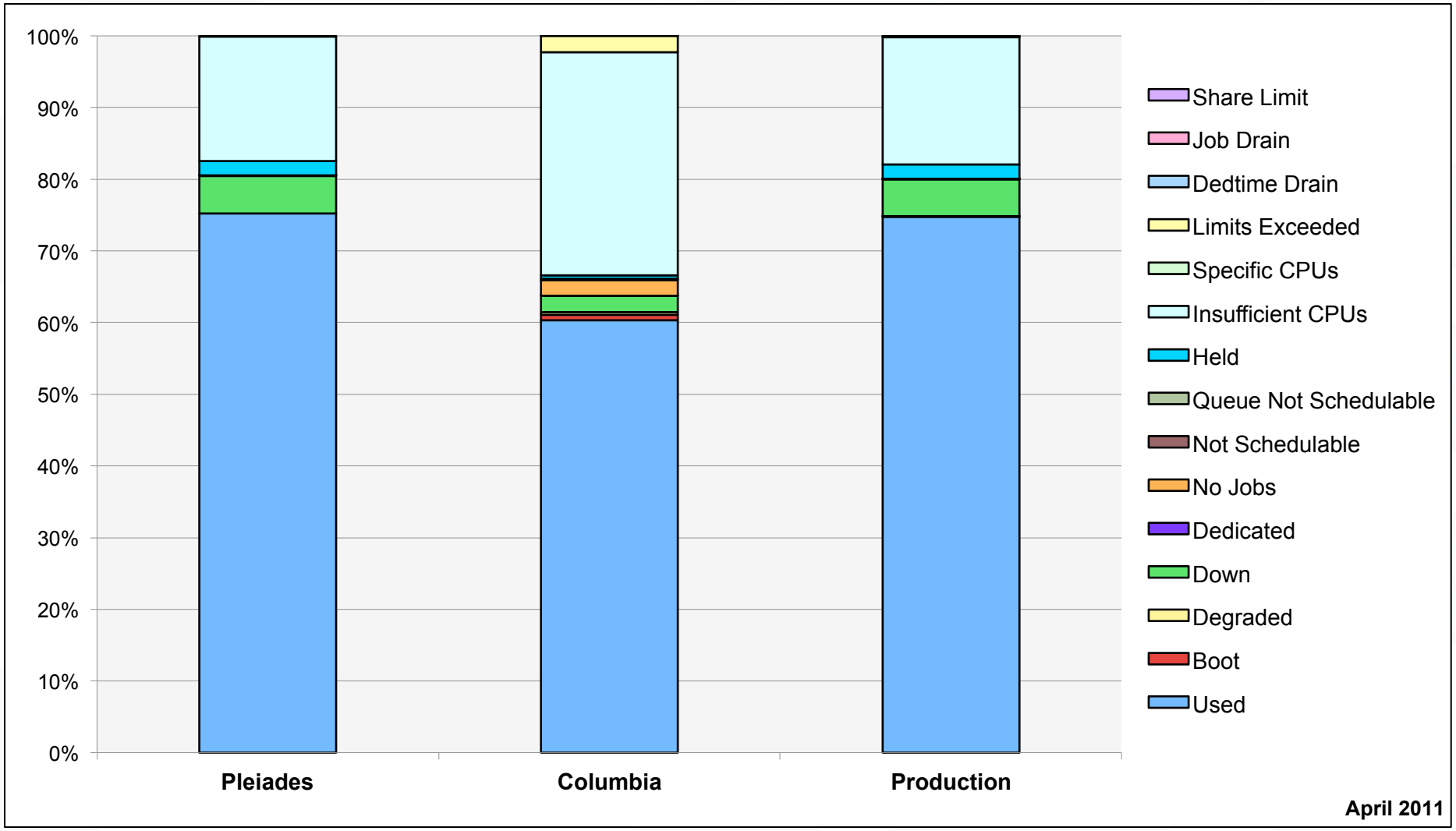
- **This Summer, Adler Planetarium Unveils the Grainger Sky Theatre, the Most Technologically Advanced Theatre in the World**, *PR Newswire,* April 25, 2011 – Article revealing the newest immersive space experience, "Deep Space Adventure," using the Grainger Sky Theatre as its centerpiece. The single seamless image's data was generated using HECC' Pleiades supercomputer with the Visualization group providing the final edited video.

  http://www.prnewswire.com/news-releases/this-summer-adler-planetarium-unveils-the-grainger-sky-theater-the-most-technologically-advanced-theater-in-the-world-120633974.html

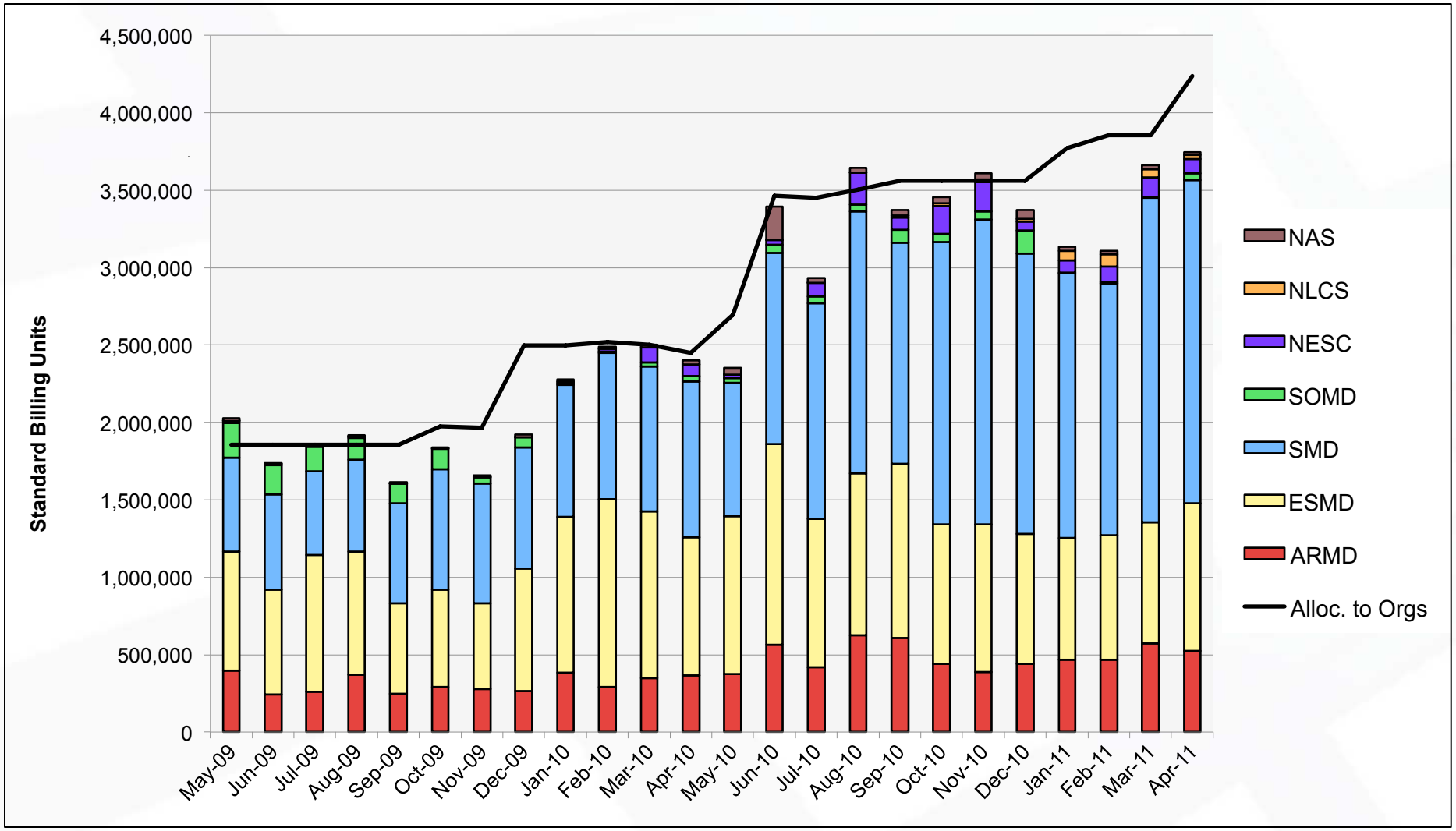
- **Google donates a billion cores to boffins**, *The Register*, April 15, 2011 – Article compares the number of hours Google is providing researchers against the Pleiades supercomputer capability. *http://www.theregister.co.uk/2011/04/15/google_hpc_donation/*

- **Innovation That Matters**, KRON4 TV Best of the Bay – Eight-minute segment focusing on supercomputing technology, giving the public a behind-the-scenes look at the HECC computer room and Pleiades, with examples of scientific projects run on the system; includes sound bites from NASA Ames Center Director Pete Worden and executives from partners SGI and Intel. *http://bestofthebaytv.com/view/1363*

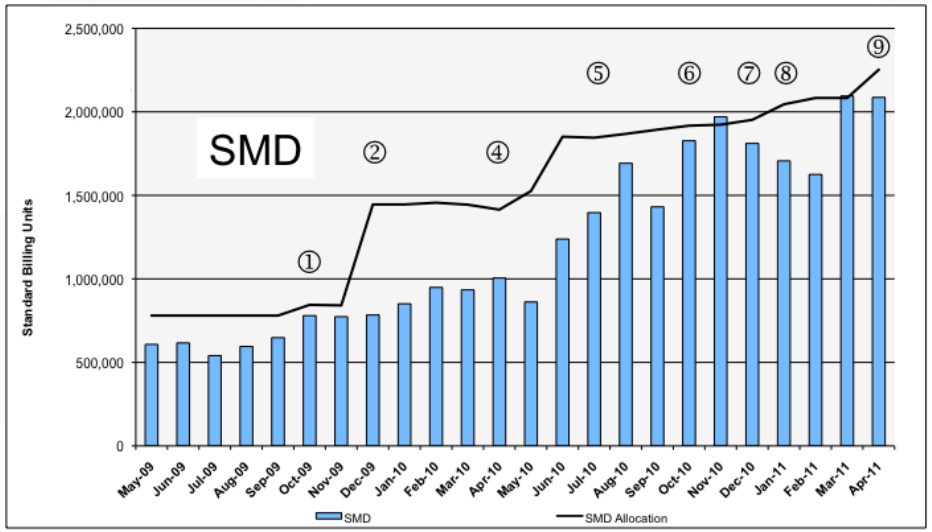
NAS Utilization

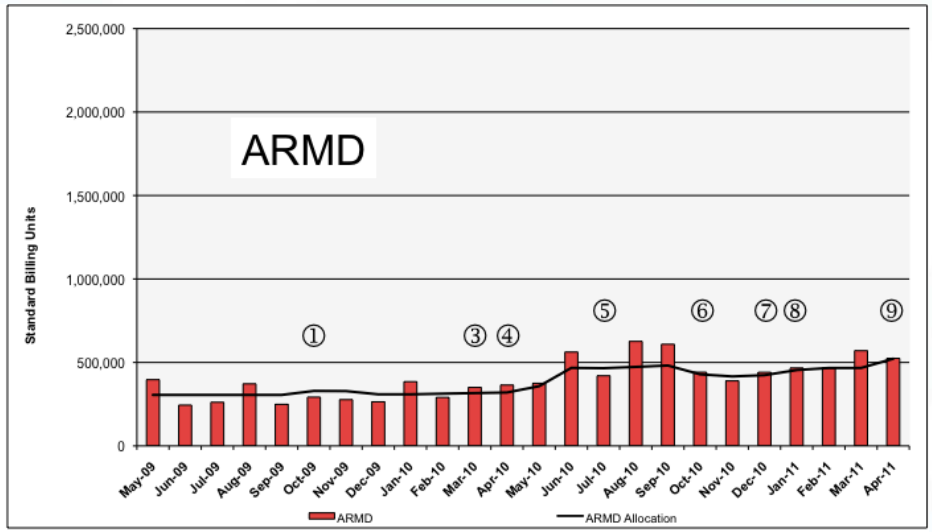


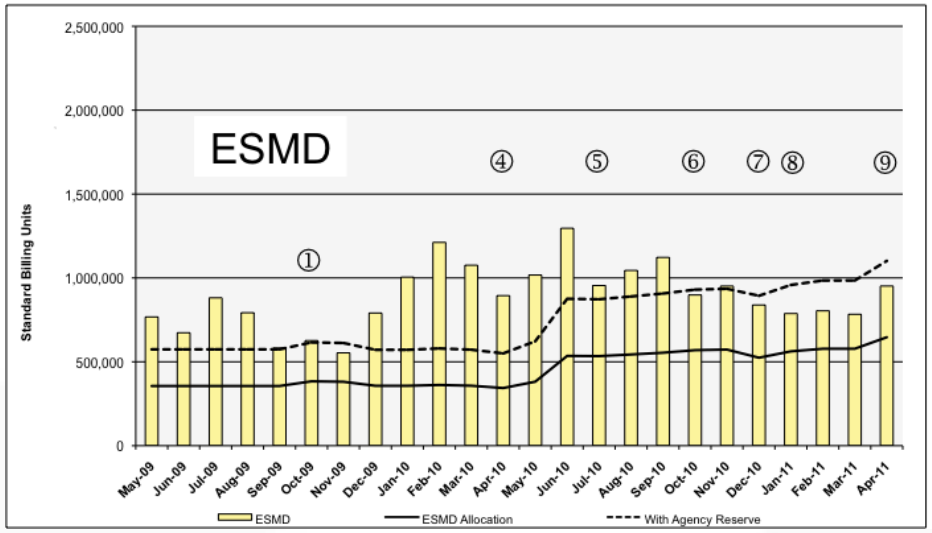
NAS Utilization Normalized to 30-Day Month

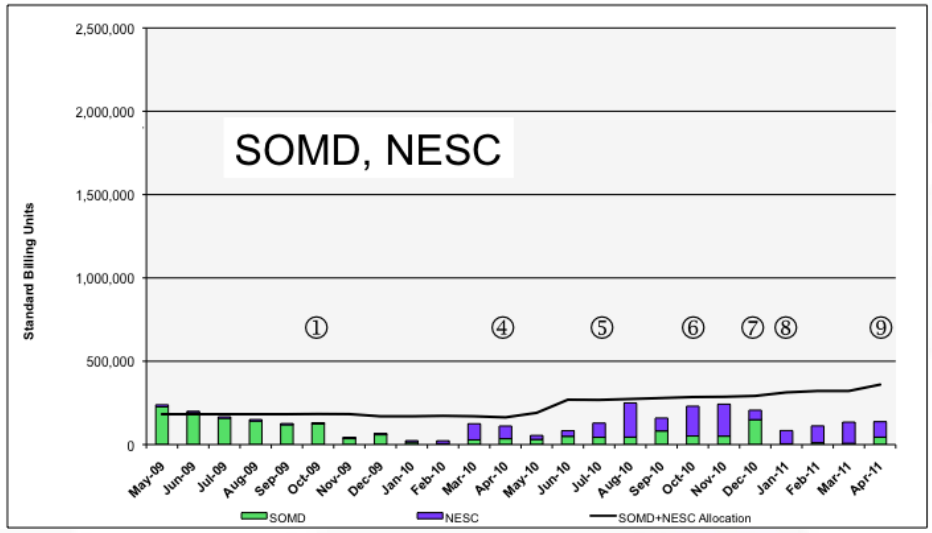


NAS Utilization Normalized to 30-Day Month



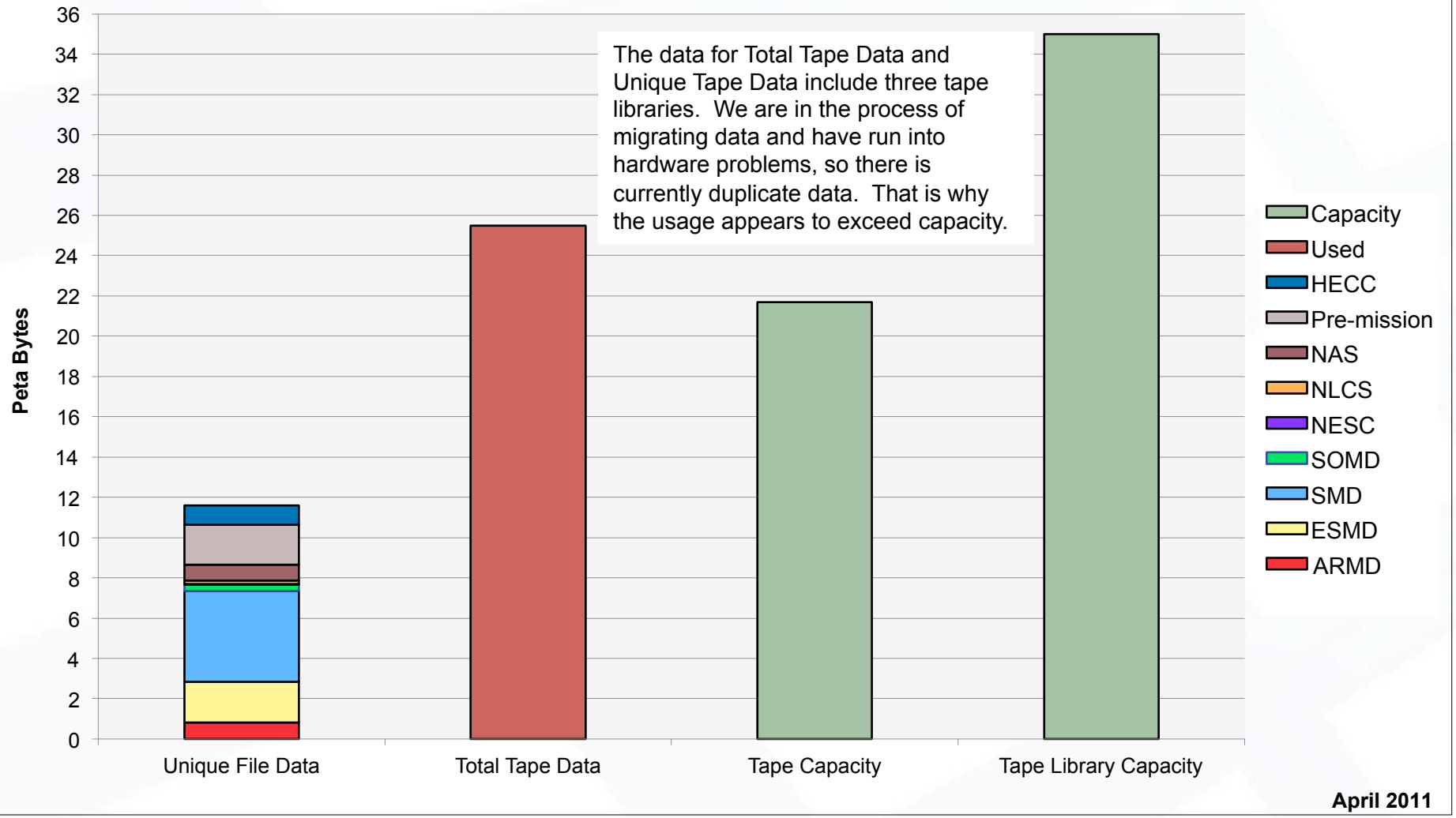




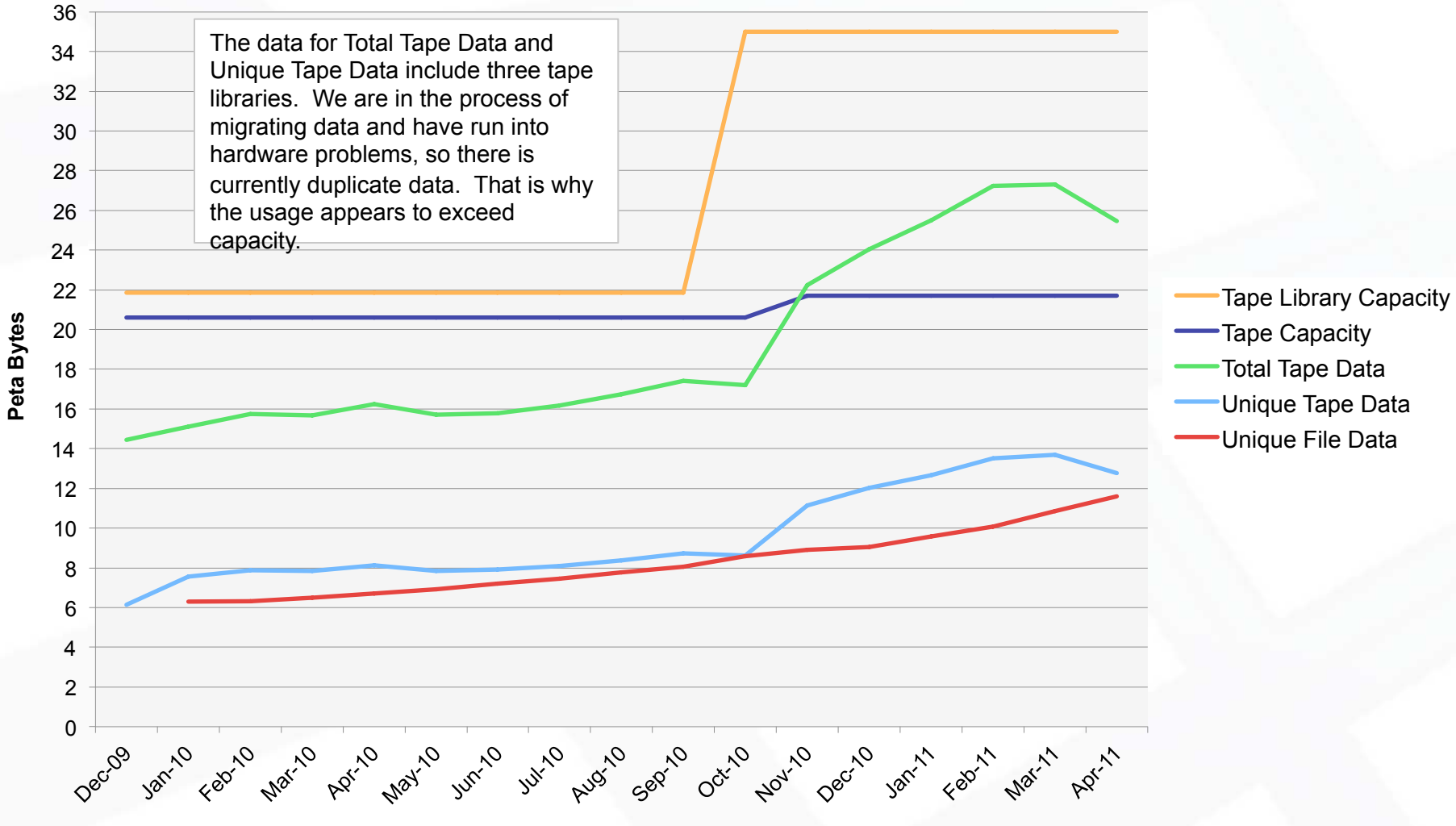


① Allocation to orgs. increased to 80% ② SMD augmentation ③ RTJones retired ④ 32 Westmere racks added
⑤ Schirra retired, 4 Westmere racks added ⑥ RTJones compensation removed ⑦ 8 Westmere racks added
⑧ Devel queue created ⑨ 12 Westmere racks added

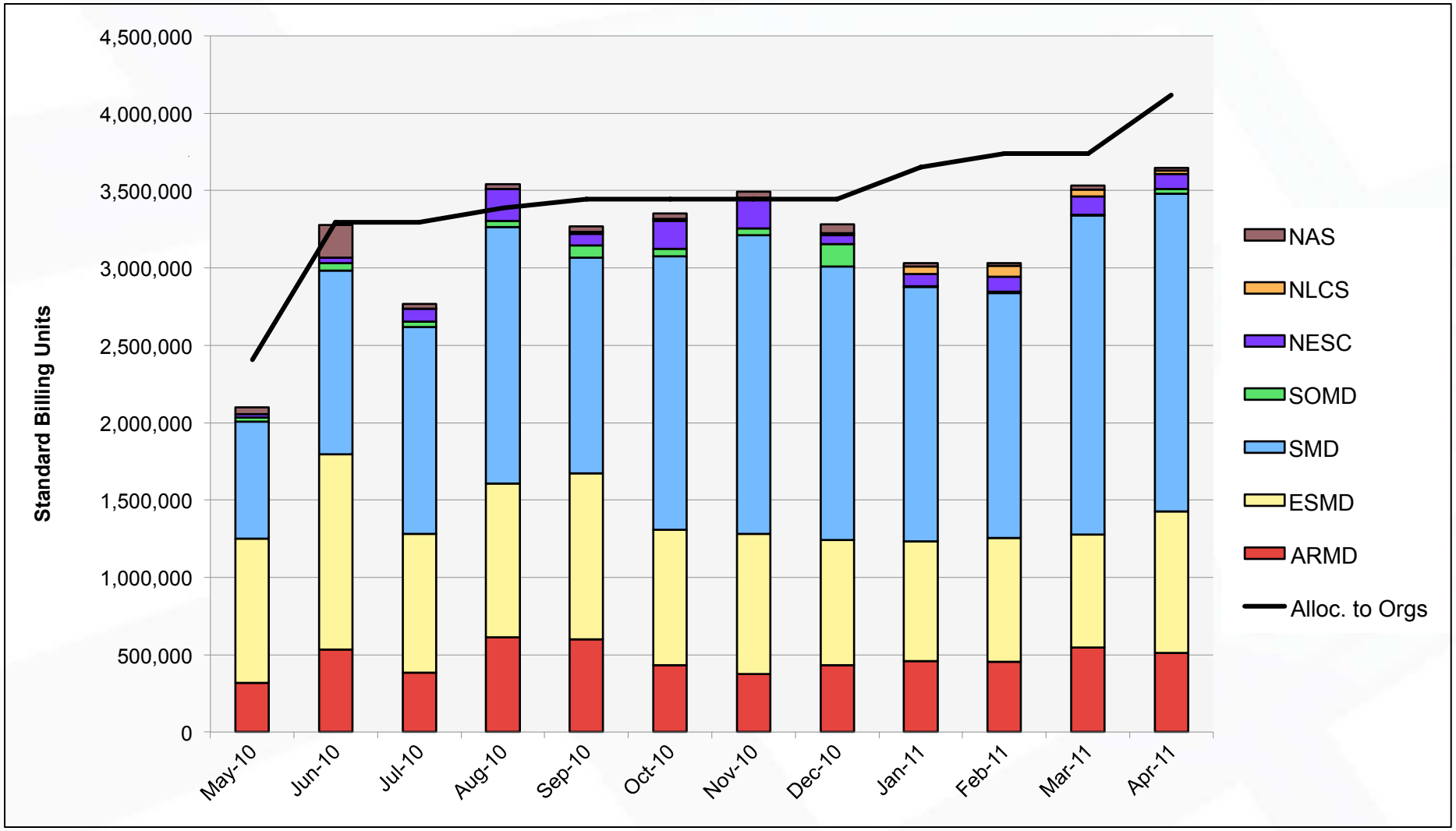
Tape Archive Status



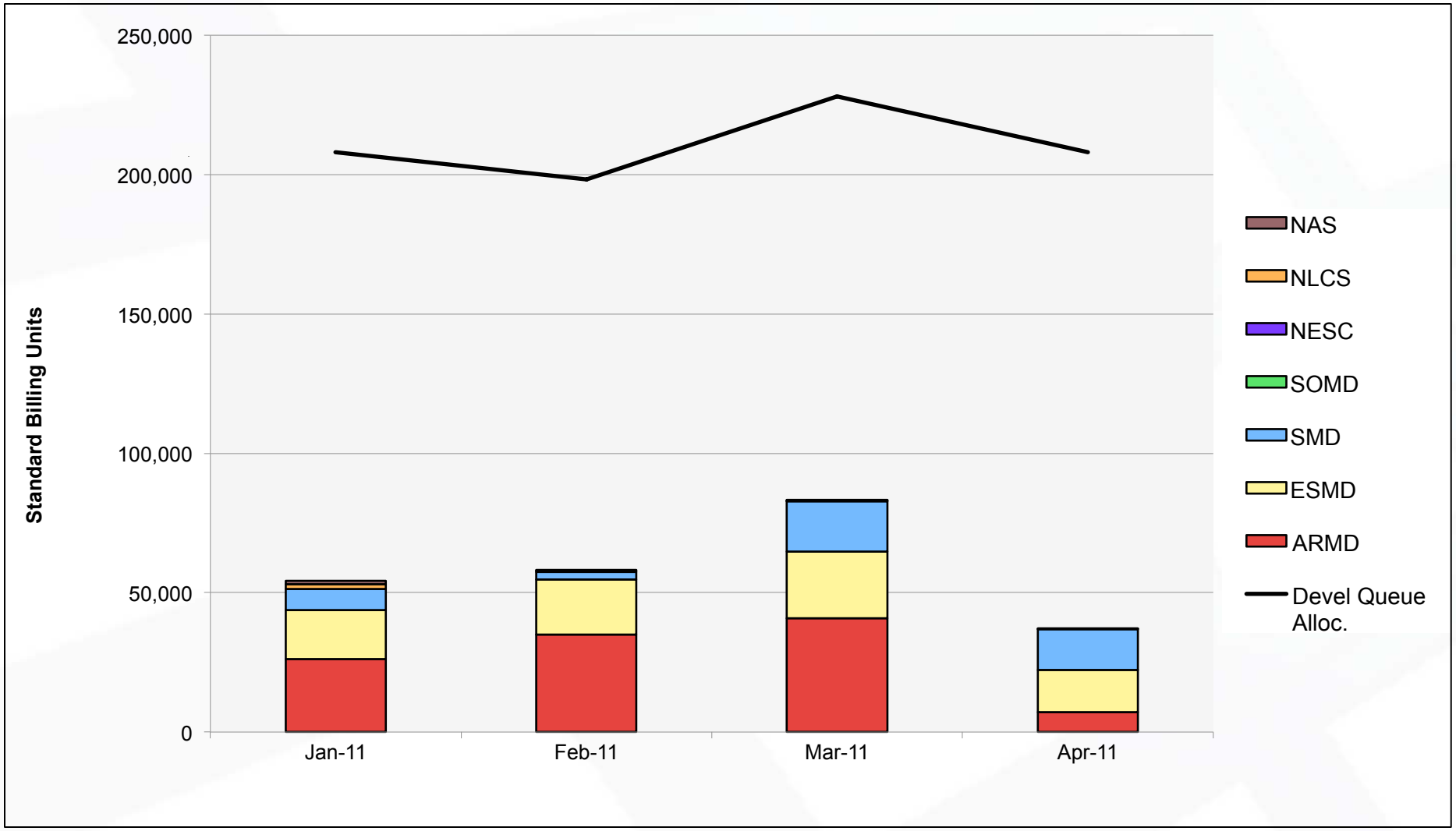
Tape Archive Status



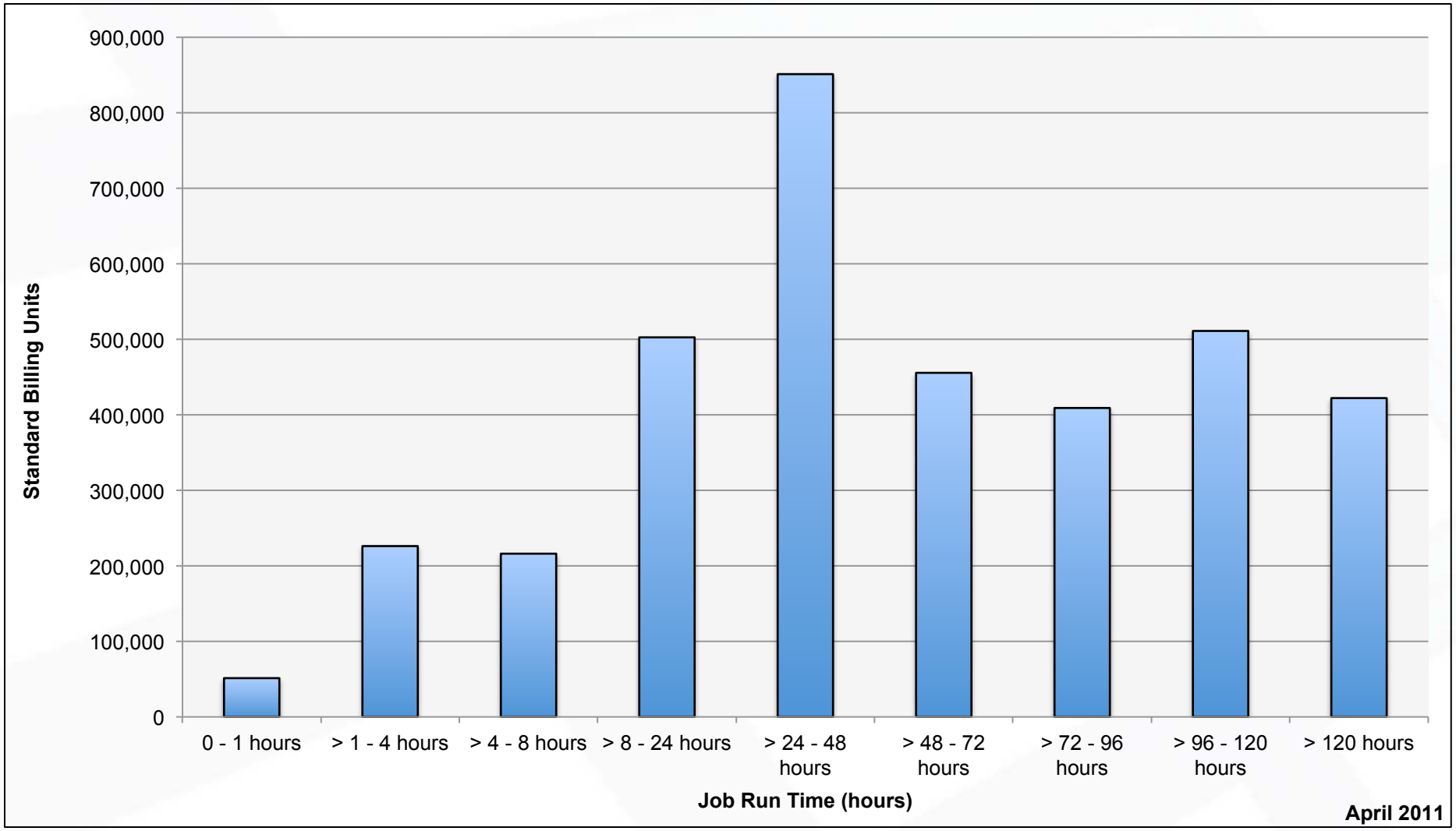
Pleiades:
SBUs Reported, Normalized to 30-Day Month



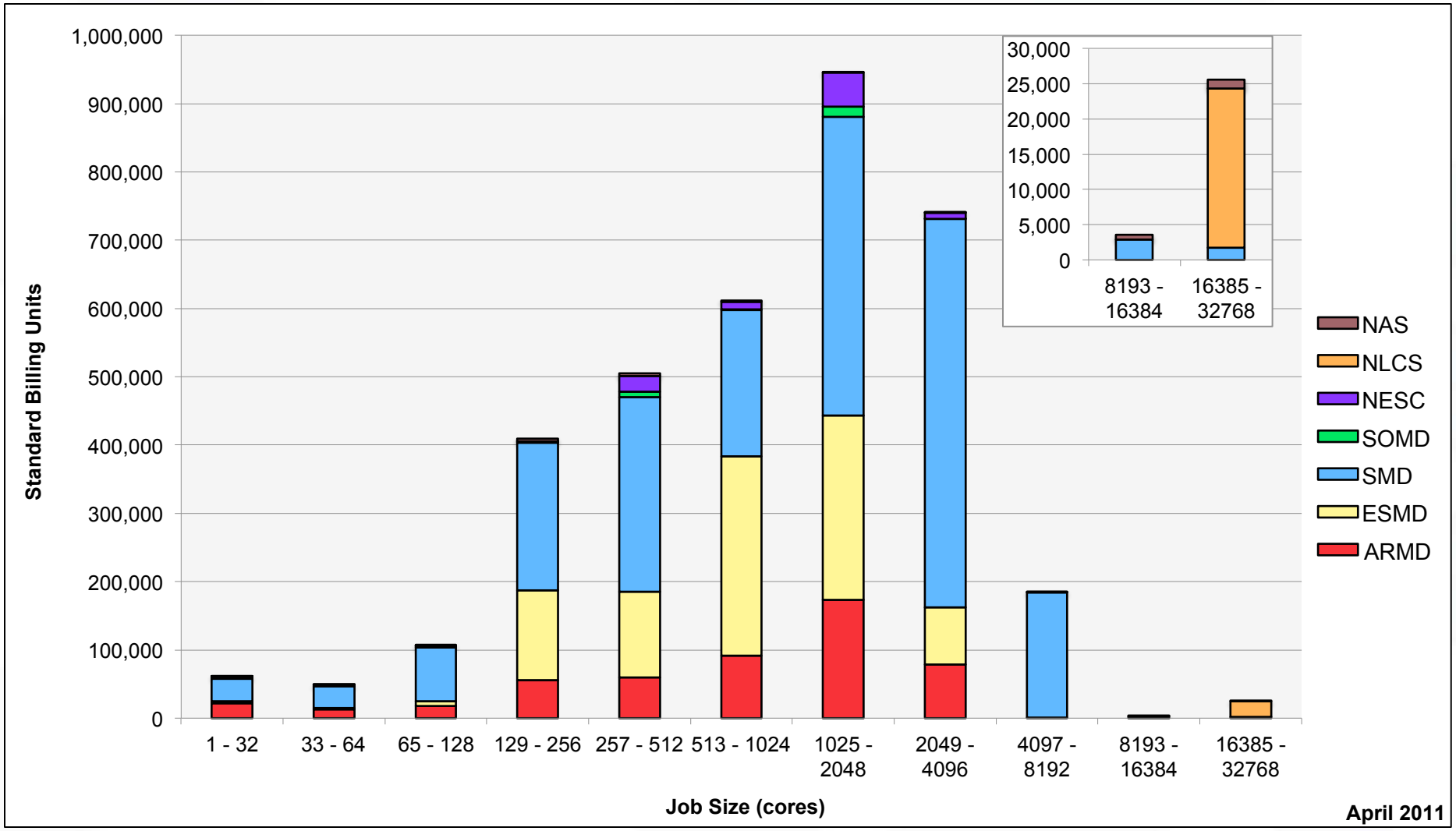
Pleiades:
Devel Queue Utilization



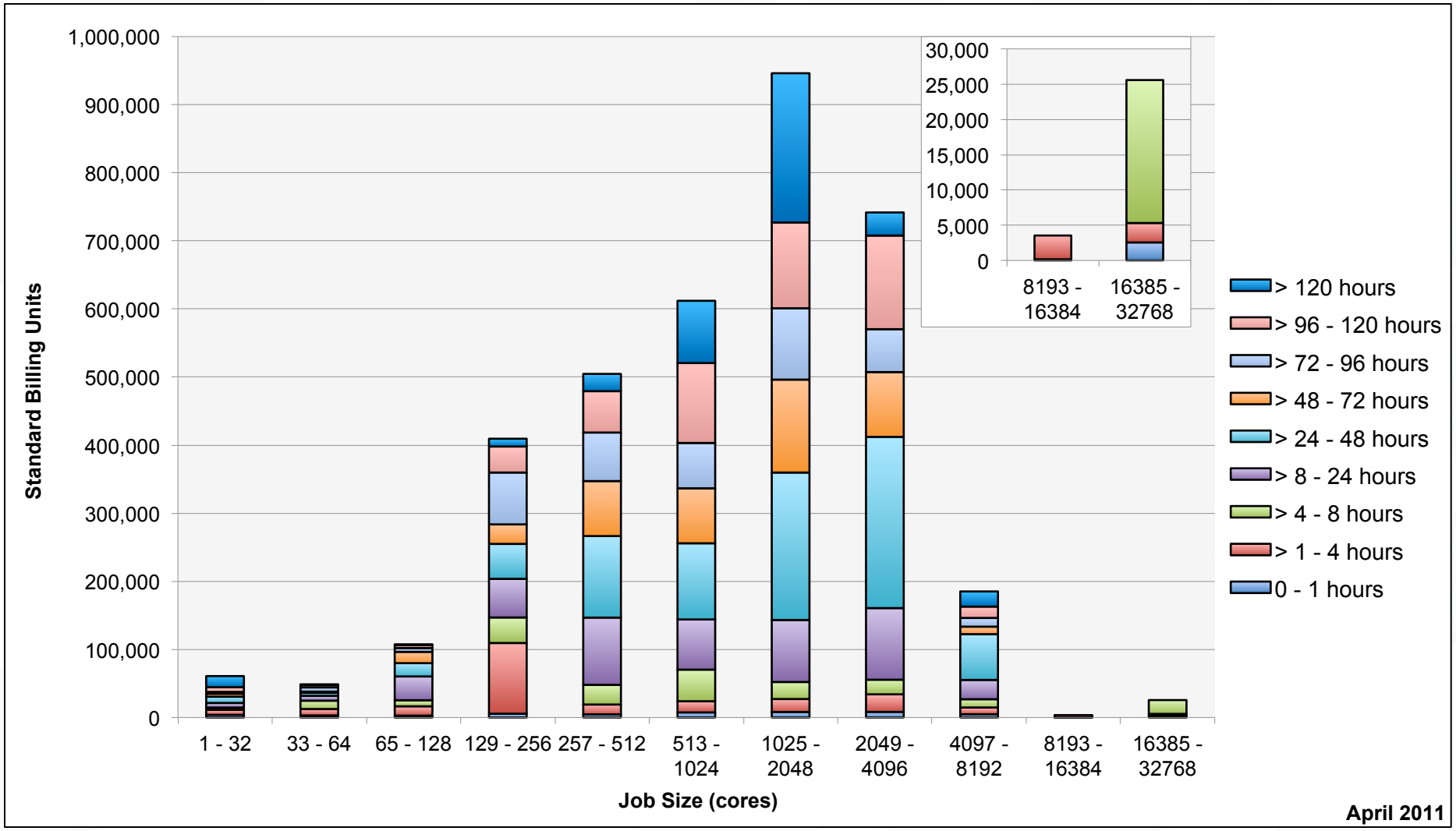
Pleiades:
Monthly SBUs by Run Time



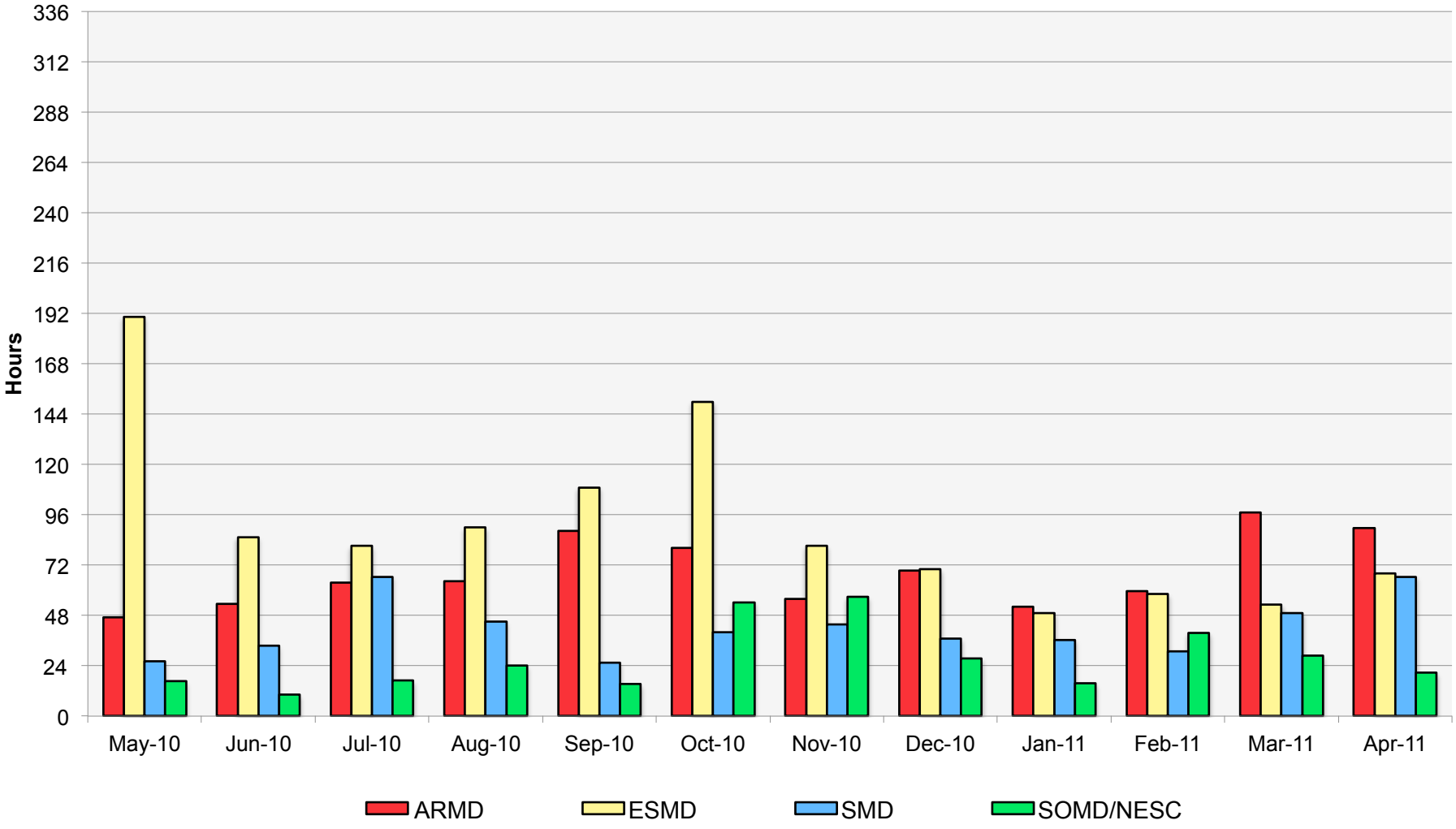
Pleiades:
Monthly Utilization by Size and Mission



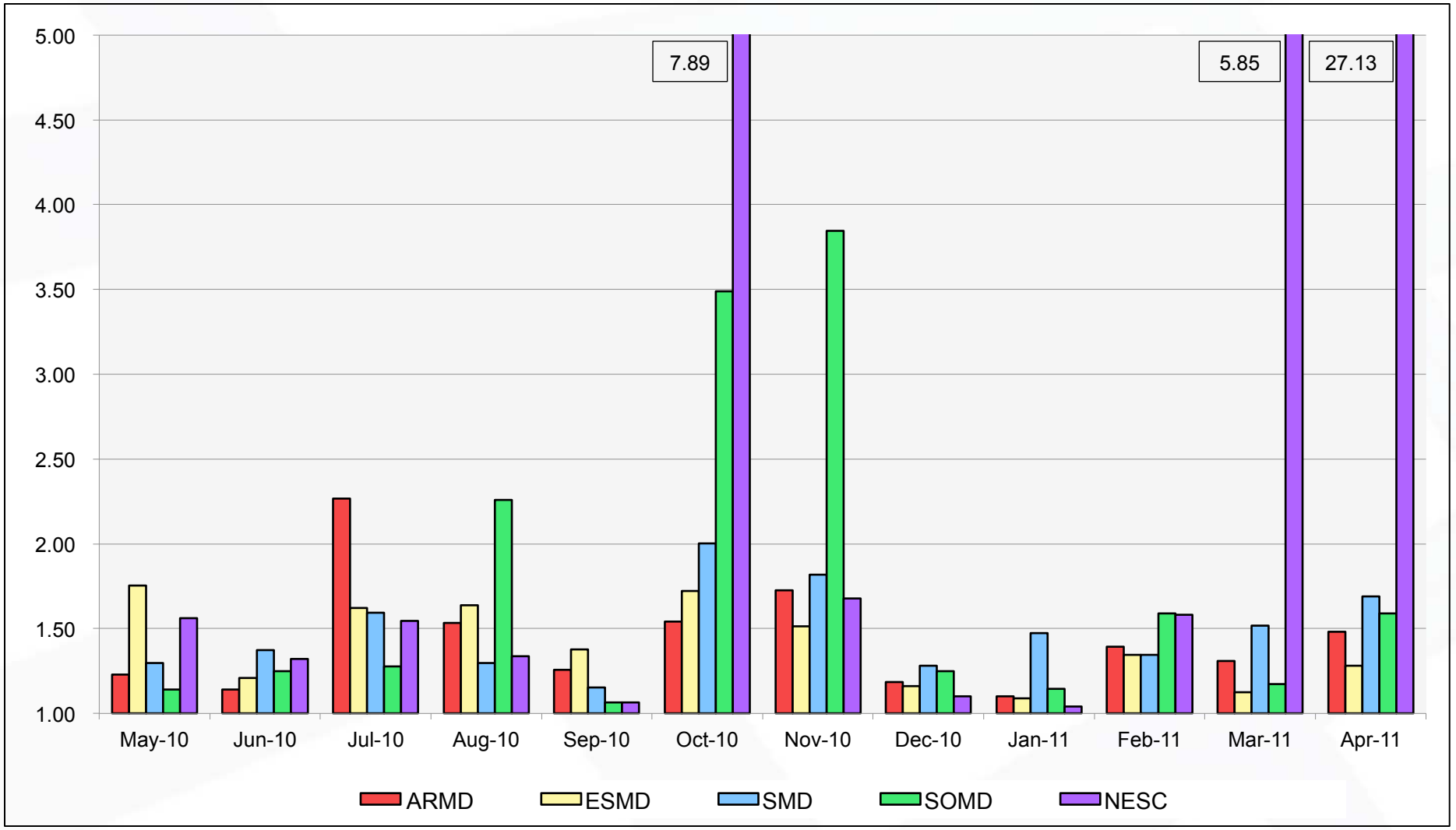
Pleiades:
Monthly Utilization by Size and Length



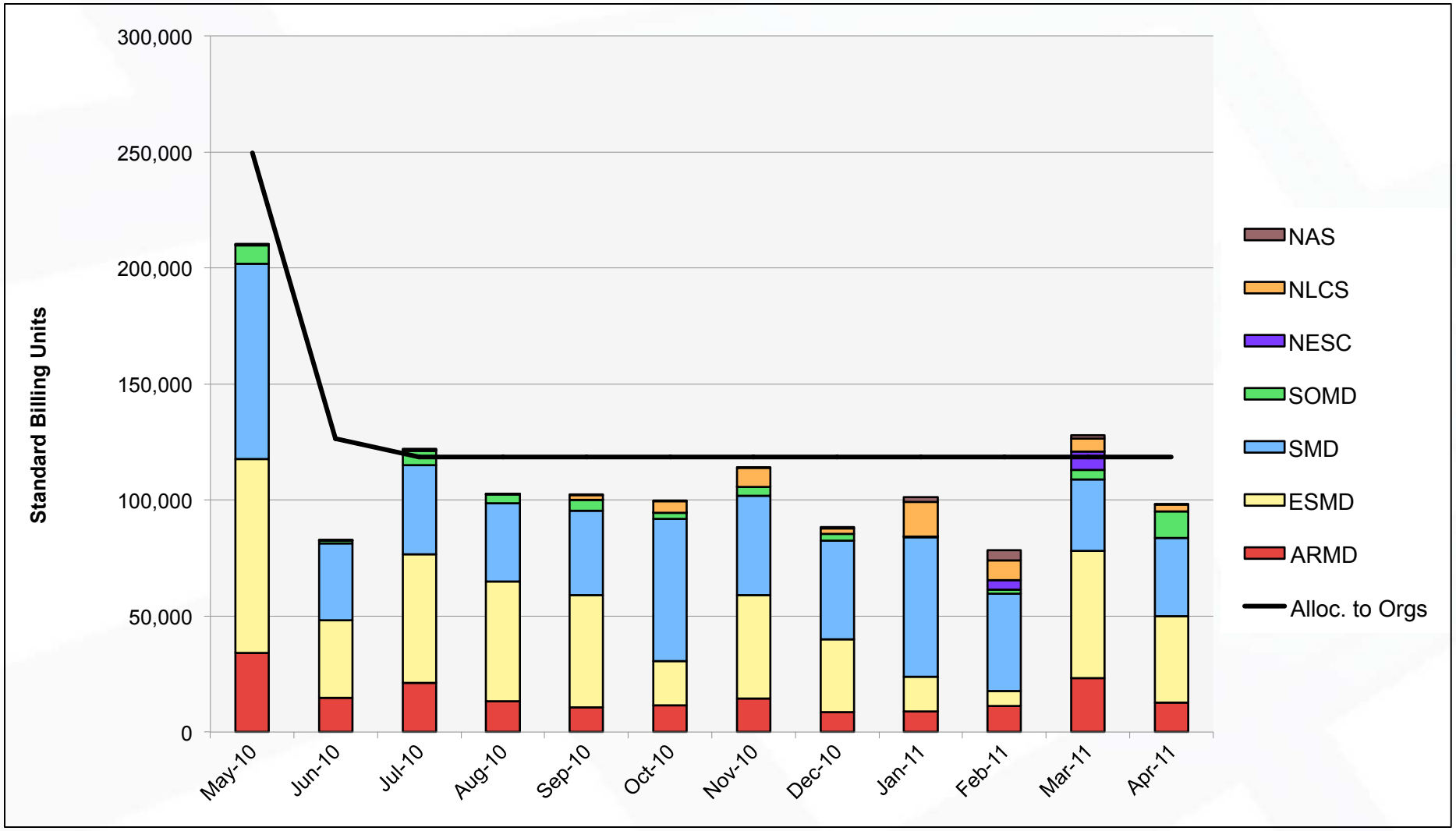
Pleiades:
Average Time to Clear All Jobs



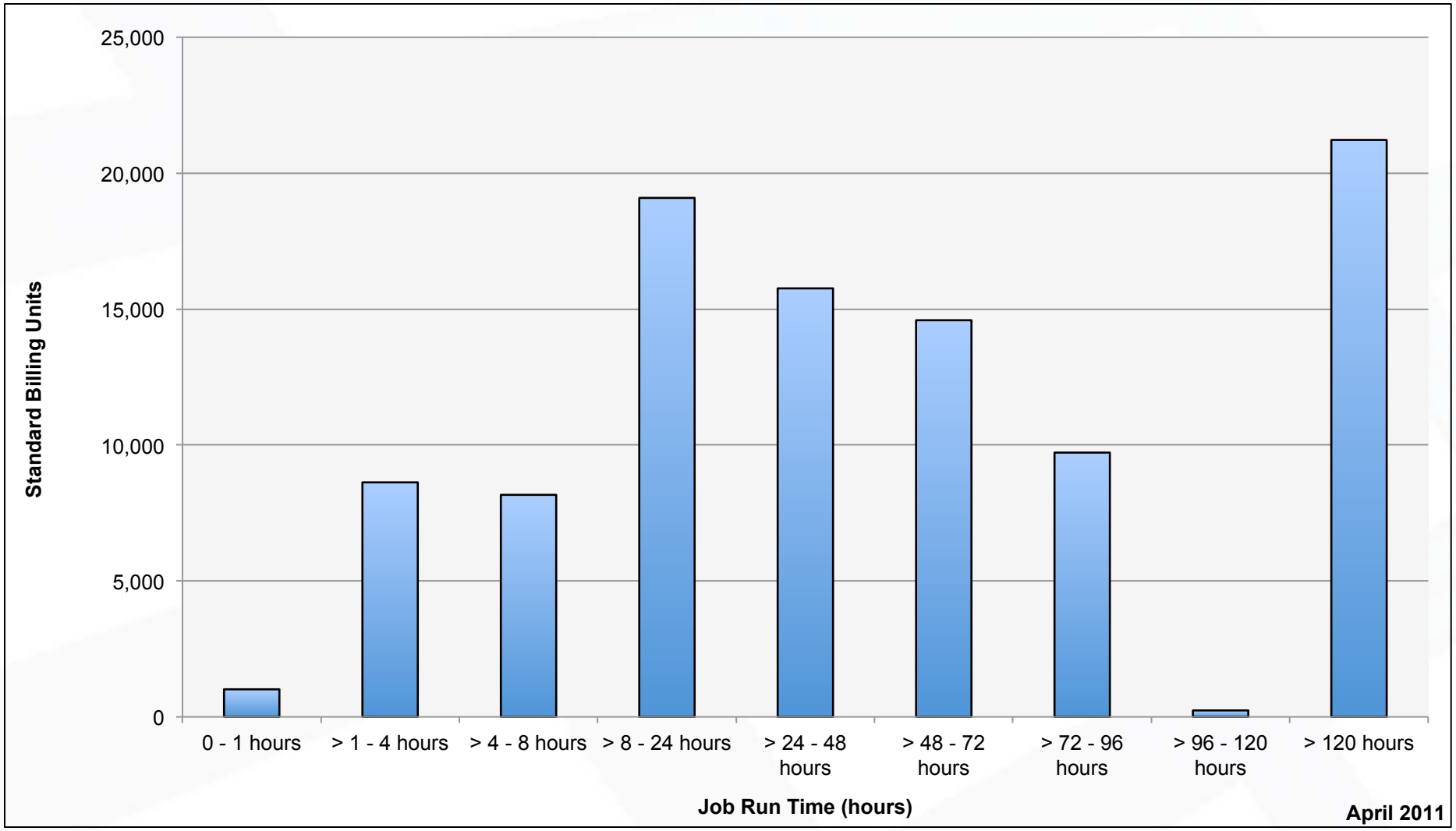
Pleiades:
Average Expansion Factor



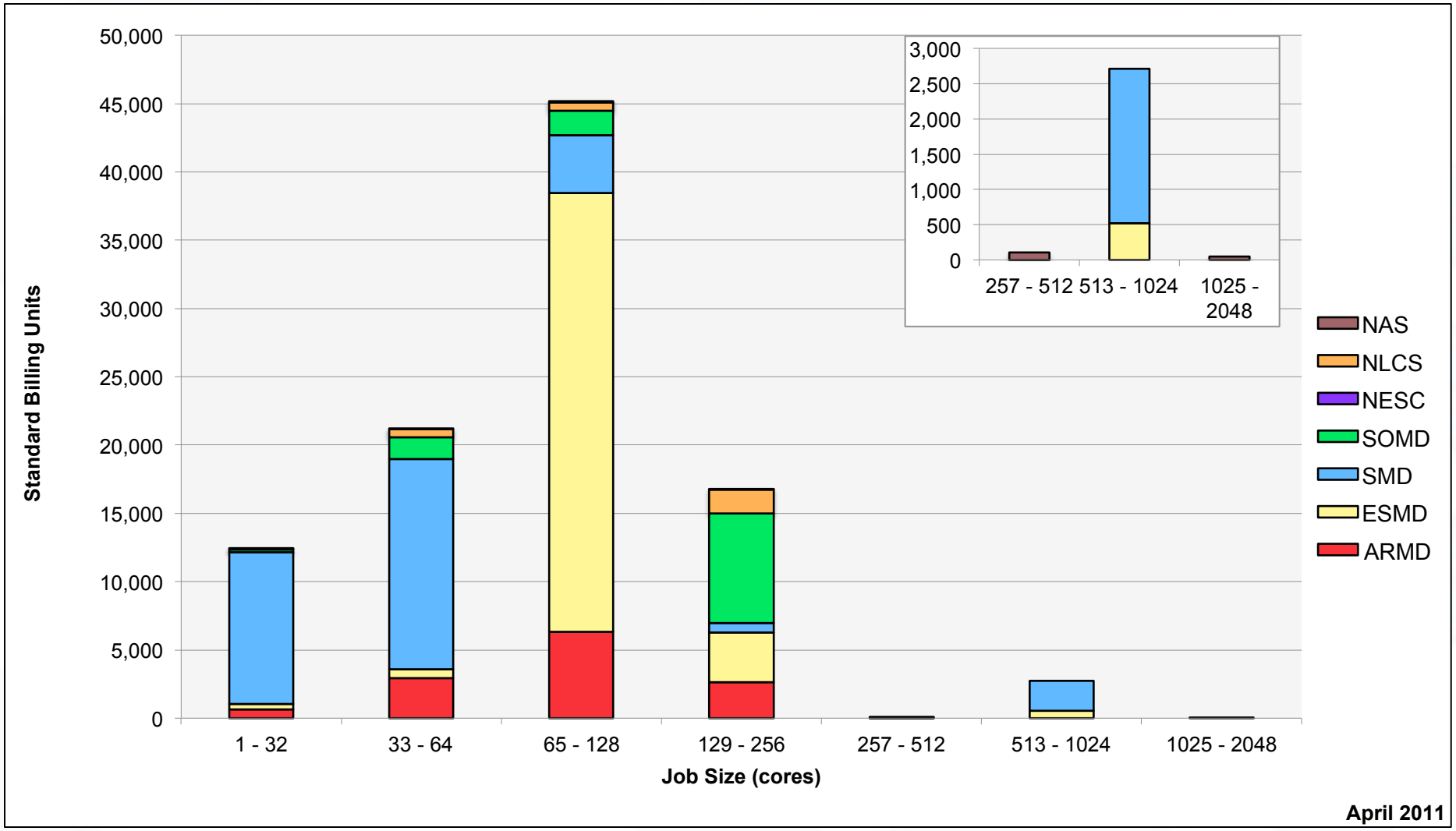
Columbia:
SBUs Reported, Normalized to 30-Day Month



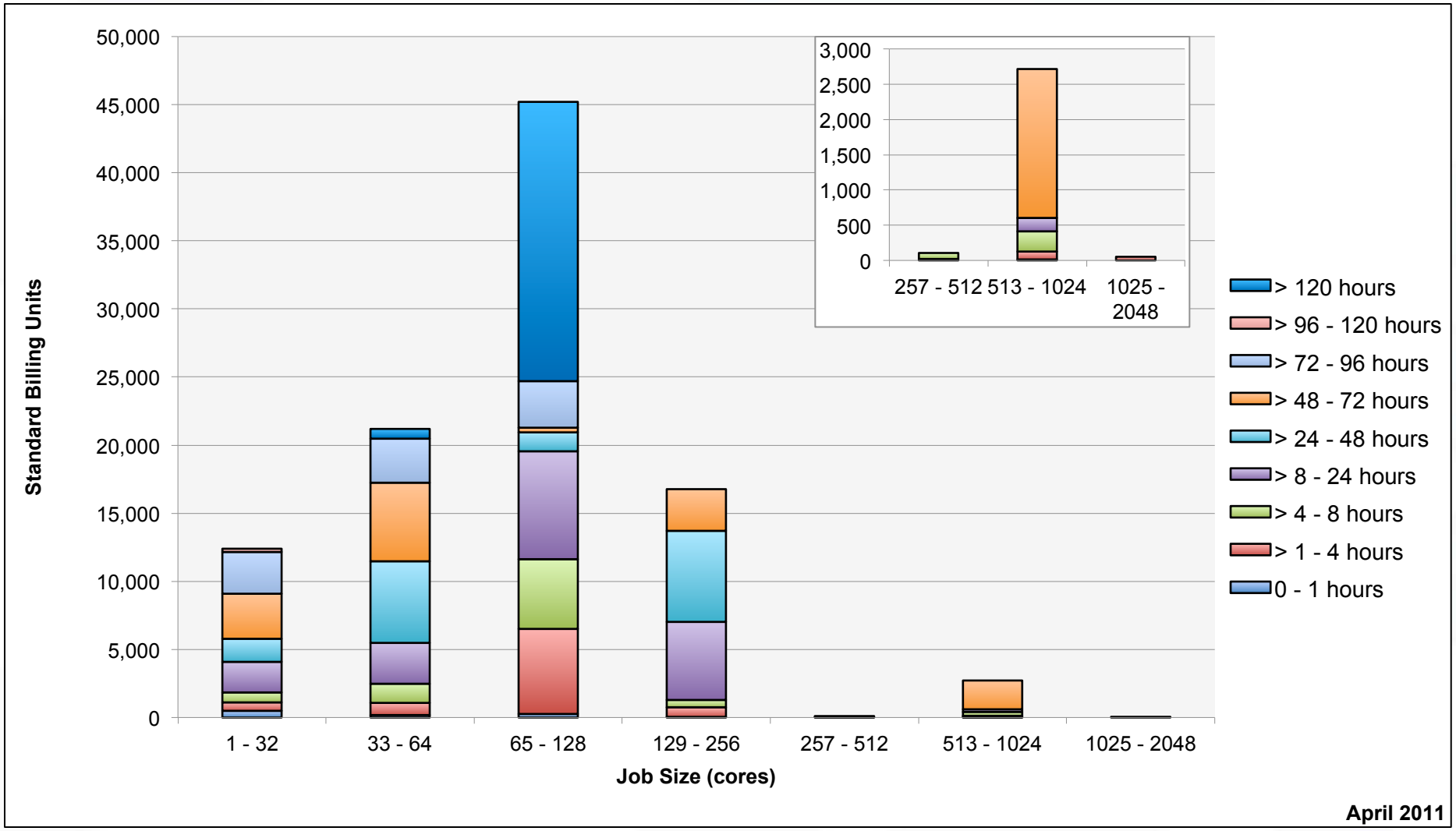
Columbia:
Monthly SBUs by Run Time



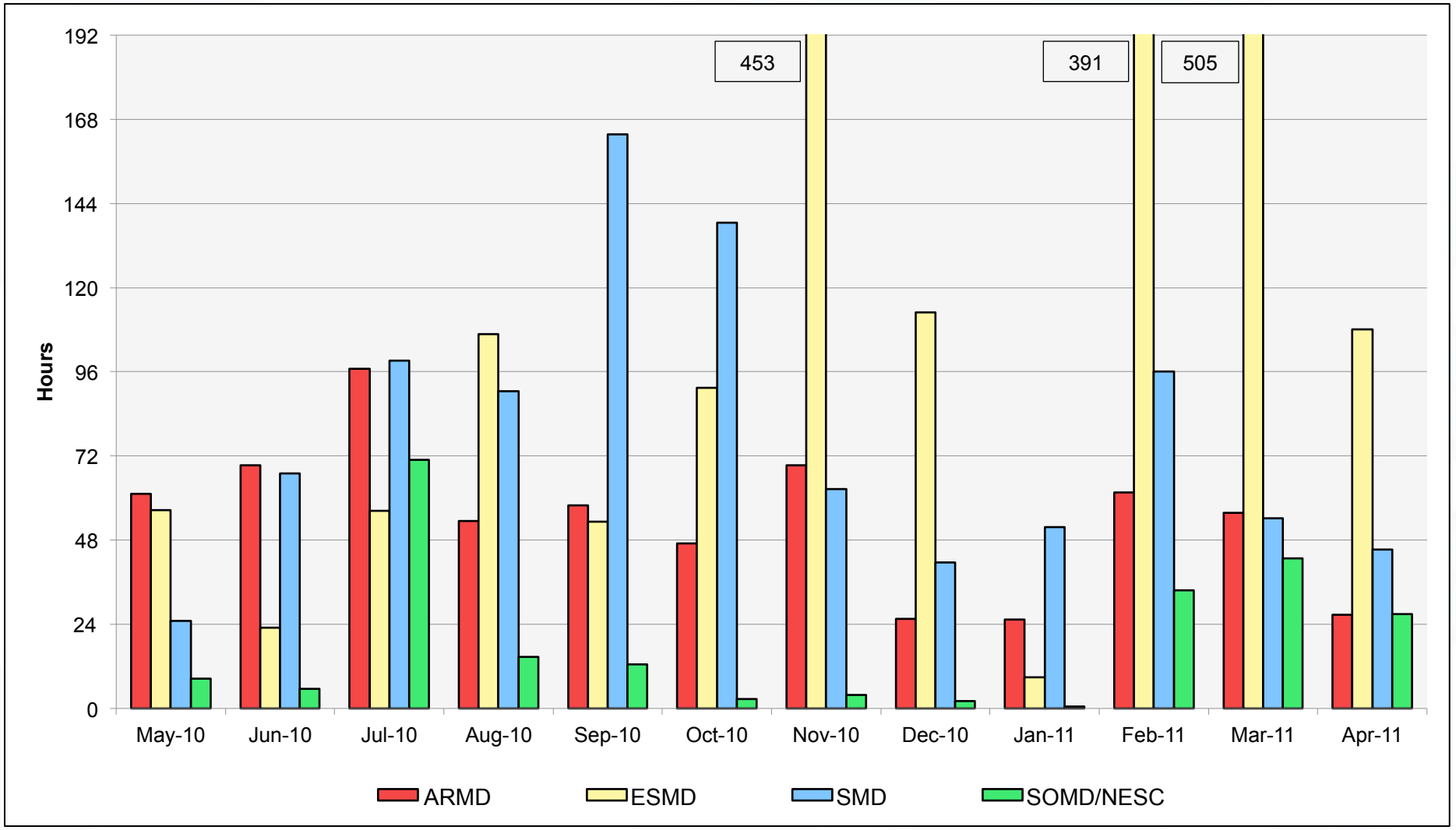
Columbia:
Monthly Utilization by Size and Mission



Columbia:
Monthly Utilization by Size and Length



Columbia:
Average Time to Clear All Jobs



Columbia:
Average Expansion Factor