# Project Status Report

## High End Computing Capability
## Strategic Capabilities Assets Program

February 10, 2016

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# HECC Teams Collaborate to Obtain Annual Authorization to Operate (ATO)

- An independent assessor led an internal team of security experts that performed a detailed security assessment of HECC systems to review compliance with the NASA Advanced Supercomputing (NAS) facility Security Plan, government regulations, and a vulnerability scan. The systems met all necessary requirements, and the ATO was signed by the NASA Ames Authorizing Official (AO).
- The HECC/NAS team produced a detailed analysis of all facets of the HECC environment by collaborating on the shared ATO goal. In addition to completing everything required by NASA policies, team members identified areas where inter-group cohesion could be improved. They adjusted strategies to improve this cohesion wherever possible, promoting greater overall efficiency for the HECC project. For example, the groups worked together to generate a new patching policy (see slide 4).
- As NASA and government security policies become increasingly stringent, the staff worked together to ensure these policies are adhered to in such a complex supercomputing environment.

**Mission Impact:** Resolving challenges posed by implementing security policies in a complex supercomputing environment helps protect NASA assets and data while maintaining access to critical mission resources for the agency's scientific and engineering users.

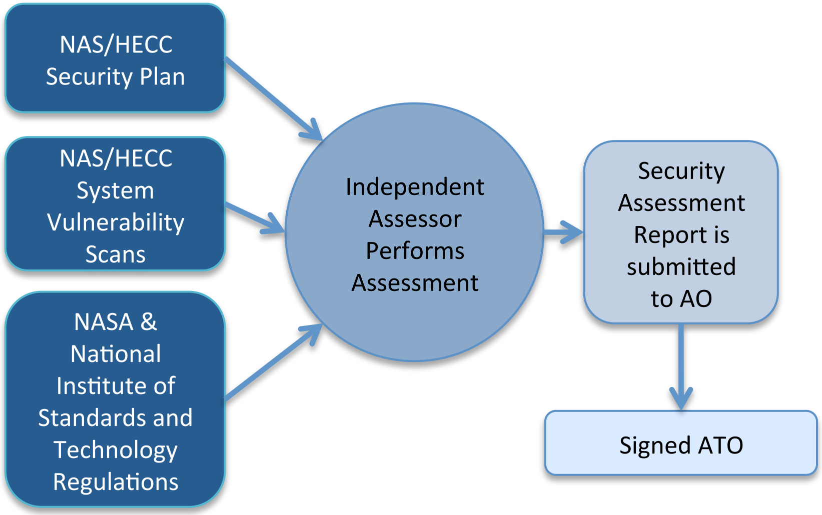



Chart showing the flow of information used by the independent security assessor to produce an annual security assessment report, which is submitted to the authorizing official to award a renewal of the authorization to operate.

***POCs:*** Tom Hinke, thomas.h.hinke@nasa.gov, (650) 604-3662, NASA Advanced Supercomputing (NAS) Division;
Chris Buchanan, chris.buchanan@nasa.gov, (650) 604-4308, NAS Division, CSC Government Solutions LLC

# HECC Teams Work Together to Implement A System Patching and Vulnerability Process

- The HECC Security team worked with various NAS IT support teams to develop and implement a new process for managing system patching and vulnerabilities documented in the “NAS Patching Schedule” document.
- This document outlines the approach for each IT support group (ESS, Systems, Networks, Security, and Visualization) to manage patches and vulnerabilities for their specific environments.
- This new approach balances system security and system availability. For example, since the HECC systems represent such a complex environment, the patching schedule was set to minimize user impact while performing critical patching activities.
- The Security team validated that the process adheres to the NASA Security Handbook (NASA Policy ITS-HBK 2810.04-01A) and the NAS System Security Plan (see slide 3).
- All HECC teams worked closely to understand and overcome the challenges associated with applying patches and bug fixes in HECC’s highly complex supercomputing environment.

**Mission Impact:** Implementing a new patching policy for one of the world’s largest supercomputing environments is quite challenging. HECC’s approach helps ensure that system patches are applied with minimum impact to NASA users.

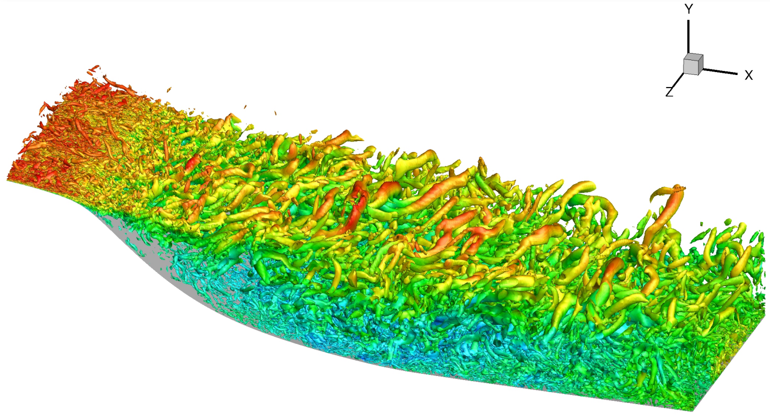

With the impact to the HECC user community inherent in bringing down a compute environment as complex as that provided through HECC, the HECC teams developed a patching process that clearly presents the specific requirements of each of the associated teams and the responsiveness to the types of issues expected.

***POCs:*** Tom Hinke, thomas.h.hinke@nasa.gov, (650) 604-3662, NASA Advanced Supercomputing (NAS) Division; Chris Buchanan, chris.buchanan@nasa.gov, (650) 604-4308, NAS Division, CSC Government Solutions LLC

# APP Team Improves Performance of Turbulence Simulation Code by Factor of 1.8

- HECC's Applications Performance and Productivity (APP) team improved performance of the Turbulence with High-Order Resolution Solver (THORS) code by a factor of 1.8.
- This high-fidelity turbulence simulation code is used at NASA Langley to study flow separation problems, where the boundary layer adjacent to an aerodynamic surface becomes detached from the surface. THORS can be used to improve designs and reduce fuel consumption, one of the goals of NASA's Environmentally Responsible Aviation project.
- The APP team optimized the code as follows:
  - Identified potential improvement areas using the op_scope and TAU performance tools.
  - Added a compiler flag to replace division with multiplication, where applicable.
  - Rewrote a routine to eliminate unneeded temporary arrays.
  - Split a routine in two to eliminate some code and to provide the compiler with more information.
  - Evaluated different options for performing Gaussian elimination and then used the best one.

**Mission Impact:** HECC's improvements to high-fidelity simulation codes, such as THORS, save significant compute resources and enable much faster turnaround time for parameter studies for cases where each execution of the solver uses thousands of cores and runs for several weeks.



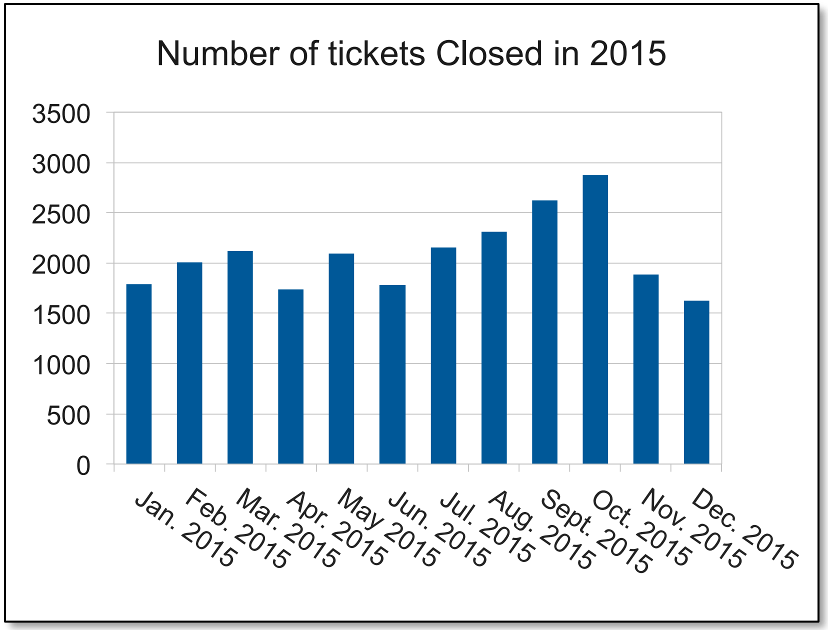

The complex structure of separated flow in the aft portion of an airfoil. The separation phenomenon commonly occurs in flows over high-lift configurations and flow control devices, and can lead to reduced aerodynamic performance. Such separated flows have traditionally been studied using lower-fidelity simulation techniques that attempt to model the boundary layer turbulence very near the surface, rather than directly resolve it. In contrast, the THORS code directly resolves the near-wall turbulence and yields more accurate predictions of flow separation.

***POC:*** Dan Kokron, daniel.kokron@nasa.gov, NASA Advanced Supercomputing Division, CSC Government Solutions LLC

# Support Staff Continue Providing Excellent Services to Users

- In 2015, HECC staff provided 24x7 support for hundreds of users from all of NASA's mission directorates.
- HECC staff processed, tracked, and resolved just under 25,000 tickets for the 12 months from January 1, 2015 through December 31, 2015.
- Tickets covered the spectrum of HECC activities and ranged from automated notifications of hardware problems, to users calling for help on compiler problems or requesting explanations of job failures.
- Support services for 2015 included:
  - Handled inquiries about accounts, allocations, jobs, and system status.
  - Modified and optimized user applications.
  - Improved data transfer times and solved data storage/retrieval issues.
  - Provided support for system outages and upgrades.
  - Addressed a wide range of automated system monitoring issues.
  - Developed high-resolution visualizations of scientific and engineering results.

**Mission Impact:** The high-quality, 24x7 support services provided by HECC experts resolve system problems and users' technical issues, and enable users to focus on their critical mission projects.




HECC staff typically resolved over 2,000 Remedy tickets per month in 2015—just under 25,000 tickets total.


***POC:*** Leigh Ann Tanner, leighann.tanner@nasa.gov, (650) 604-4468, NASA Advanced Supercomputing Division, CSC Government Solutions LLC

# HECC Doubles Memory on Merope Supercomputer

- HECC doubled the memory on the Merope supercomputer cluster from 24 gigabytes (GB) per node to 48 GB per node, to provide users with a higher memory configuration of Westmere nodes.
- The compute nodes were upgraded in stages to minimize the impact on users. While there was a reduction in computational resources during the month-long upgrade period, HECC continued to provide the majority of Merope nodes while each subset of the system was being upgraded.
- The memory for the upgrade was utilized from decommissioned Pleiades Nehalem and Westmere nodes that are kept for spare parts.

**Mission Impact:** Repurposing retired hardware enables HECC to deliver additional, cost-effective computational cycles to NASA users.


The Merope supercomputer consists of 1,152 Westmere nodes that were decommissioned from Pleiades due to power and cooling constraints in the primary compute facility; Merope is located in the secondary compute facility.

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Davin Chan, davin.chan@nasa.gov, (650) 604-3613, NAS Division, CSC Government Solutions LLC

# ESS Team Upgrades OS X and Red Hat Linux Systems to CFEngine Version 3

- HECC's Engineering Servers and Services (ESS) team upgraded the open-source configuration management system, CFEngine, from version 2 to version 3 for the OS X and Red Hat Linux systems at the NAS facility.
- Enhancements in version 3 include:
  – Supports  concept of "services" as a collection of individual system processes for maintenance.
  – Supports community-based code library to leverage contributions of others.
  – User-extensible—can more easily write code snippets for local needs.
  – Prebuilt binaries for Red Hat Enterprise Linux.
  – More extensive routines to customize configuration files using Perl regular expressions.
- Over 100 NAS-supported CFEngine modules were upgraded to support OS X systems on CFEngine 3, and to accommodate CFEngine 3 on Red Hat 7 as the Linux systems are upgraded.

**Mission Impact:** The CFEngine 3 upgrade provides staff at the NAS facility with the most current features available for open-source configuration management for our services.


CFEngine 3, running on both Red Hat Linux and OS X Yosemite, is used to manage configuration files on all infrastructure servers and desktop systems at the NASA Advanced Supercomputing facility.

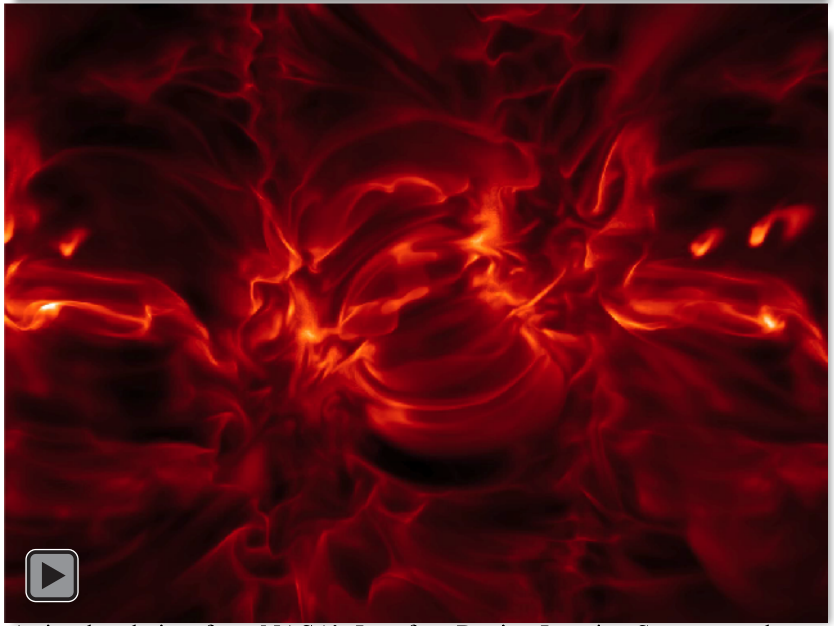
***POCs:*** Frank Cianci, frank.cianci@nasa.gov, (650) 604-2559 and Jeff Melin, jeffrey.melin@nasa.gov, (650) 604-0725, NASA Advanced Supercomputing Division, ADNET, Inc.

# Solar Atmosphere Simulations Run on Pleiades Shed Light on IRIS Observations *

- Astrophysicists are running simulations of the Sun's atmosphere on Pleiades and comparing the results with observations from NASA's Interface Region Imaging Spectrograph (IRIS) to learn more about how the Sun's atmosphere is shaped and heated.
- Together with the IRIS data, the advanced, multi-dimensional radiative magnetohydrodynamic simulations are providing insight into:
  - How magnetic fields generated in the Sun's interior affect its lower atmosphere, or chromosphere.
  - How friction between ionized and neutral particles dissipates magnetic energy and helps heat the chromosphere.
  - How the complex interactions of magnetic fields, hydrodynamics, and radiation fields shape the Sun's atmosphere.
- These findings may help solve several longstanding mysteries, such as why the outer atmosphere of the Sun (the corona) is millions of degrees hotter than its surface.
- The team is working on new solar simulations with higher spatial resolution that will provide even better agreement with IRIS observations, which is expected to further improve understanding of how the Sun works.

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

**Mission Impact:** Simulations of the Sun's atmosphere, enabled by the Pleiades supercomputer's parallel processing capabilities, are crucial to interpreting data from NASA's IRIS observatory.



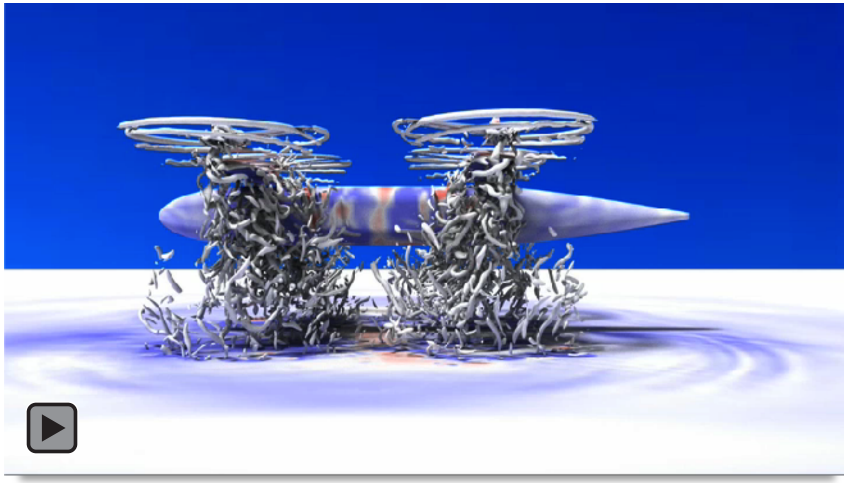
A simulated view from NASA's Interface Region Imaging Spectrograph (IRIS) spacecraft flying above the Sun's surface at 10,000 kilometers, with a filter showing only light from plasma at about 20,000 Kelvin. The video is derived from numerical simulations that reveal how the Sun's magnetic field affects the structure of its atmosphere on fine scales.

***POCs:*** Mats Carlsson, mats.carlsson@astro.uio.no, University of Oslo; Bart De Pontieu, bdp@lmsal.com, Lockheed Martin Solar and Astrophysics Laboratory

# HECC Resources, Services Critical to Simulation and Analysis of Multi-Rotor Drone Performance *

- Researchers at NASA Ames used thousands of cores on Pleiades to perform simulations for investigating the complex physics of multi-rotor drones and other vertical lift vehicles.
- The team investigated new concept designs ranging from small-scale drones to large-scale, heavy-lift vehicles (including a dual-winged quadcopter and a tandem coaxial rotorcraft) to analyze flow interactions between multiple rotors, wings, and vehicle body.
- They also assessed aerodynamic performance and noise levels using various hybrid turbulence models for interactional aerodynamics.
- Results showed that, unlike most helicopters with a single main rotor, quadrotors can be scaled up in size without sacrificing performance.
- Access to Pleiades was essential to performing the high-fidelity simulations; and visualizations developed by HECC experts were critical to understanding the complex, unsteady, turbulent flow interactions.
- Use of multiple rotors provides safety, redundancy and cost efficiency, as the cost is lower than that of a single, complex rotor.

**Mission Impact:** HECC supercomputing resources and services are essential to improving understanding of performance and noise levels of multi-rotor vehicles that may become the new paradigm for helicopter designs for human and cargo transportation, delivery systems, surveillance, and disaster relief.



This video of NASA's conceptual design of a large-scale quadrotor vehicle reveals intriguing details of complex flow interactions between multiple rotors, wings, and the fuselage. Rotors used in this simulation are from the Bell XV-15 tilt-rotor aircraft, which was partially developed at NASA's Ames Research Center. Tim Sandstrom, NASA/Ames

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

# HECC Facility Hosts Several Visitors and Tours in January 2016

- HECC hosted 12 tour groups in January; guests learned about the agency-wide missions being supported by HECC assets, and some groups viewed also the D-Wave 2X quantum computer system. Visitors this month included:
  - Francisco Javier Mendieta Jiménez, Director General, Mexican Space Agency.
  - Rick Marrs, Deputy Assistant Administrator, NASA Office of Strategic Infrastructure.
  - Mario Cosmo, Director General of the Italian Aerospace Research Center (CIRA).
  - A group of HECC users from the Science Mission Directorate, along with staff from the NASA Astrobiology Institute (NAI) and the SETI Institute, who were attending the NAI quarterly review at NASA Ames.
  - A large group from the White House Digital Service team.
  - Guests attending the NASA-New Jersey Institute of Technology Workshop in Computational Heliophysics.
  - 25 students from the Department of Mathematics at California State University, Stanislaus.
  - 16 high school students from Izumo High School, Izumo, Japan. These students were visiting Ames as part of an exchange student program with Wilcox High School, Santa Clara, CA.

NAS Division aerospace engineer Stuart Rogers (far right) takes HECC scientific users on a tour through the main computer room at the NAS facility. Tour guests also included staff of the NASA Astrobiology Institute and the SETI Institute. *Nick Bonifas, NASA/Ames*

***POC:*** Gina Morello, gina.f.morello@nasa.gov, (650) 604-4462, NASA Advanced Supercomputing Division

# Papers

- **2016 AIAA SciTech Conference**, San Diego, CA, January 4–8, 2016.
  - "**Numerical Simulation of Shock Trains in a 3D Channel**," R. Fievet, H. Koo, V. Raman, A. Auslender. *
    http://arc.aiaa.org/doi/10.2514/6.2016-1018
  - "**Computational Analysis of the Transonic Dynamics Tunnel Using FUN3D**," P. Chwalowski, E. Quon, S. Brynildsen. *
    http://arc.aiaa.org/doi/10.2514/6.2016-1775
  - "**LES of a Soothing Flame in Pressurized Swirl Combustor**," H. Koo, et al. *
    http://arc.aiaa.org/doi/10.2514/6.2016-2123
  - "**High Fidelity Simulations of a Non-Premixed Rotating Detonation Engine**," P. Cocks, et al. *
    http://arc.aiaa.org/doi/10.2514/6.2016-0125
  - "**Large Eddy Simulation of Flame Stabilization in a Multi-Jet Burner Using a Non-Adiabatic Flamelet Approach**," Y. Tang, M. Hassanaly, H. Koo, V. Raman. *
    http://arc.aiaa.org/doi/10.2514/6.2016-1395
  - "**The Mixture Fraction for High-Pressure Turbulent Reactive Flows**," J. Bellan. *
    http://arc.aiaa.org/doi/10.2514/6.2016-1686
  - "**Hybrid Reynolds-Averaged / Large Eddy Simulation of the Flow in a Model Scramjet Cavity Flameholder**," R. Baurle. *
    http://arc.aiaa.org/doi/10.2514/6.2016-1898
  - "**Isolated Open Rotor Noise Prediction Assessment Using the F31A31 Historical Blade Set**," D. Nark, W. Jones, D. Boyd, N. Zawodny. *
    http://arc.aiaa.org/doi/10.2514/6.2016-1271

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

# Papers (cont.)

- **2016 AIAA SciTech Conference (cont.)**
  - "**Numerical Simulation of a Complete Low-Speed Wind Tunnel Circuit**," S. Nayani, W. Sellers, A. Tinetti, S. Brynilden, E. Walker. * http://arc.aiaa.org/doi/10.2514/6.2016-2117
  - "**Overview of the NASA Glenn Flux Reconstruction Based High-Order Unstructured Grid Code**," S. Spiegel, J. DeBonis, H. Huynh. * http://arc.aiaa.org/doi/10.2514/6.2016-1061
  - "**Wind Tunnel Model Design for Sonic Boom Studies of Nozzle Jet Flows with Shock Interactions**," S. Cliff, M. Denison, S. Moini-Yekta, D. Morr, D. Durston. * http://arc.aiaa.org/doi/10.2514/6.2016-2035
  - "**NASA CFD Vision 2030 Visualization and Knowledge Extraction (panel summary)**," E. Duque, S. Imlay, S. Ahern, G. Chen, D. Kao. http://arc.aiaa.org/doi/10.2514/6.2016-1927
  - "**Open Rotor Computational Aeroacoustic Analysis with an Immersed Boundary Method**," C. Brehm, M. Barad, C. Kiris. * http://arc.aiaa.org/doi/10.2514/6.2016-0815
  - "**Numerical Simulation of Bolide Entry with Ground Footprint Prediction**," M Aftosmis, D. Mathias, M. Nemec, M. Berger. * http://arc.aiaa.org/doi/10.2514/6.2016-0998
  - "**Space Launch System Booster Separation Aerodynamic Database Development and Uncertainty Quantification**," D. Chan, J. Pinier, F. Wilcox, D. Dalle, S. Rogers, R. Gomez. * http://arc.aiaa.org/doi/10.2514/6.2016-0798

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

# Papers (cont.)

- **2016 AIAA SciTech Conference (cont.)**
  - "**NASA Environmentally Responsible Aviation Hybrid Wing Body Flow-Through Nacelle Wind Tunnel CFD**," M. Schuh, J. Garcia, M. Carter, K. Deere, P. Stremel, D. Tompkins. *
    http://arc.aiaa.org/doi/10.2514/6.2016-0263
  - "**Unsteady PSP Measurements on Flat Plate Subject to Vortex Shedding from a Rectangular Prism**," N. Roozeboom, L. Diosady, S. Murman, N. Burnside, J. Pandya, J. Ross. *
    http://arc.aiaa.org/doi/10.2514/6.2016-2017
  - "**Structured Overlapping Grid Simulations of Contra-Rotating Open Rotor Noise**, J. Housman, C. Kiris. *
    http://arc.aiaa.org/doi/10.2514/6.2016-0814
  - "**Dynamic Stability Analysis of Hypersonic Transport During Reentry**," G. Guruswamy. *
    http://arc.aiaa.org/doi/10.2514/6.2016-0280
  - "**Computational Analysis of Multi-Rotor Flows**," S. Yoon, H. Lee, T. Pulliam. *
    http://arc.aiaa.org/doi/10.2514/6.2016-0812
  - "**Simulation of a Hammerhead Payload Fairing in the Transonic Regime**," S. Murman, L. Diosady. *
    http://arc.aiaa.org/doi/10.2514/6.2016-1548
- "**Modelling Repeatedly Flaring Delta-Sunspots**," P. Chatterjee, V. Hansteen, M. Carlsson, arXiv:1601.00749 [astro-ph.SR], January 5, 2016. *
  http://arxiv.org/abs/1601.00749

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

# Papers (cont.)

- "**Energy Flows in Thick Accretion Disks and Their Consequences for Black Hole Feedback**," A. Sadowski, J.-P. Lasota, M. Abramowicz, R. Narayan, Monthly Notices of the Royal Astronomical Society, vol. 456, issue 4, January 14, 2016. * https://mnras.oxfordjournals.org/content/456/4/3915.full
- "**Reconstructing the Solar Wind from its Early History to Current Epoch**," V. Airapetian, A. Usmanov, arXiv:1601.04085 [astro-ph.SR], January 15, 2016. * http://arxiv.org/abs/1601.04085
- "**A Three-Dimensional Model of Active Region 7986: Comparison of Simulations with Observations**," Y. Mok, et al., The Astrophysical Journal, vol. 817, no. 1, Jan. 16, 2016.* http://iopscience.iop.org/article/10.3847/0004-637X/817/1/15/meta
- "**The Formation of Massive, Quiescent Galaxies at Cosmic Noon**," R. Feldmann, et al., arXiv:1601.04704 [astro-ph.GA], January 18, 2016. * http://arxiv.org/abs/1601.04704
- "**Assessing Astrophysical Uncertainties in Direct Detection with Galaxy Simulations**," J. Sloane, et al., arXiv:1601.05402 [astro-ph.GA], January 20, 2016. * http://arxiv.org/abs/1601.05402
- "**Iron Opacity Bump Changes the Stability and Structure of Accretion Disks in Active Galactic Nuclei**," Y.-F. Jiang, et al., arXiv:1601.06836 [astro-ph.HE], January 25, 2016. * http://arxiv.org/abs/1601.06836

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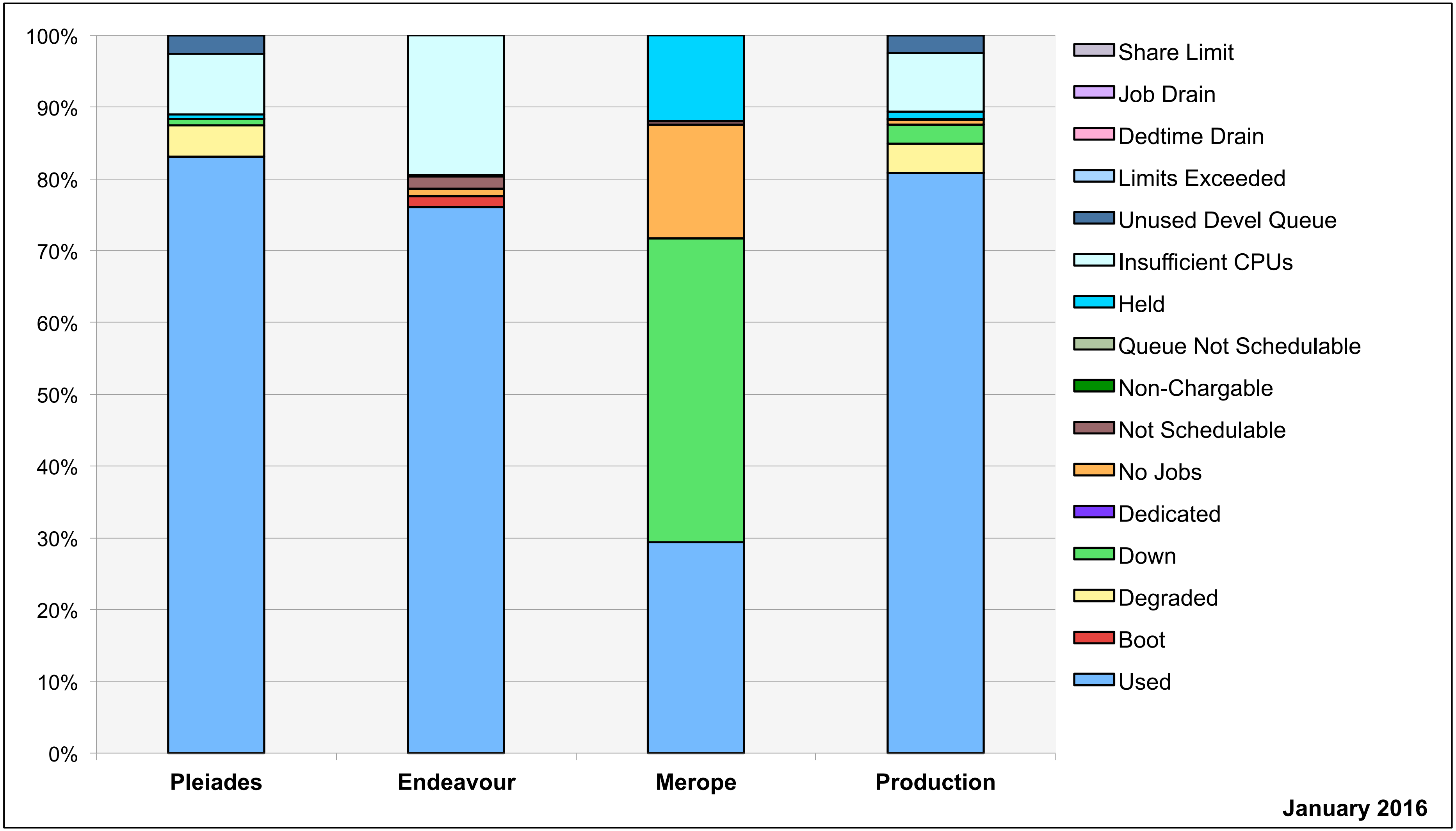
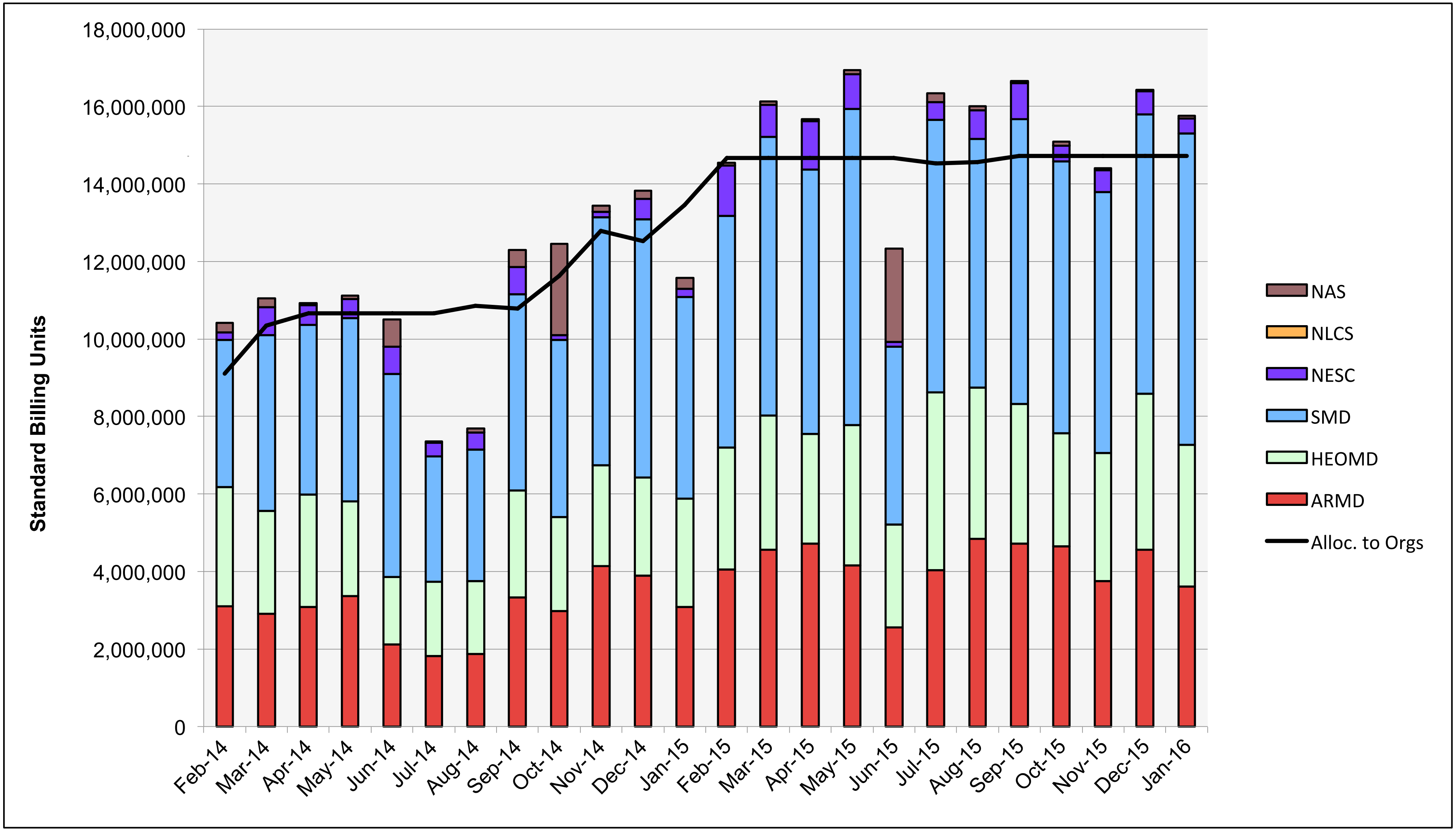
# HECC Utilization



# HECC Utilization Normalized to 30-Day Month



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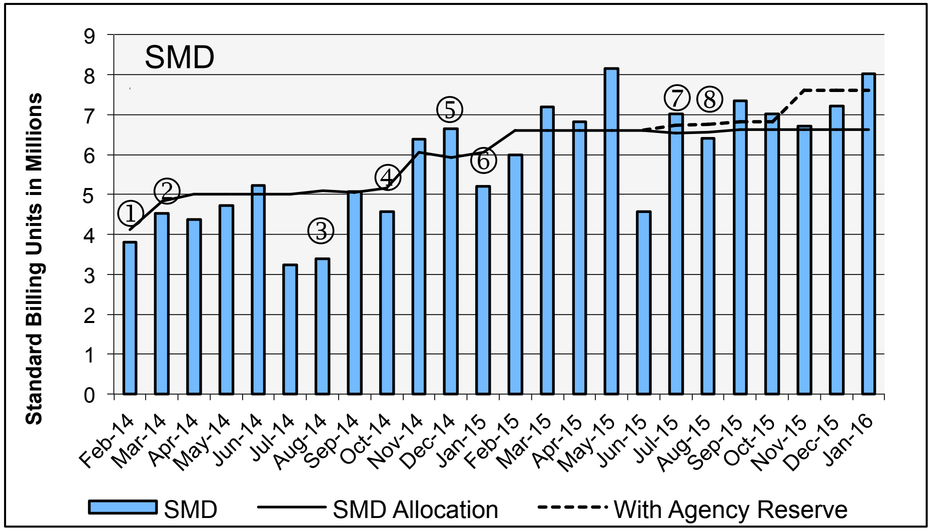
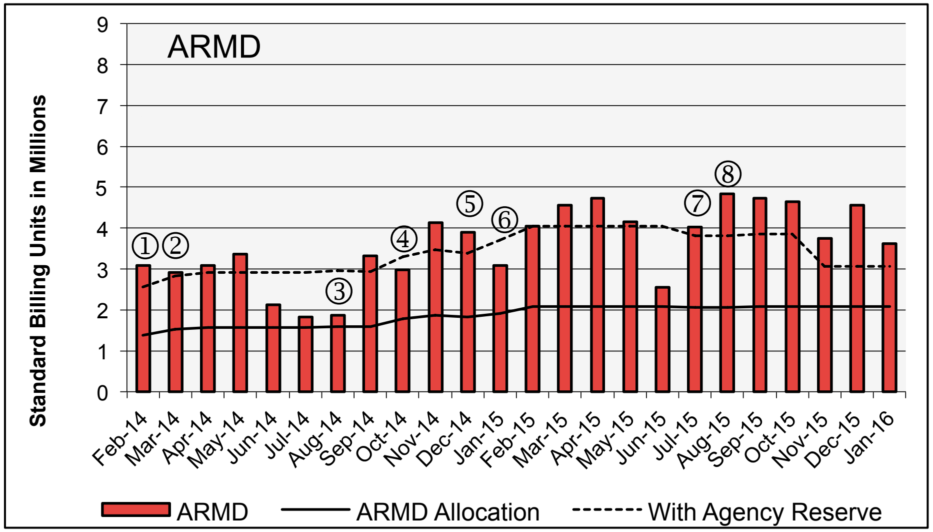
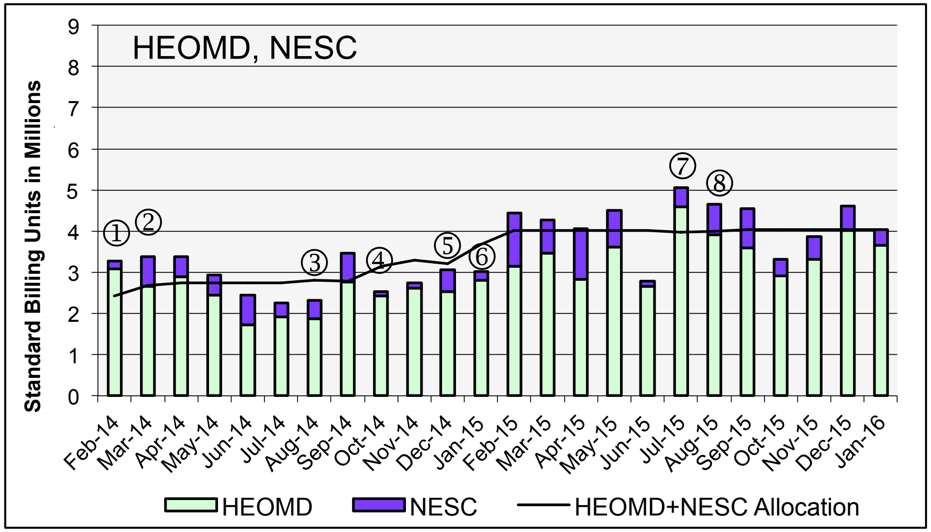



① 8 Ivy Bridge Racks added mid-Feb; 8 Ivy Bridge Racks added late Feb to Pleiades

② 4 Ivy Bridge Racks added mid-March to Pleaides

③ 6 Westmere Racks added to Merope, Merope Harpertown retired

④ 16 Westmere Racks retired, 3 Ivy Bridge Racks added, 15 Haswell Racks added to Pleiades; 10 Nehalem Racks and 2 Westmere Racks added to Merope

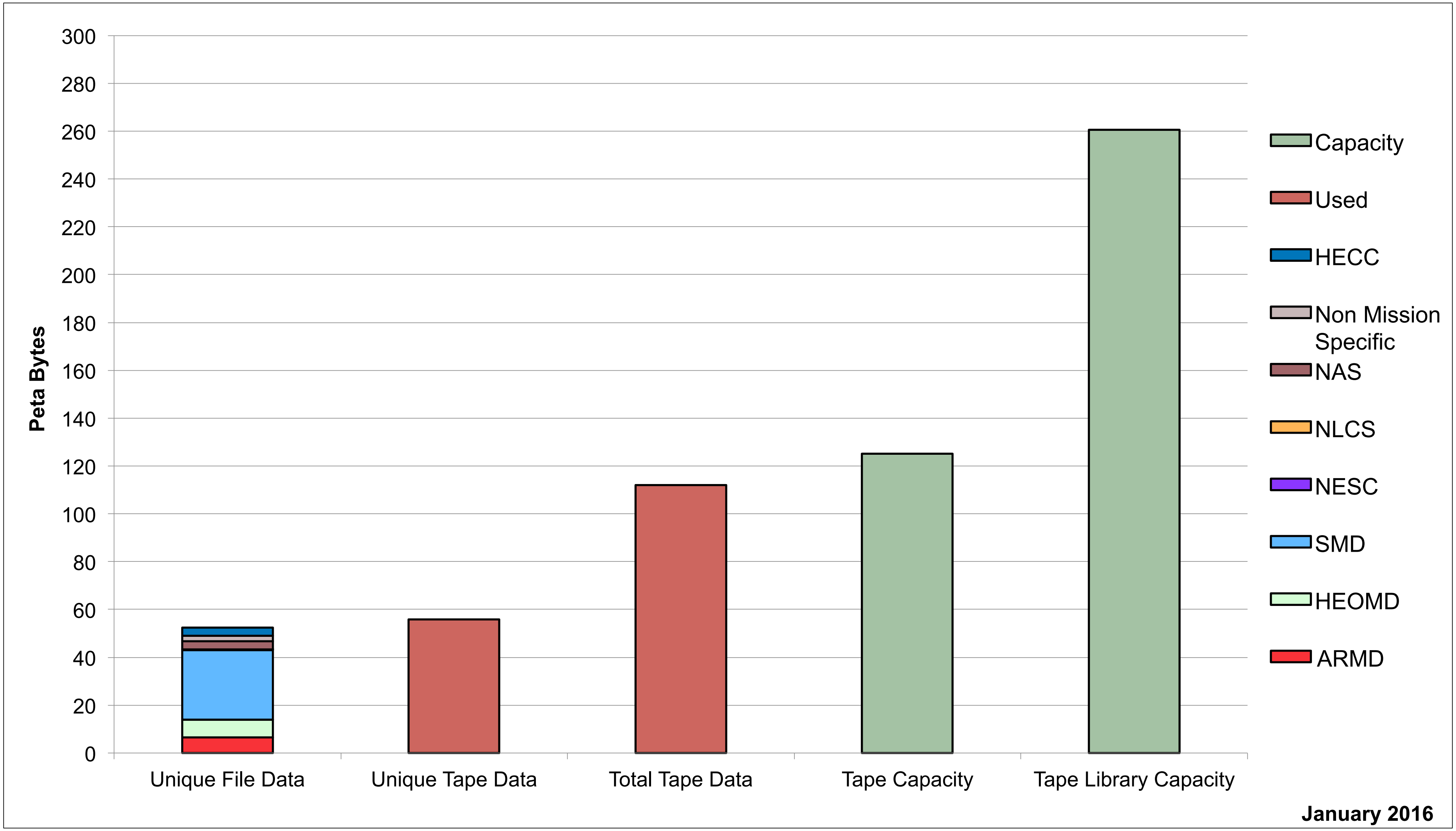
⑤ 16 Westmere Racks retired from Pleiades

⑥ 14 Haswell racks added to Pleiades

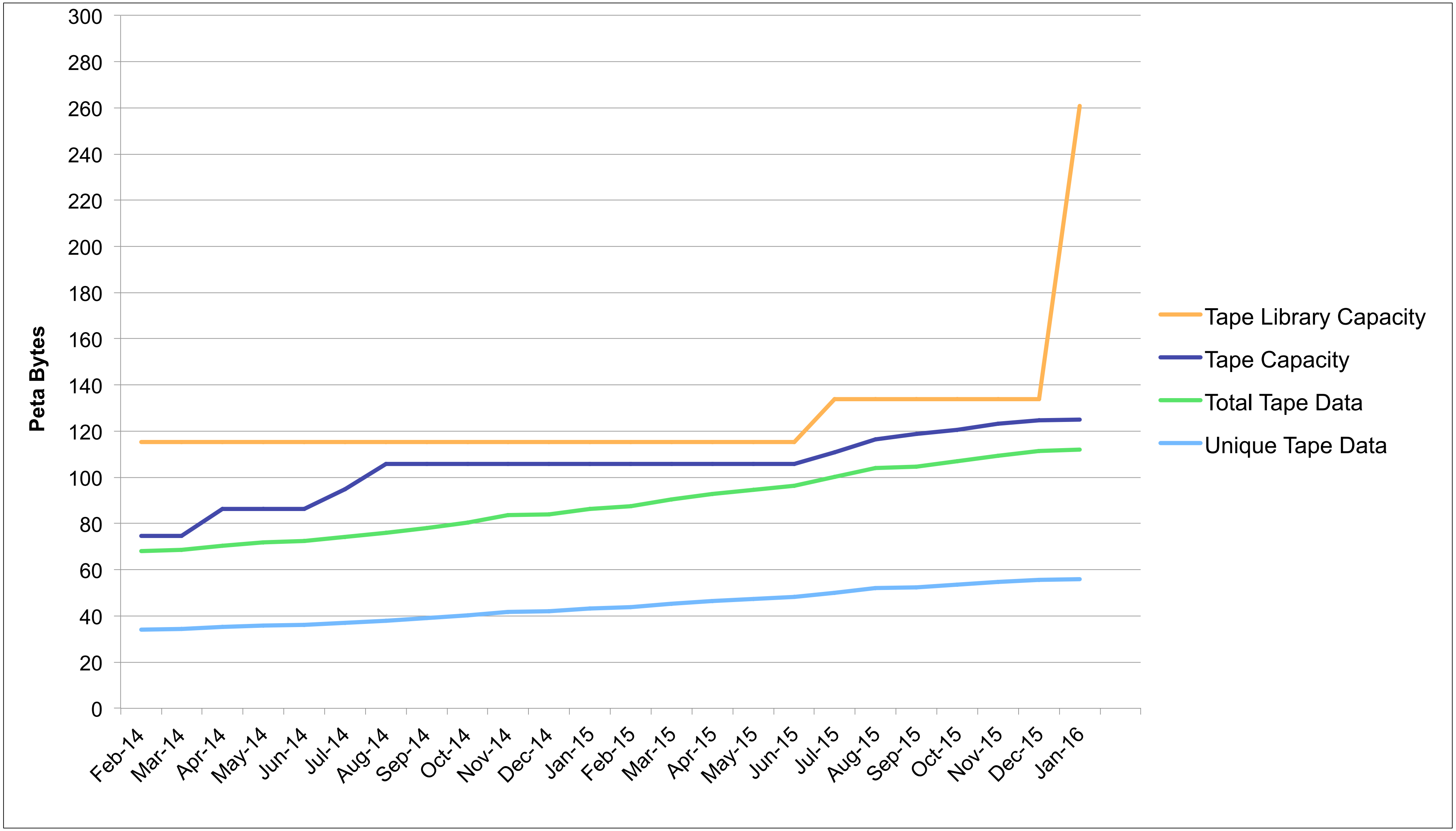
⑦ 7 Merope Nehalem Racks removed from Merope

⑧ 7 Merope Westmere Racks added from Merope

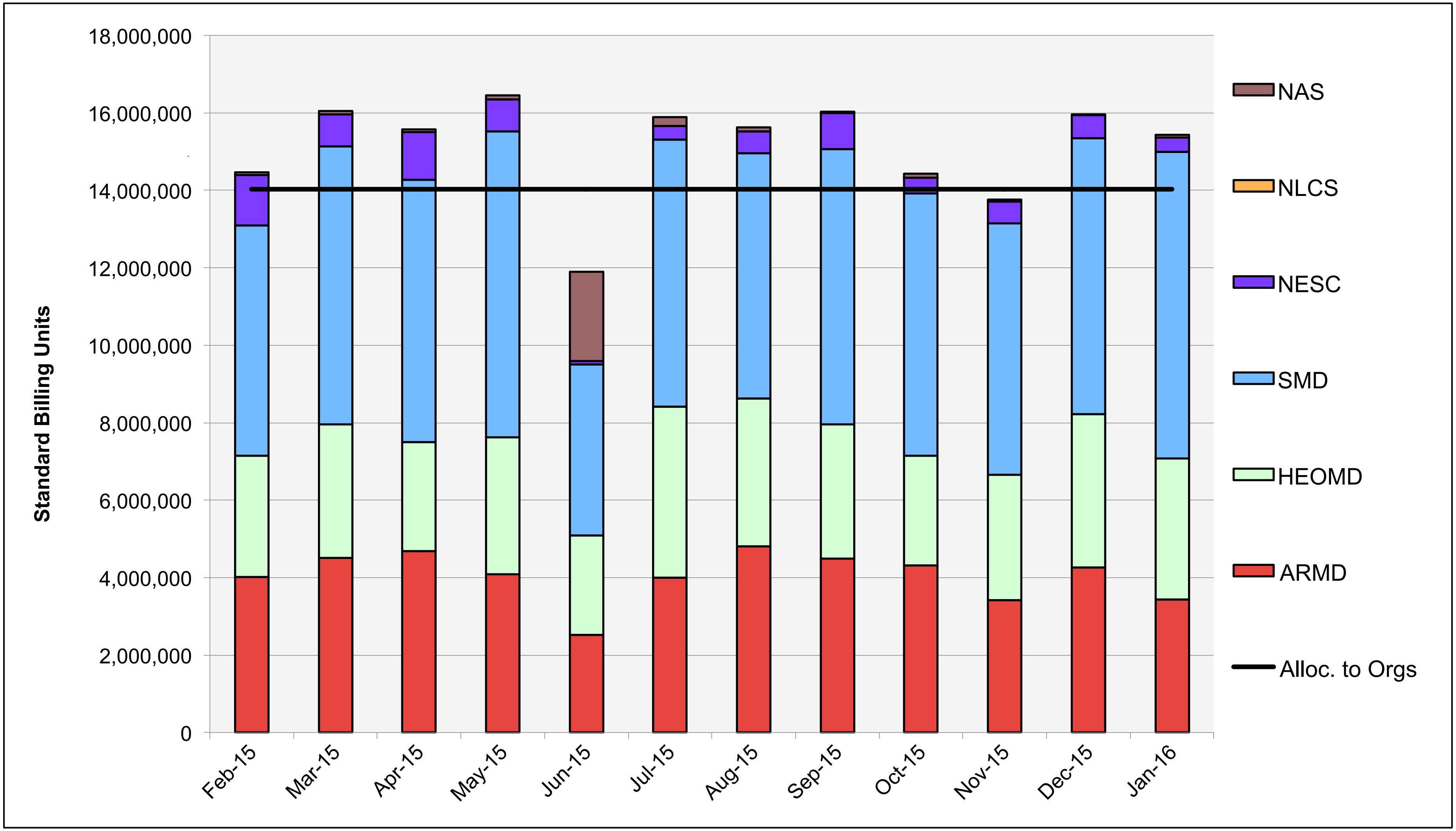
# Tape Archive Status



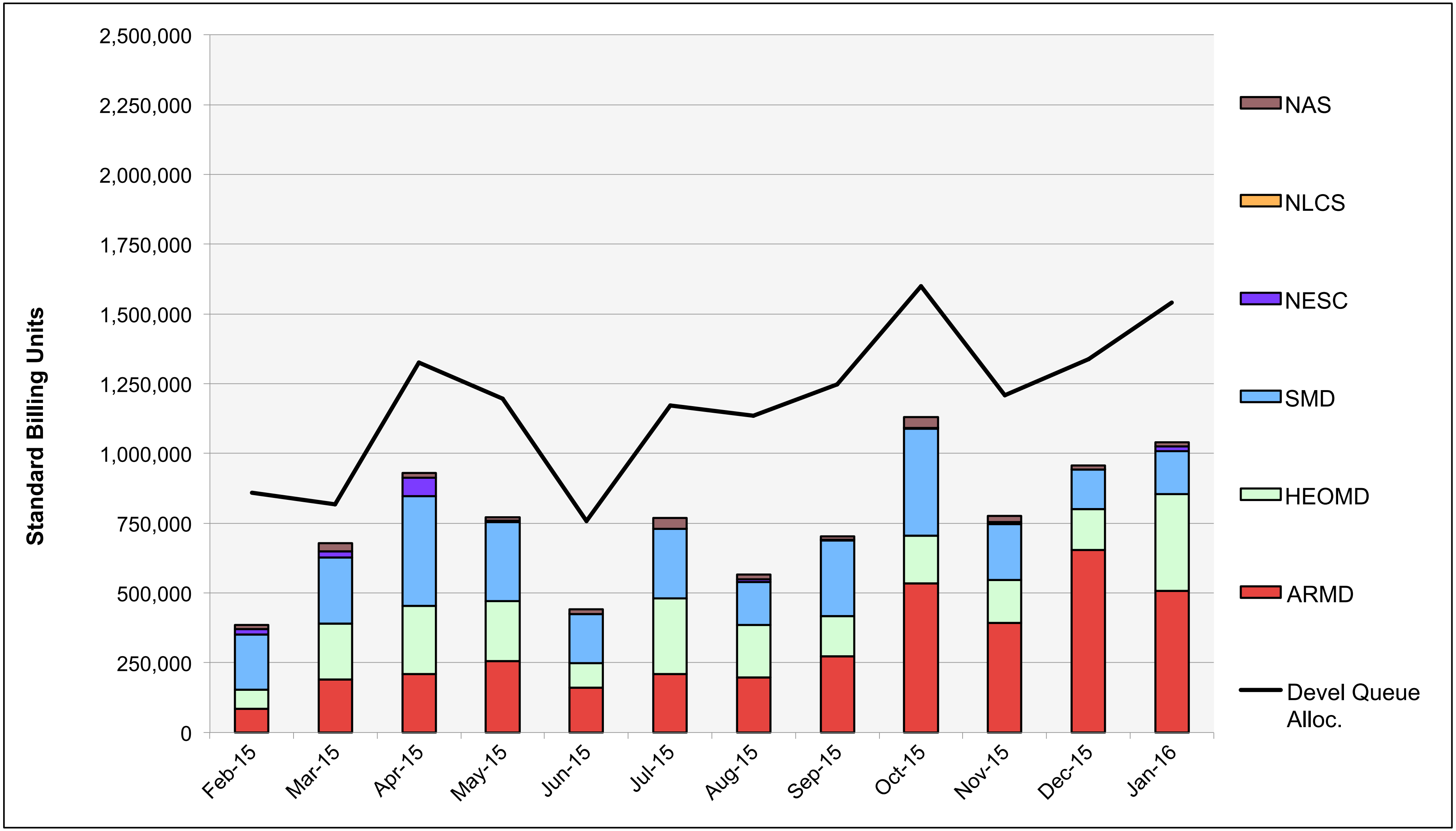
# Tape Archive Status



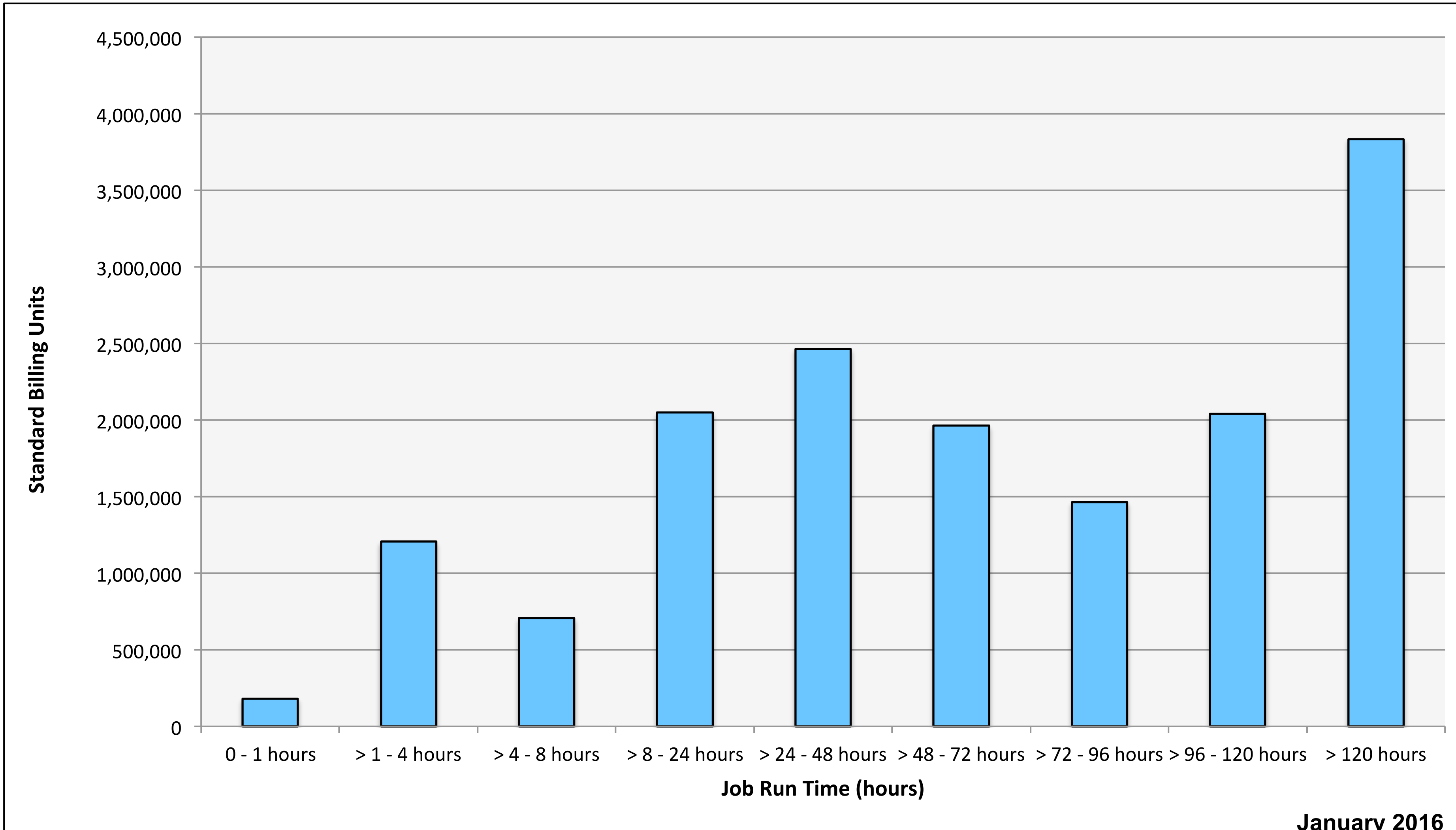
# Pleiades:
# SBUs Reported, Normalized to 30-Day Month



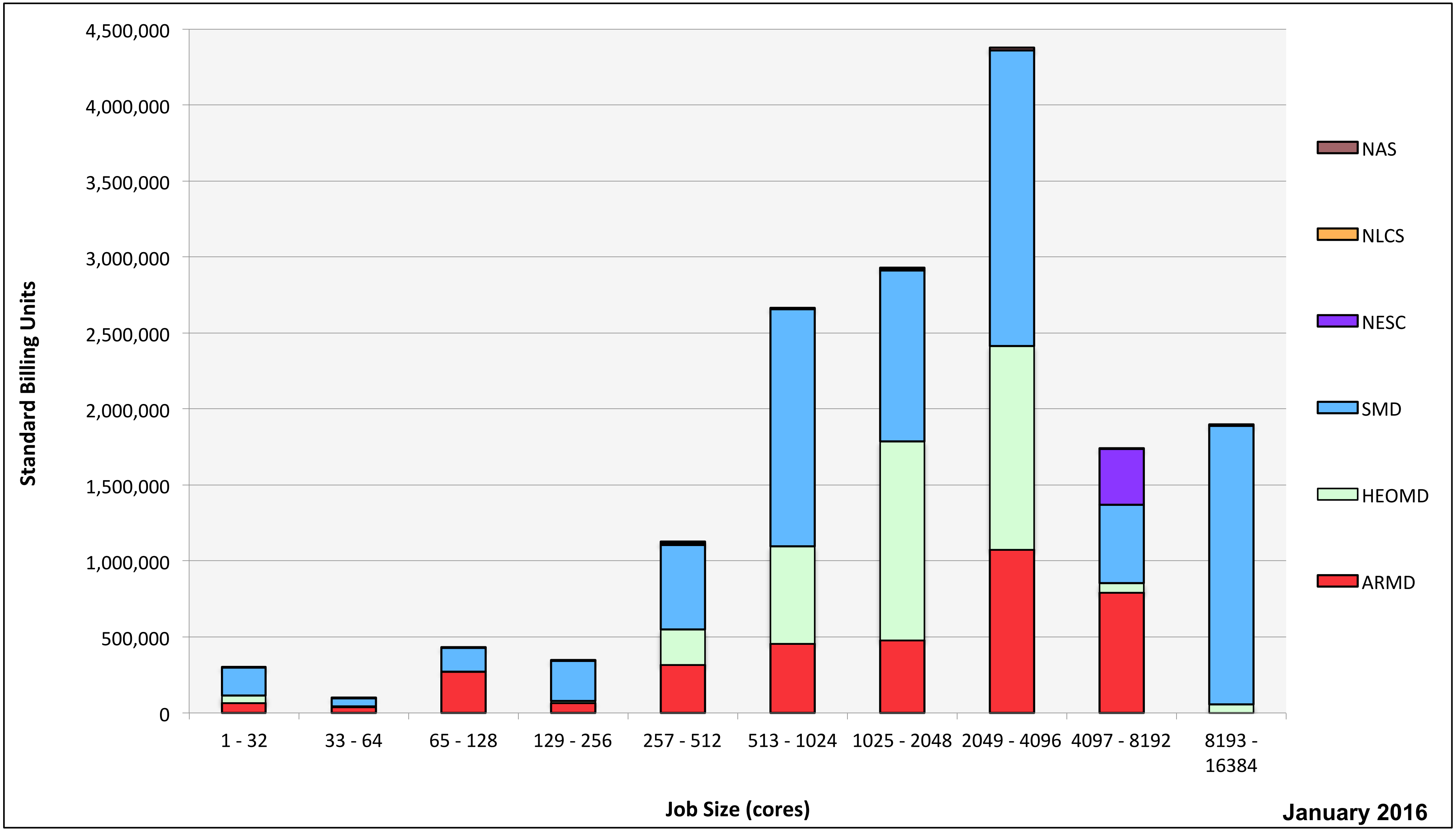
# Pleiades: Devel Queue Utilization



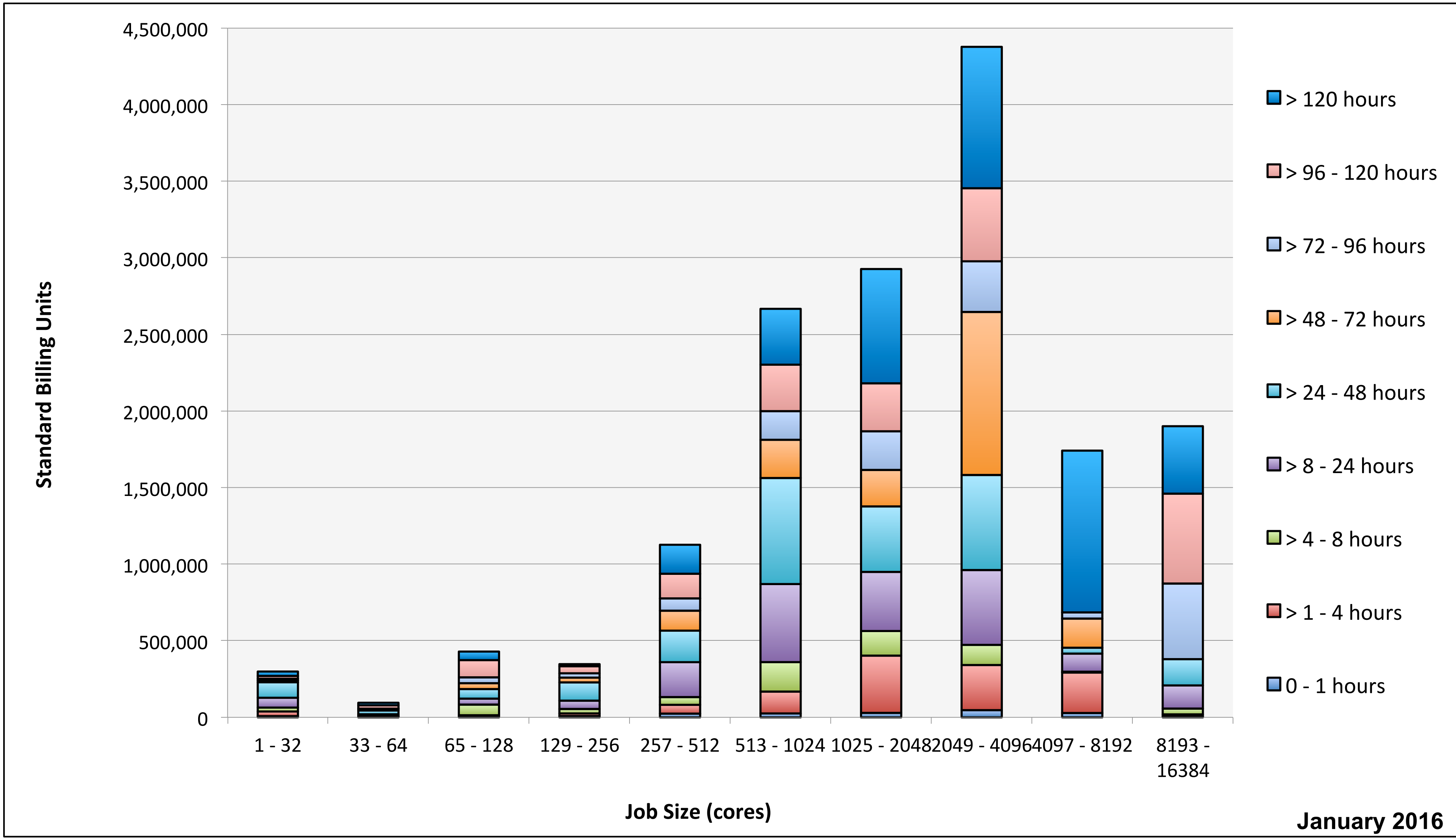
# Pleiades:
# Monthly Utilization by Job Length



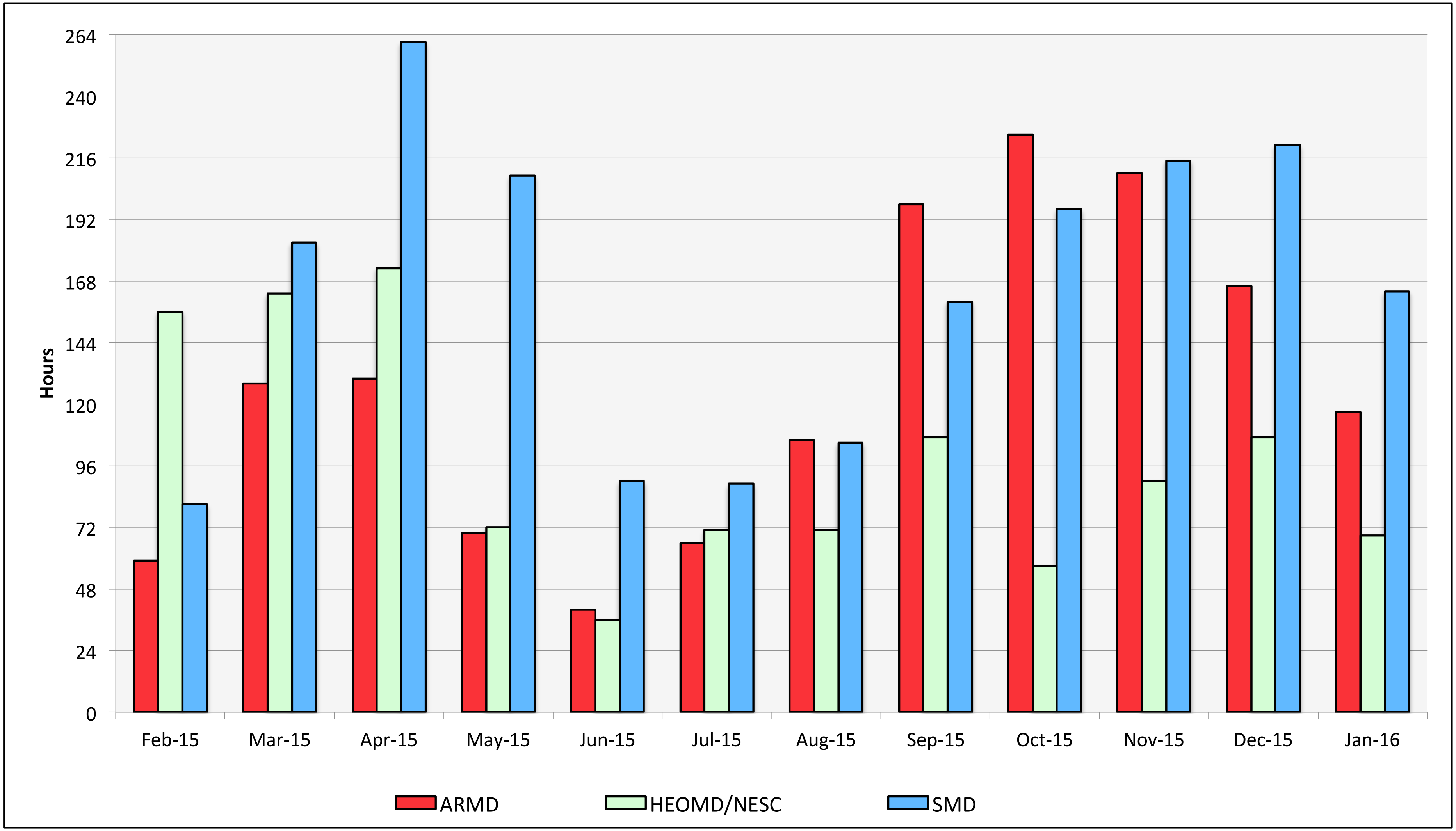
# Pleiades: Monthly Utilization by Size and Mission



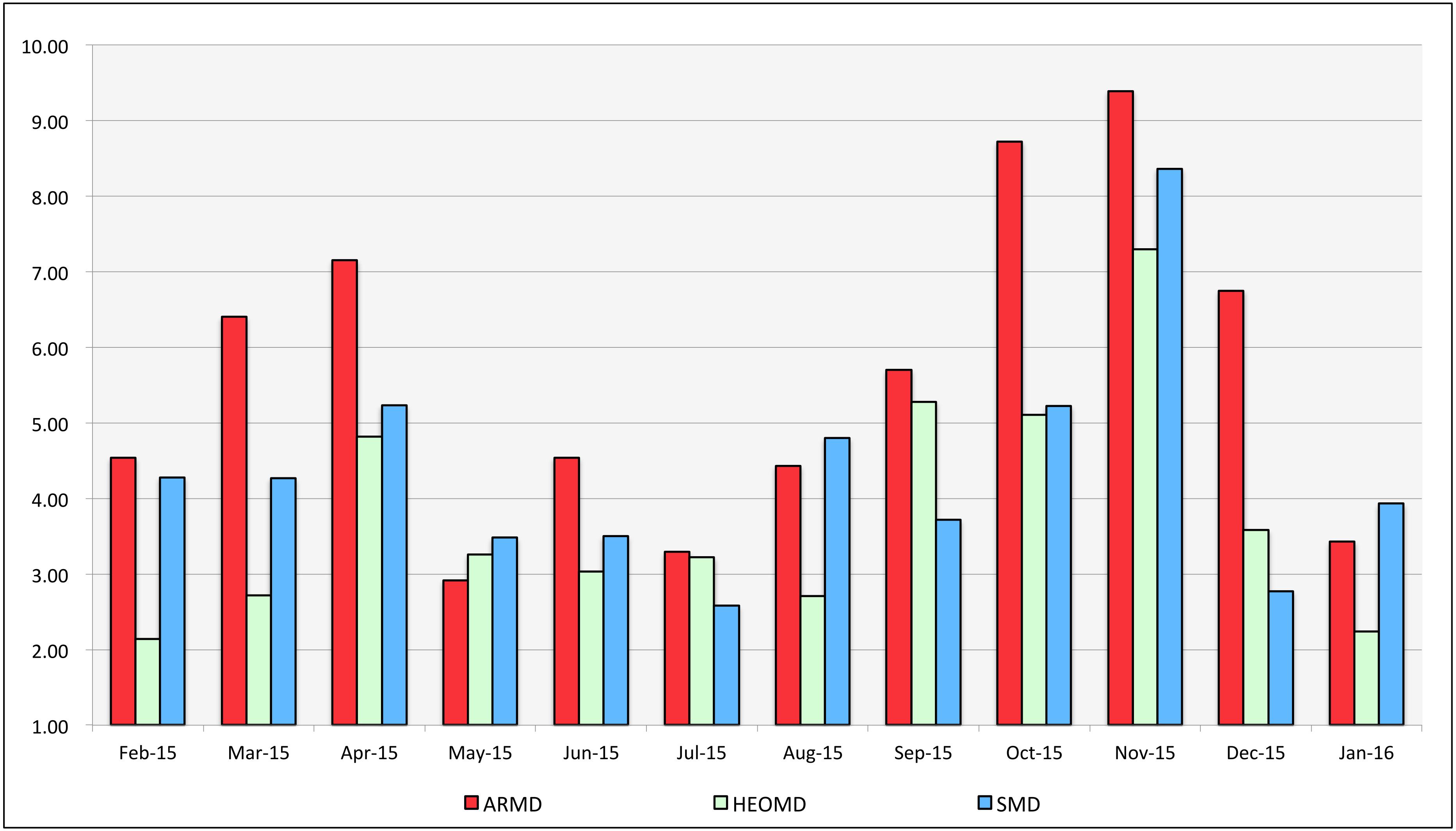
# Pleiades:
# Monthly Utilization by Size and Length



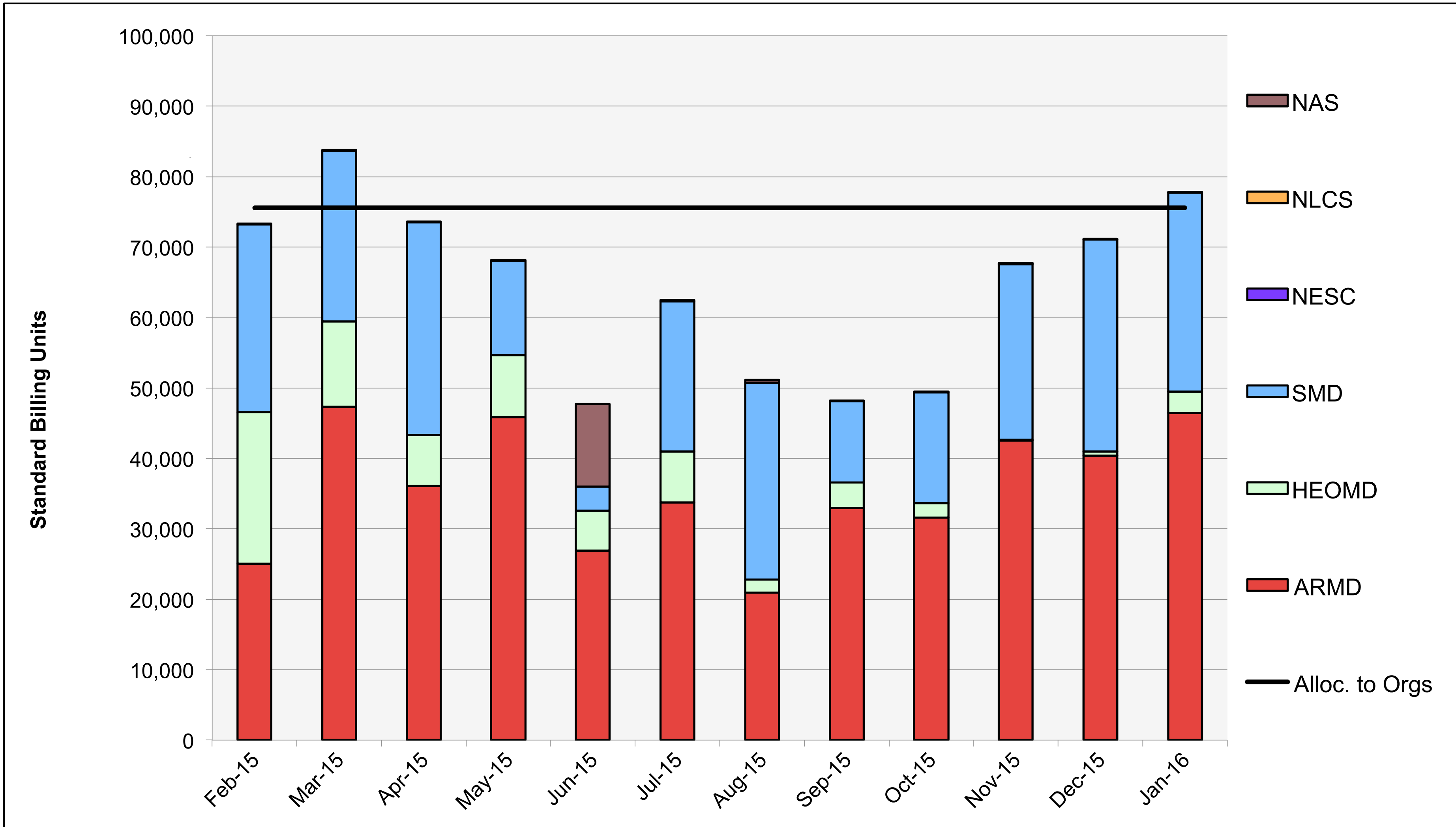
# Pleiades: Average Time to Clear All Jobs



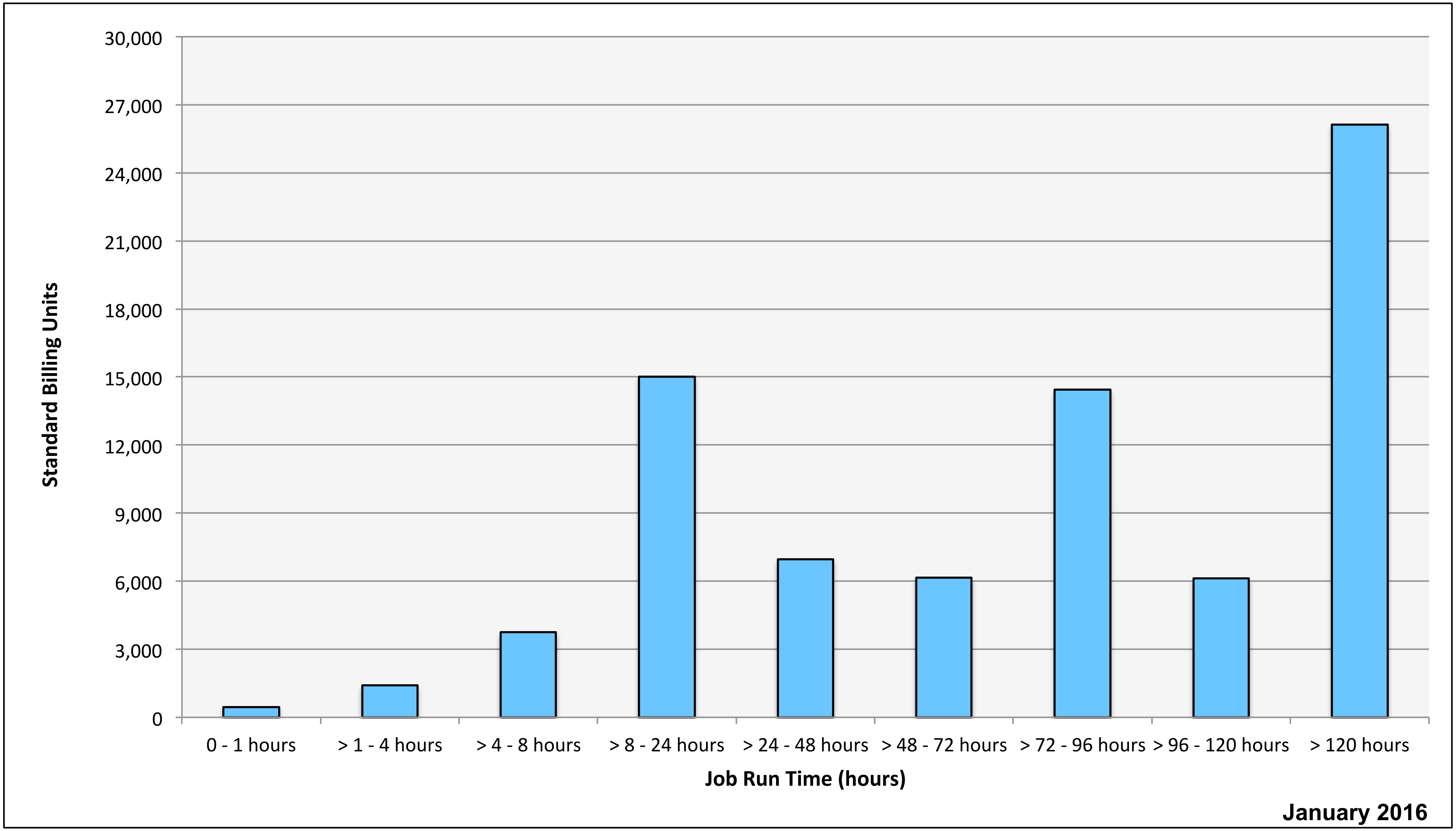
# Pleiades:
# Average Expansion Factor



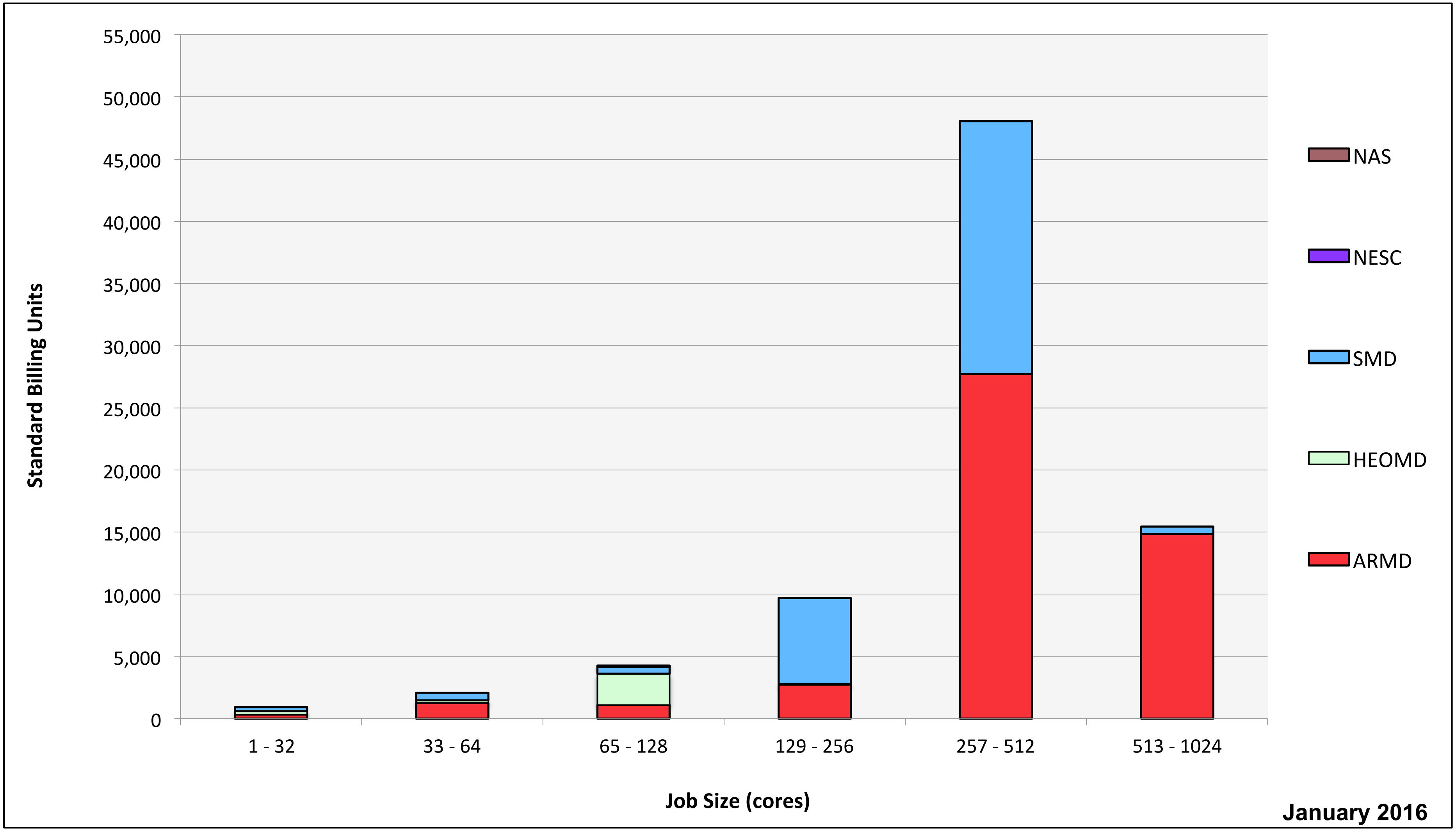
# Endeavour: SBUs Reported, Normalized to 30-Day Month



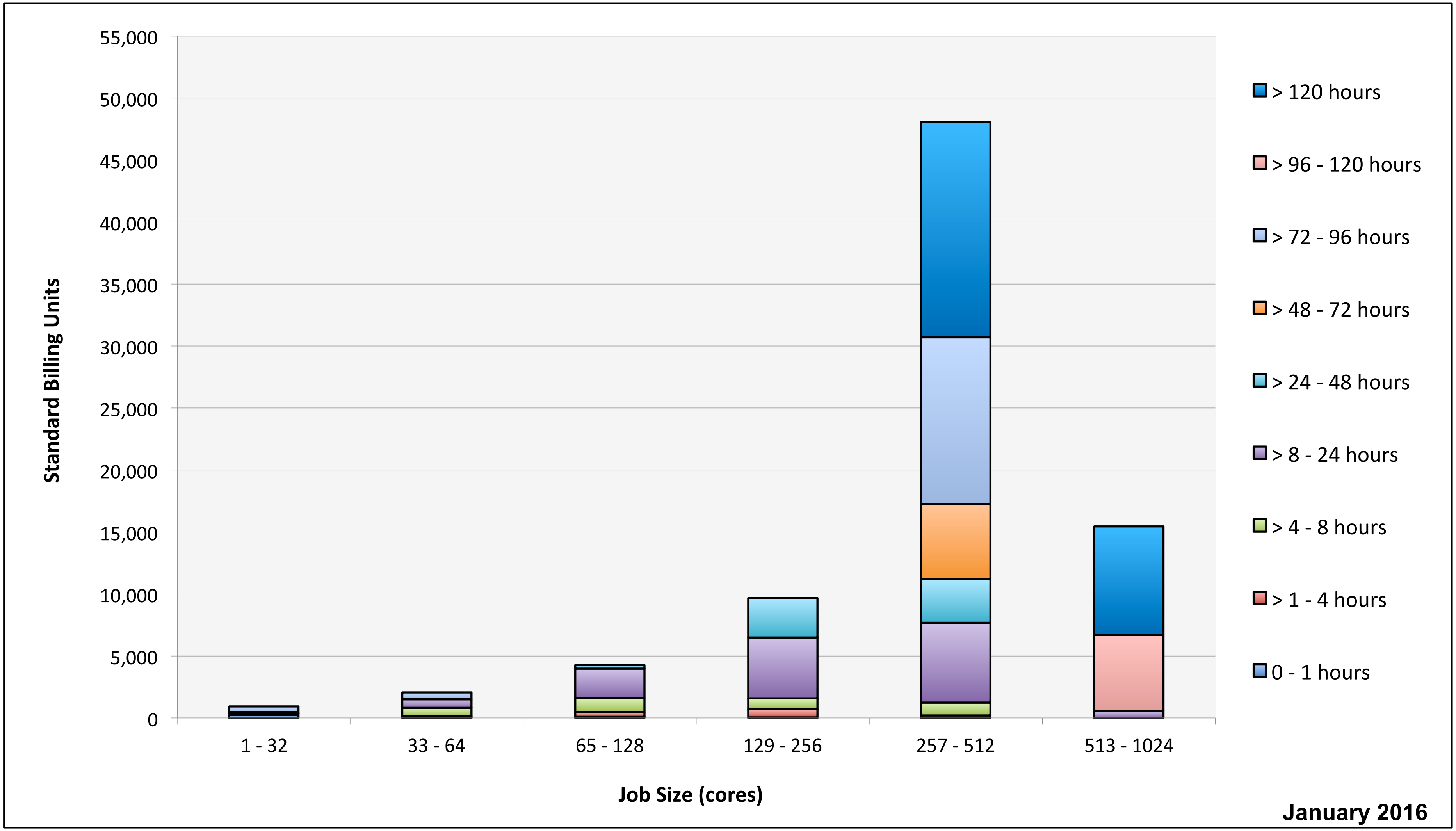
# Endeavour: Monthly Utilization by Job Length



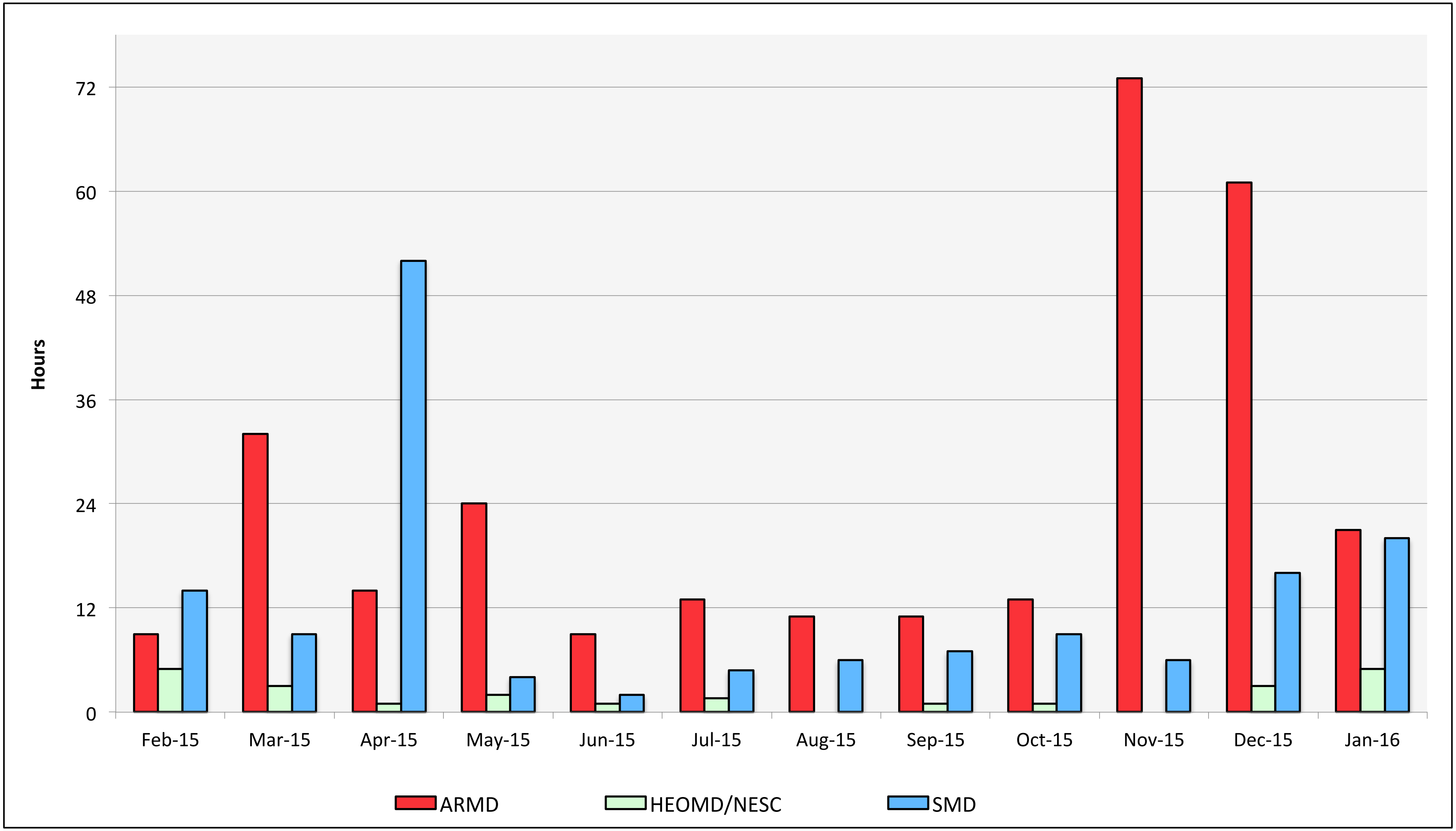
# Endeavour:
# Monthly Utilization by Size and Mission



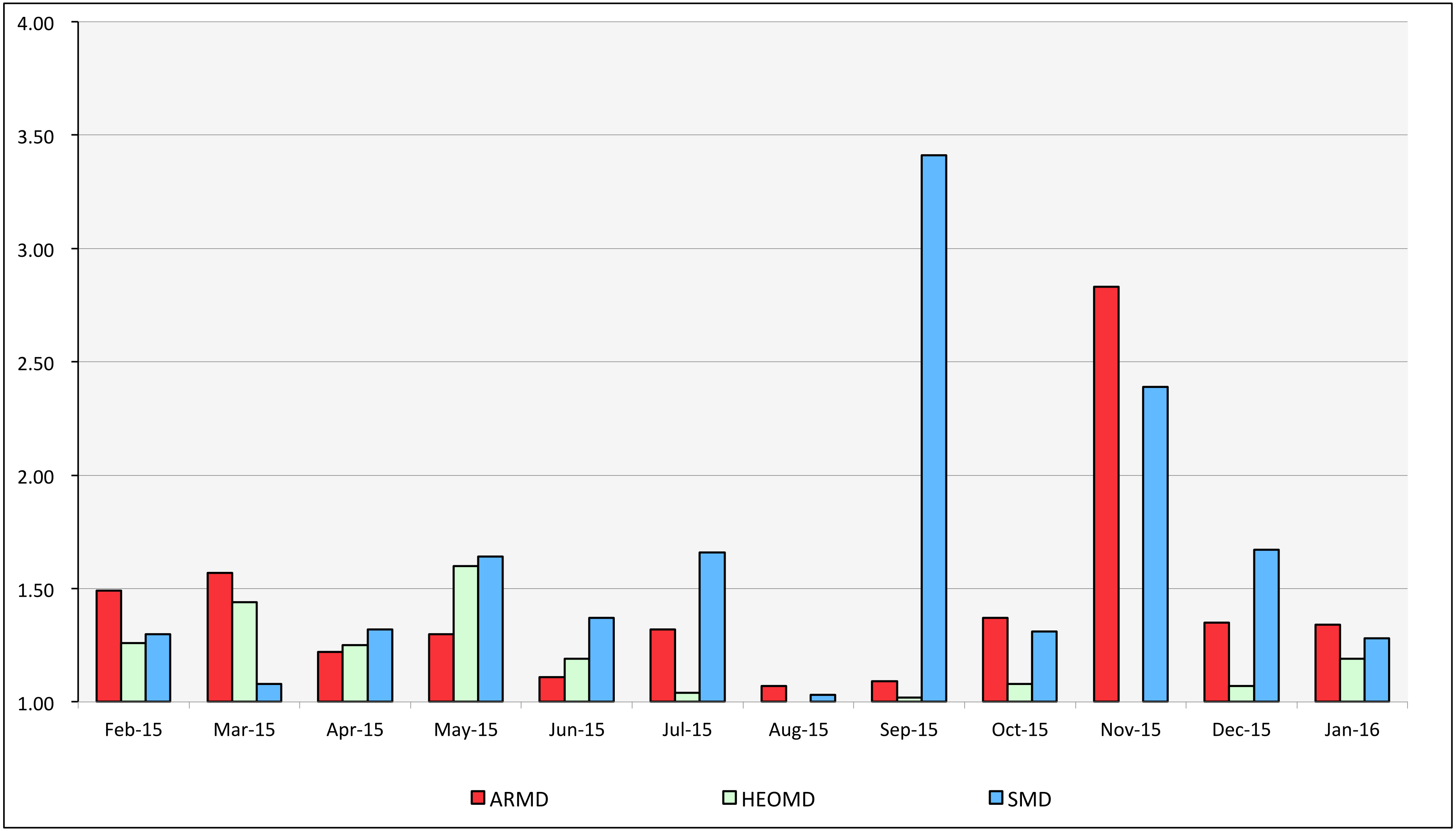
# Endeavour: Monthly Utilization by Size and Length



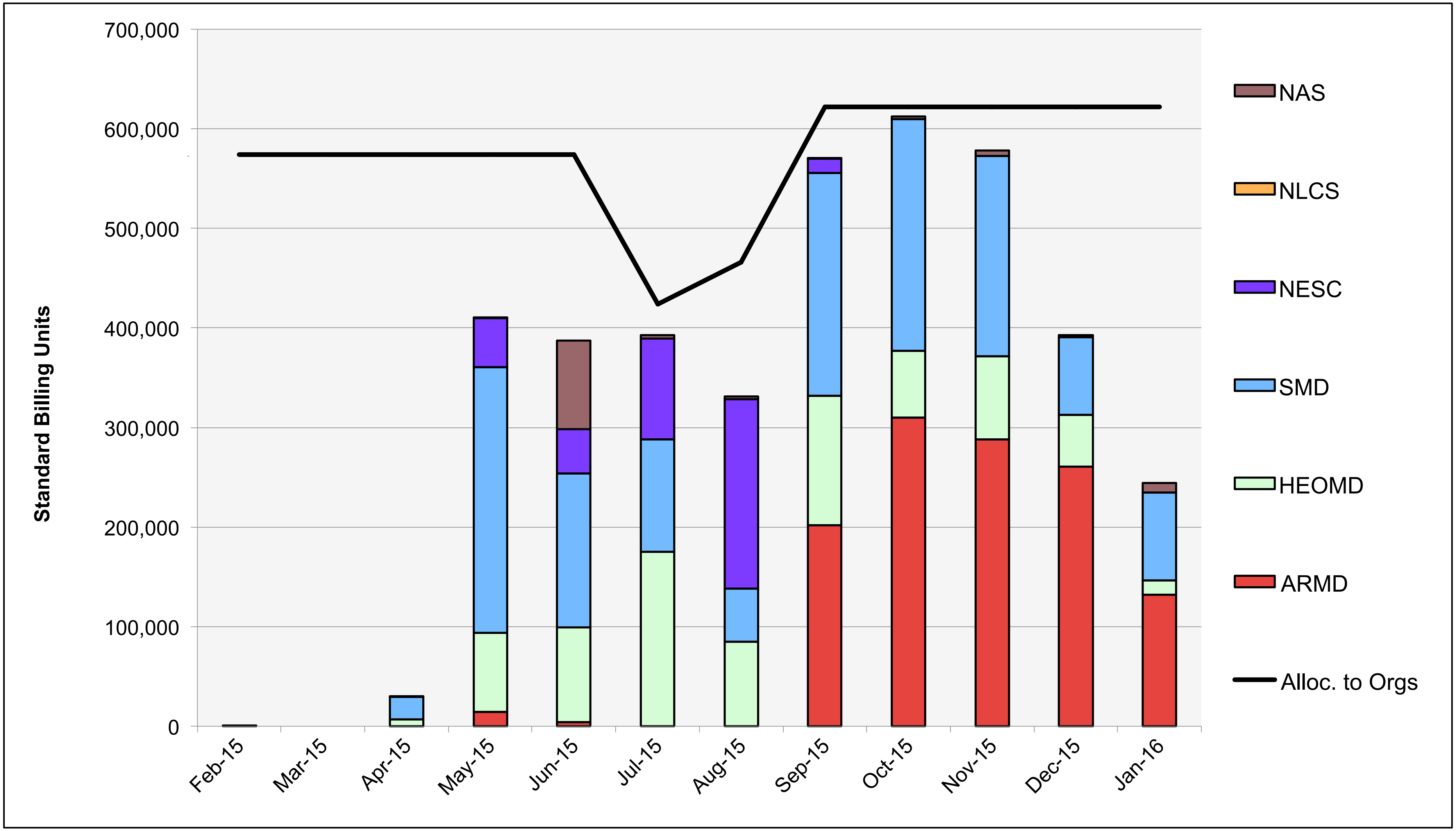
# Endeavour: Average Time to Clear All Jobs



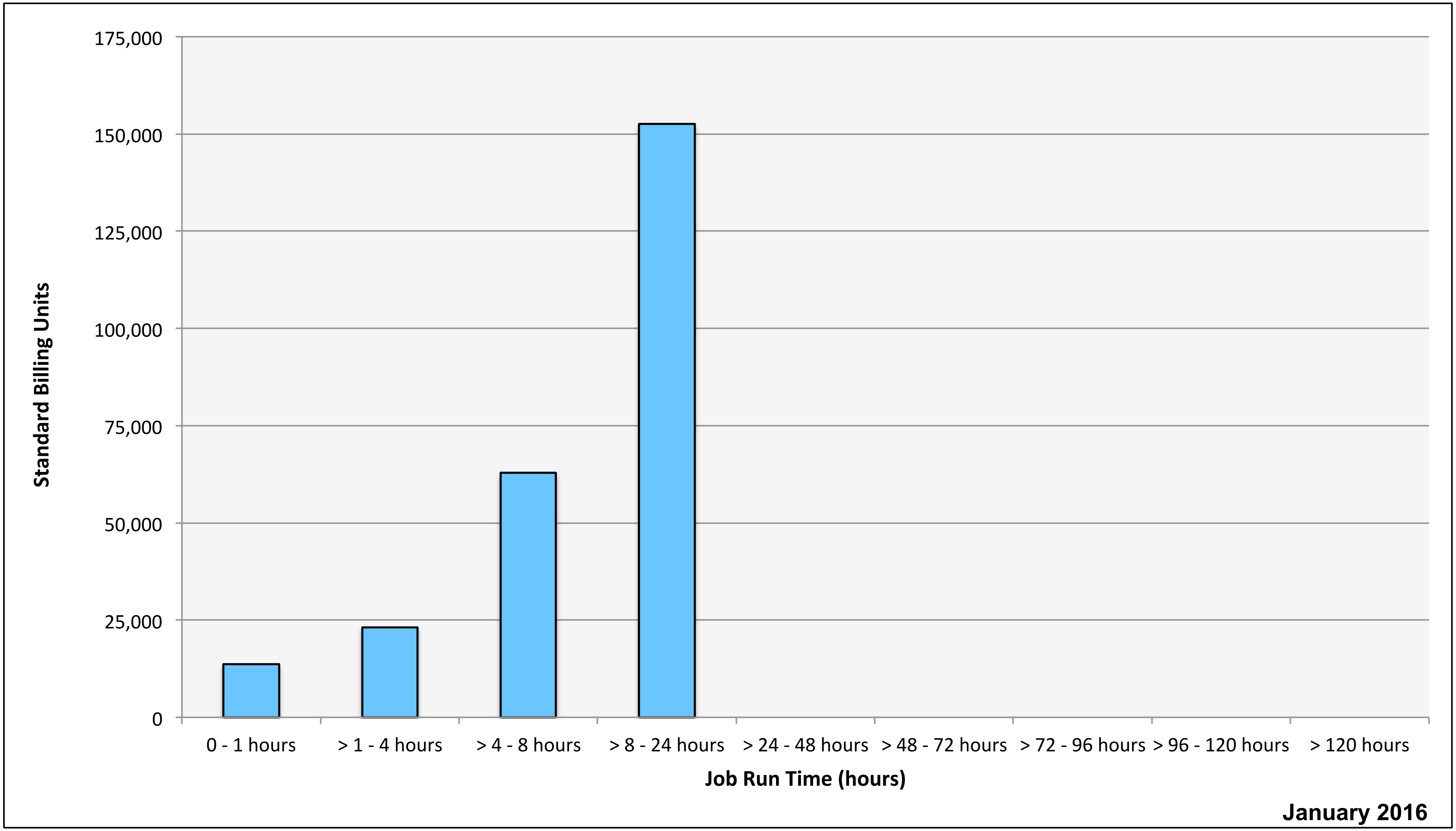
# Endeavour: Average Expansion Factor



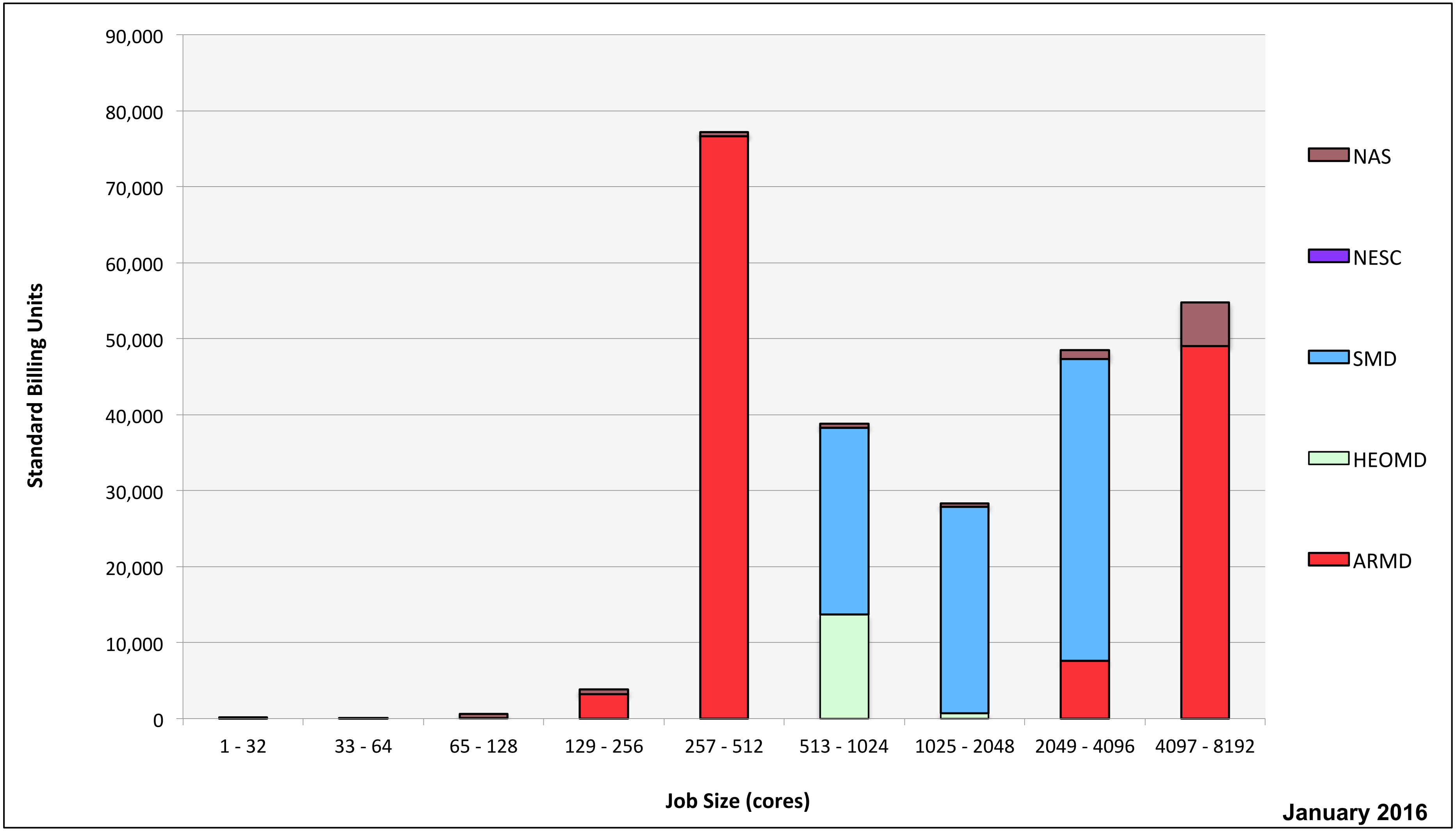
# Merope:
# SBUs Reported, Normalized to 30-Day Month



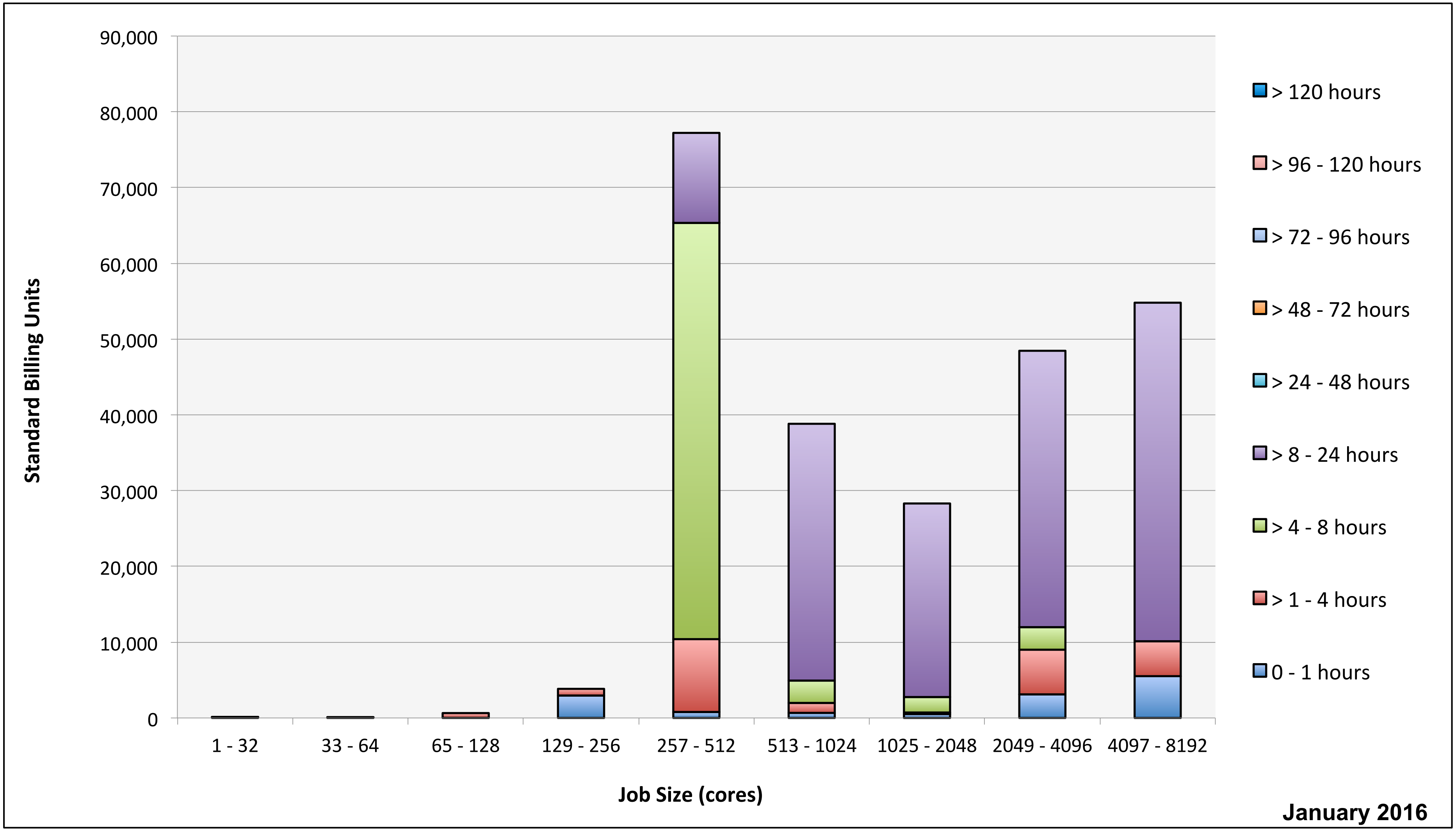
# Merope: Monthly Utilization by Job Length



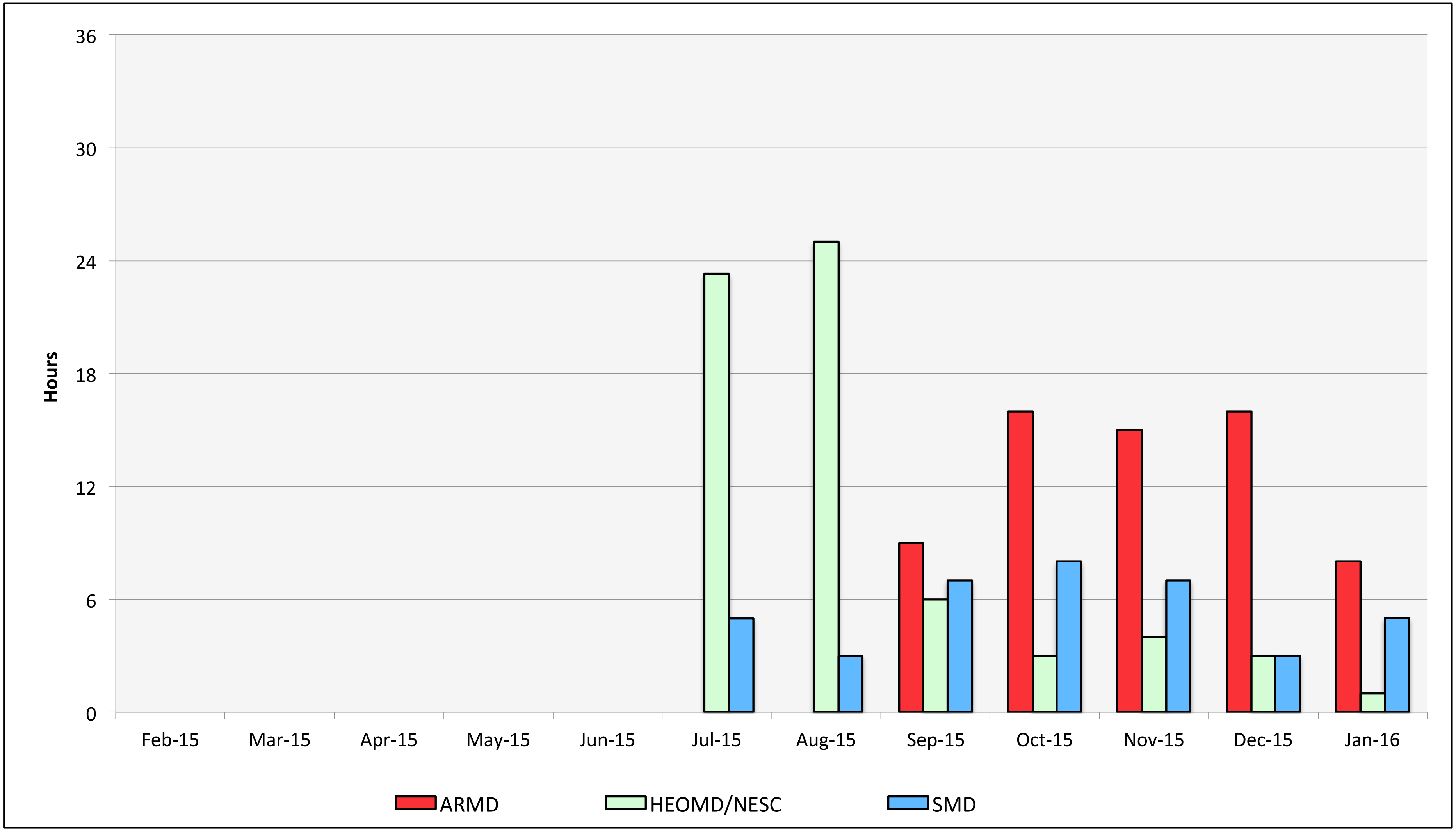
# Merope: Monthly Utilization by Size and Mission



# Merope: Monthly Utilization by Size and Length



# Merope: Average Time to Clear All Jobs



# Merope: Average Expansion Factor