Project Status Report

High End Computing Capability
Strategic Capabilities Assets Program

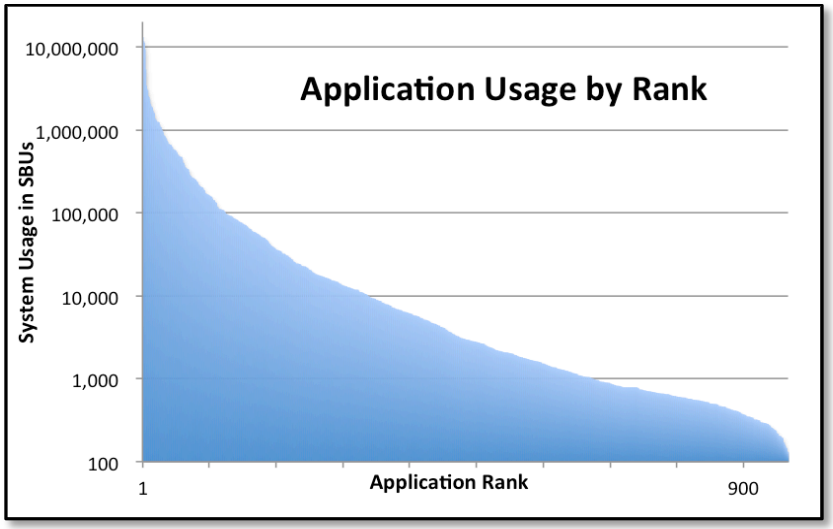
January 10, 2016

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Rupak.Biswas@nasa.gov
(650) 604-4411

HECC Begins Proactive Effort to Evaluate and Improve User Project Productivity

- HECC Application Performance and Productivity (APP) staff recently designed and began implementing a process to work with user project groups with high Standard Billing Unit (SBU) usage to evaluate and improve their overall productivity.
- APP staff identified the applications used by 30 projects with the highest SBU usage, and asked the mission directorate managers to prioritize which projects and applications should be evaluated and potentially optimized.
- The output of a project evaluation will be a Project Productivity Report containing:
  - Description of the project, including the computational approach currently employed.
  - Description of the performance analysis process used.
  - Description of the "low-hanging" optimizations made during performance analysis.
  - Discussion of further improvement opportunities, including the potential productivity impacts on both the application and workflow.
  - Findings, including tradeoffs for implementing further improvements.
- As APP staff become more experienced with the process, they anticipate working with 2 or 3 project groups simultaneously. At that rate, they should be able to evaluate 10 to 12 projects a year. Evaluating the highest usage projects in the first year would account for roughly half of the SBU usage of Pleiades.

Mission Impact: Besides the direct effect on a project, improving its productivity through application optimization can also result in improvements for other mission projects by reducing the demand for HECC resources.



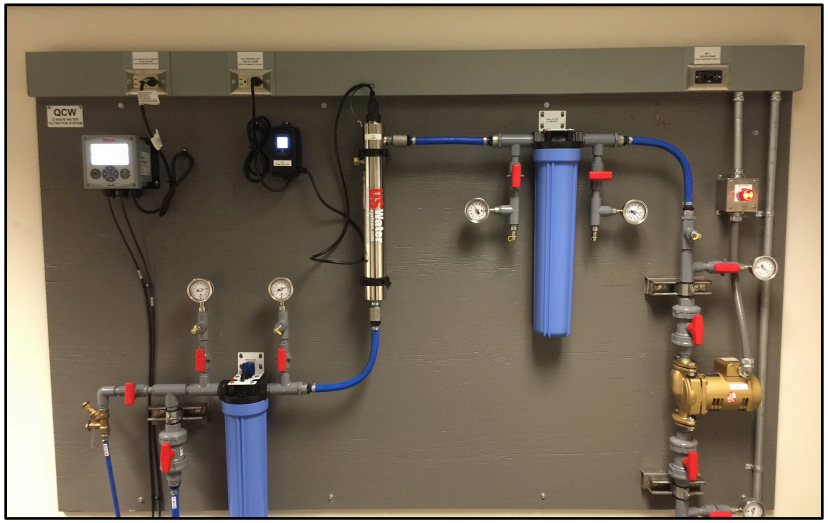
While over 900 MPI applications have been run on Pleiades in the last 12 months, a small number of them account for a majority of the Standard Billing Units used. Half of the overall system usage is expended by only 11 applications.

POCs: Henry Jin, haoqiang.jin@nasa.gov, (650) 604-0165, NASA Advanced Supercomputing (NAS) Division;
Robert Hood, robert.hood@nasa.gov, (650) 604-0740, NAS Division, CSRA, Inc.

Facilities Team Installs Filtration System to Improve Quantum Chilled Water Loop

- The HECC Facilities team, working with engineers from D-Wave, University Space Research Associates, and NASA Ames Code J, designed and installed a filtration system for the D-Wave quantum computer's chilled water loop.
- The filtration system is essential for removing particulates and eliminating biological contamination from the system.
- This first-of-its-kind filtration system in a D-Wave Quantum computing environment involved many months of requirements gathering, design work, and coordination to complete.
- HECC Facilities engineers worked closely with the other teams to reduce the cost of the overall system—one proposed design would have cost over $750K. The final design came in under $100K.
- By carefully coordinating and planning the installation process, the downtime during the commissioning and transition to the filtration system was kept to just a few hours, minimizing the impact to operations.

Mission Impact: HECC's careful planning and design of the filtration system for the D-Wave quantum computer dramatically reduced costs and minimized impact to scientific users. The new filtration system will help ensure that hardware components of D-Wave's cooling loop do not fail.



The D-Wave quantum computer water cooling loop filtration system that was commissioned and placed into production on December 16, 2015.

POCs: John Parks, john.w.parks@nasa.gov, (650) 604-4225, NASA Advanced Supercomputing (NAS) Division;
Chris Buchanan, chris.buchanan@nasa.gov, (650) 604-4308, NASA Advanced Supercomputing Division, CSRA, Inc.

HECC Teams Support First Quantum Computing Media Event

- HECC staff collaborated with the NASA Ames Public Affairs Office and partners to plan and support the first quantum computing media event, held on December 8, 2015 at the NAS facility.
- The Publications & Media team (PUB) activities over several months included: photographing D-Wave upgrade activities, updating print and web material, planning audio/lighting setup, coordinating event details with participants from the Quantum Artificial Intelligence Laboratory (QuAIL) project, and supporting the escort/tour/media sign-in process on event day.
- PUB members also helped craft a November 20 media advisory and responded to requests from around the world, from both media and non-media sources, including requests for interviews from media who were unable to attend.
- HECC Facilities staff worked with USRA and D-Wave to reduce the risk of system downtime prior to and during the event. The commissioning of the filtration system (see slide 4) was delayed to ensure that there was no impact to the system until after the event.
- About 40 media representatives from the U.S., U.K., Japan, and Canada attended the event, which generated 6 interviews, more than a dozen TV and radio broadcasts, and more than 100 stories online during the week after the event.

Mission Impact: The quantum media event provided a rare opportunity for the QuAIL team to provide public-friendly information on their extensive studies in quantum annealing and to share their insights and results. Such collaboration may bring about leaps in quantum technologies and significantly change the way NASA solves challenging, real-world problems.



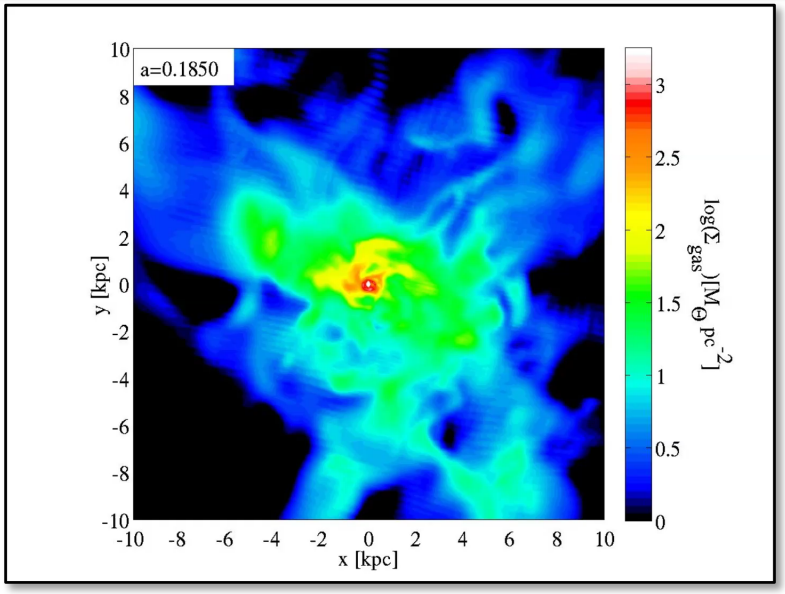
Left: Ames Exploration Technology Acting Director Rupak Biswas (center), answers questions during a tour of the D-Wave quantum computer room. Right: A panel of experts from NASA, Google, and USRA field media questions at the quantum media event held on December 8.

POCs: Gina Morello, gina.f.morello@nasa.gov, (650) 604-4462, NASA Advanced Supercomputing (NAS) Division,
Jill Dunbar, jill.a.dunbar@nasa.gov, (650) 604-3534, NAS Division, CSRA, Inc.

Discovering How Galaxies Form: Comparing High-Res Simulations with Hubble Images *

- A team of astrophysicists from several universities are using advanced simulation codes on Pleiades to run some of the most realistic galaxy formation simulations ever produced.
- The simulated galaxies help explain many key features of Hubble Space Telescope observations of galaxies in the process of formation, which is challenging for theoretical astrophysicists. For example:
  - Forming galaxies are elongated because they form along the filaments of the cosmic web of dark matter.
  - Large amounts of gas in early galaxies cause their disks to become violently unstable, leading to giant clumps of massive stars that have been observed by Hubble.
  - This instability is one reason forming galaxies shrink rather than growing in size, as previously thought.
- Recent code improvements are enabling even more realistic, higher-resolution simulations that extend all the way from the Big Bang to the present, providing further insight into the origin and evolution of galaxies.
- This research supports the largest-ever Hubble project, the Cosmic Assembly Near-infrared Deep Extragalactic Legacy Survey (CANDELS).

Mission Impact: Galaxy simulations run on HECC resources support the agency's goal to "explore the origin and evolution of the galaxies, stars, and planets that make up our universe." This work also helps researchers make predictions for upcoming NASA missions, such as the James Webb Space Telescope.



Evolution of gas in a simulated galaxy, showing gas surface density in a region spanning 20 kiloparsecs (kpc)—about 60,000 light years—from about 1.4 billion to 2.2 billion years after the Big Bang. During this time, the gas takes shape from an elongated structure to a small spiral galaxy.

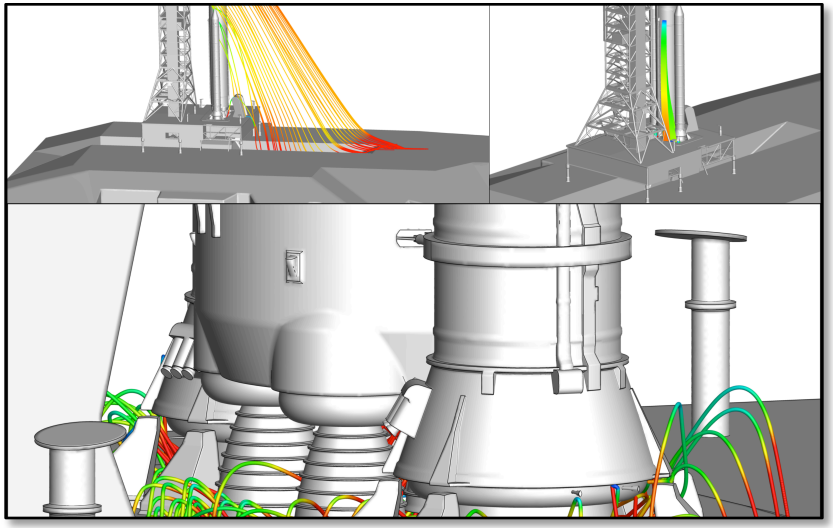
POC: Joel Primack, joel@ucsc.edu, (831) 459 2580, University of California, Santa Cruz

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

High-Fidelity Simulation and Analysis of the Space Launch System (SLS) Debris Environment *

- Researchers at Marshall Space Flight Center ran high-fidelity computational fluid dynamics (CFD) simulations on Pleiades to help understand and predict fluid flow features that may impact debris trajectories on the SLS.
- The debris environment analysis included:
  - 25 static CFD simulations of the vehicle on the launch pad with various combinations of wind speed and direction, and rocket plumes on/off.
  - Time-accurate simulation of the vehicle's ignition transient and motion along a launch trajectory for the first few seconds of flight. Features included solid rocket booster ignition overpressure, rocket plume entrainment and impingement, and ambient winds.
- Use of these high-fidelity simulations reduced the uncertainty and overly conservative analysis of earlier, simpler models and analyses.
- Each static simulation used ~75,000 processor-hours on Pleiades. The dynamic simulation used ~4 million hours, which would have been impractical just 10 years ago, and which now allows NASA to run these simulations during the design process.

Mission Impact: HECC supercomputing resources are instrumental to completing high-fidelity simulation and debris environment analyses for the design of the Space Launch System. Results were important to a recent critical SLS critical design review.



CFD simulation data is coupled with debris transport models in order to predict debris trajectories and impacts on the SLS vehicle. The colored streamlines illustrate potential debris trajectories from various parts of the launch pad and SLS structures.

POC: Brandon Williams, brandon.williams@nasa.gov, NASA Marshall Space Flight Center

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

HECC Facility Hosts Several Visitors and Tours in December 2015

- HECC hosted 8 tour groups in December. Guests learned about the agency-wide missions being supported by HECC assets; some groups also viewed the D-Wave 2X quantum computing system. Visitors this month included:
  - NASA Associate Administrator John Grunsfeld was briefed on the NAS facility and the D-Wave 2X quantum computer.
  - The new head of the German Aerospace Center (DLR), Pascale Ehrenfreund, visited the NAS facility as part of her center tour.
  - John A. Guerra-Gómez (Yahoo), Ricardo A. Garcia (Google), Maria F. Zuñiga-Zabala, Eduardo Torres Jara (SRI International), and Delfina Garcia-Pintos (Stanford University) visited NAS to explore collaboration for development of visualization tools for results in quantum computing research.
  - A group of astrophysics students from San Jose State University's Physics, Astronomy & Aerospace Engineering class visited NAS and learned about the D-Wave system.
  - A group from an "innovation club" comprised of executives from Austrian companies toured Ames to learn about the center, including HECC offerings.



NAS Division Chief Piyush Mehrotra (left) and Ames Exploration Technology Acting Director Rupak Biswas (right) discuss research being done on the quantum computing system with NASA Associate Administrator John Grunsfeld.

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

Papers

- "**The Atacama Cosmology Telescope: Dynamical Masses for 44 SZ-Selected Galaxy Clusters over 755 Square Degrees**," C. Sifon, et al., arXiv:1512.00910 [astro-ph.CO], December 3, 2015. * http://arxiv.org/abs/1512.00910
- "**Low Temperature Formation of Nitrogen-Substituted Polycyclic Aromatic Hydrocarbons (PANHs)—Barrierless Routes to Dihydro(iso)quinolines**," D. Parker, et al., The Astrophysical Journal, December 16, 2015. * http://iopscience.iop.org/article/10.1088/0004-637X/815/2/115/meta
- "**Evolution of Galaxy Shapes from Prolate to Oblate Through Compaction Events**," M. Tomassetti, et al., arXiv:1512.06268 [astro-ph.GA], December 19, 2015. * http://arxiv.org/abs/1512.06268

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Presentations

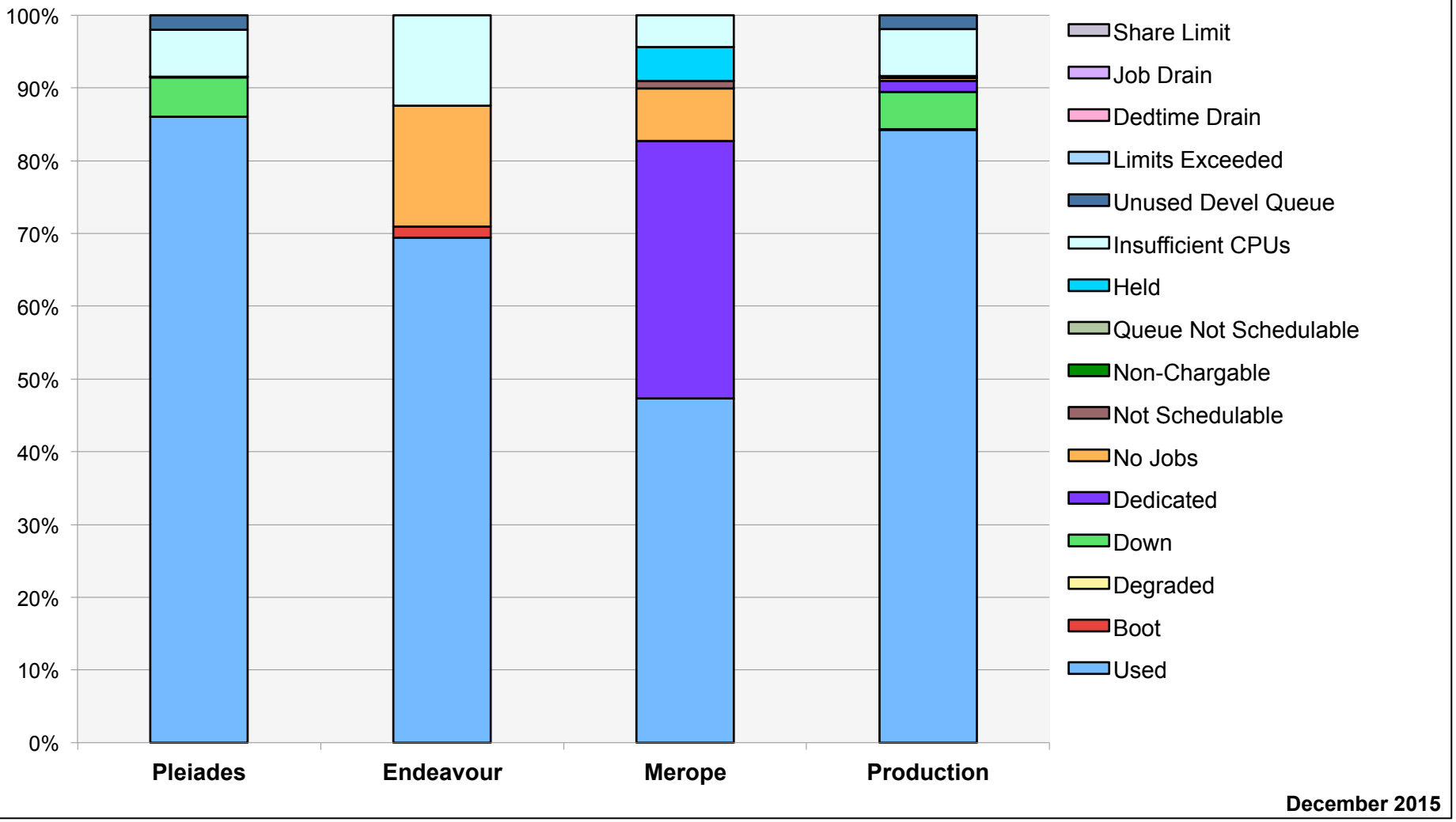
- **"NASA High-End Computing Capability (HECC)"** section of **"NASA Science FY2016 Agency Review of BY17 Exhibit 300's,"** W. Thigpen, presented to Renee Wynn, NASA CIO via teleconference, December 10, 2015.
- "**Effect of Different Rock Models on Hydrocode Simulations of Asteroid Airburst and Impact Blast**," D. Robertson, D. Mathias, presented at the 2015 AGU Fall Meeting, San Francisco, CA, December 14, 2015. * *https://agu.confex.com/agu/fm15/meetingapp.cgi/Paper/85036*
- "**Sensitivity to Uncertainty in Asteroid Impact Risk Assessment**," D. Mathias, et al., presented at the 2015 AGU Fall Meeting, San Francisco, CA, December 14, 2015. * *https://agu.confex.com/agu/fm15/meetingapp.cgi/Paper/85116*
- "**Solar Dynamo on Small and Global Scales**," I. Kitiashvili, et al. presented at the 2015 AGU Fall Meeting, San Francisco, CA, December 15, 2015. * *https://agu.confex.com/agu/fm15/meetingapp.cgi/Paper/77740*
- "**Solar Cycle Prediction with the Advective Flux Transport (AFT) Code**," D. Hathaway, et al., presented at the 2015 AGU Fall Meeting, San Francisco, CA, December 15, 2015. * *https://agu.confex.com/agu/fm15/meetingapp.cgi/Paper/86313*
- "**Recalculated Sunspot Cycle Characteristics Using the New Sunspot Number Series**," D. Hathaway, invited talk, presented at the 2015 AGU Fall Meeting, San Francisco, CA, December 15, 2015. * *https://agu.confex.com/agu/fm15/meetingapp.cgi/Paper/60997*
- "**Partially Ionized Plasma Three-Fluid Modeling of Magnetic Reconnection in the Sun Chromosphere**," N. Mansour, et al., presented at the 2015 AGU Fall Meeting, San Francisco, CA, December 17, 2015. * *https://agu.confex.com/agu/fm15/meetingapp.cgi/Paper/83277*

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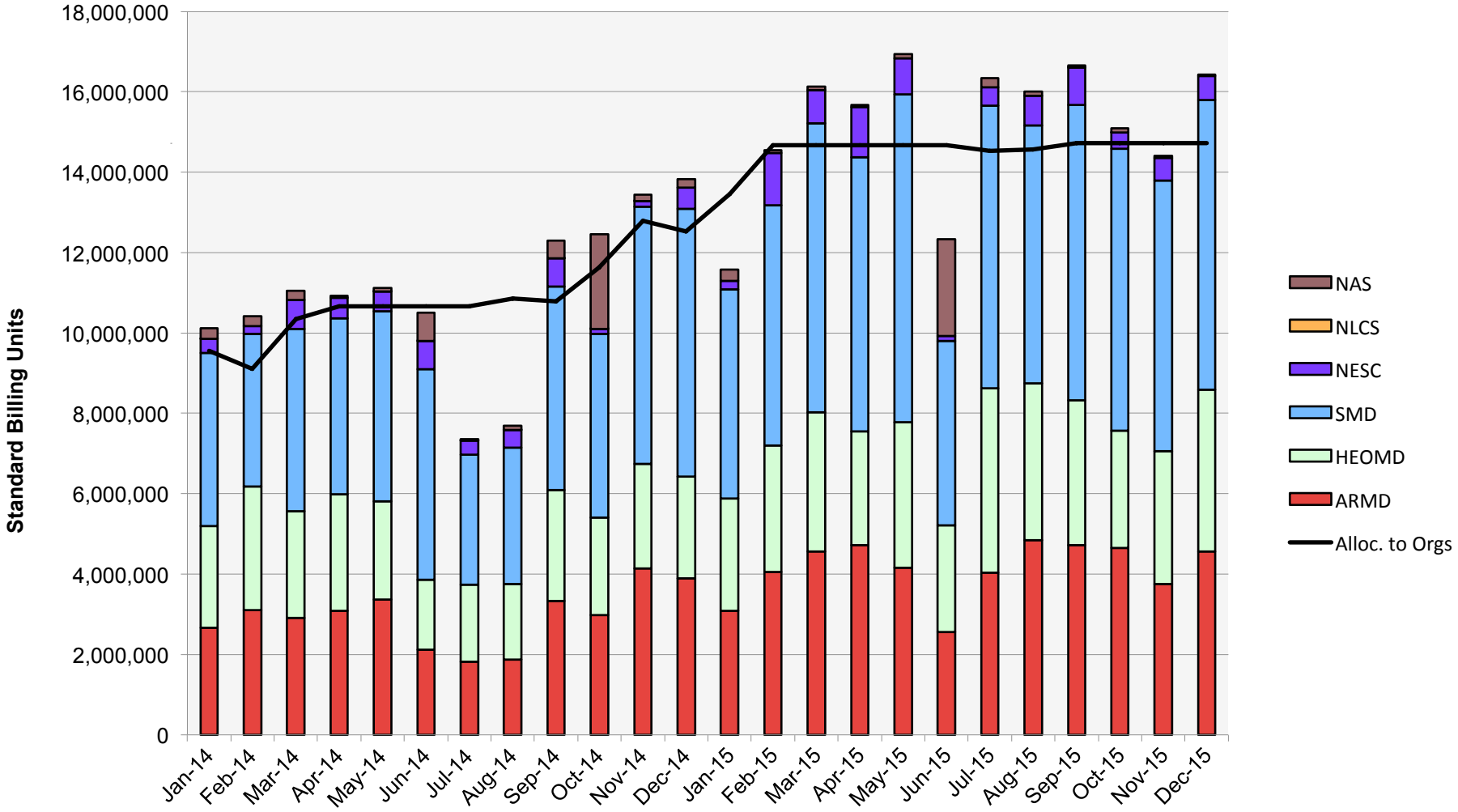
News and Events

- **Google Says It Has Proved Its Controversial Quantum Computer Really Works**, *MIT Technology Review*, December 8, 2015—Researchers from Google's AI Lab say that a controversial quantum machine that it and NASA have been testing since 2013 resoundingly beat a conventional computer in a series of tests. *http://www.technologyreview.com/news/544276/google-says-it-has-proved-its-controversial-quantum-computer-really-works/*
  - **NASA, Google Reveal Quantum Computing Leap**, *Computerworld*, December 8, 2015. *http://www.computerworld.com/article/3013102/high-performance-computing/nasa-google-unveil-a-quantum-computing-leap.html*
  - **Google, NASA's Quantum Computer is 100 Million Times Faster Than Yours,** *Mashable*, December 9, 2015. *http://mashable.com/2015/12/09/google-nasa-quantum-computer-fast/#bkczXTuBOkq3*
  - **USRA's David Bell Engages Media During Quantum Computing Event**, *USRA Press Release*, December 10, 2015. *http://www.usra.edu/news/pr/2015/mediaquantum/*
  - **A Quantum Leap for Silicon Valley,** *Mountain View Voice*, December 11, 2015. *http://mv-voice.com/news/2015/12/11/a-quantum-leap-for-silicon-valley*
  - Other coverage of the quantum computing media event included stories from the Wall Street Journal, Wired, PCWorld, Fortune, Tech Times, New Scientist, and more.

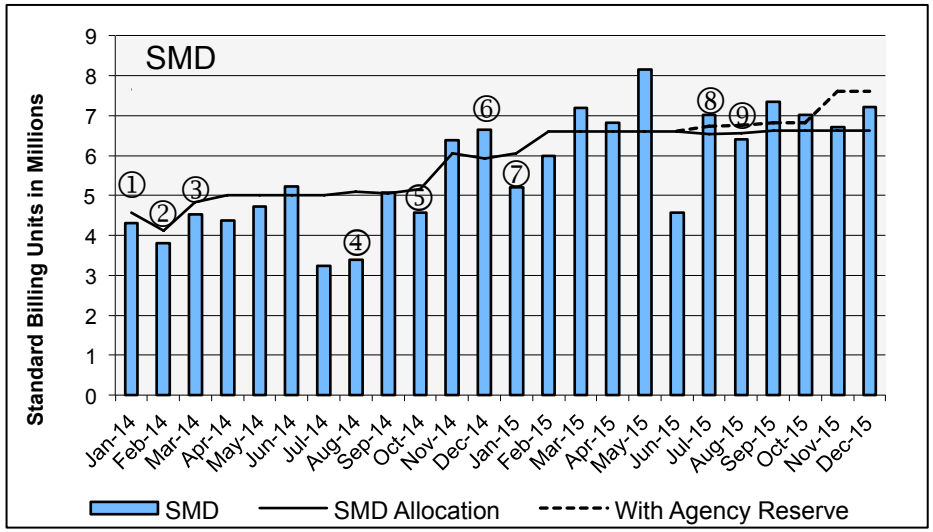
HECC Utilization

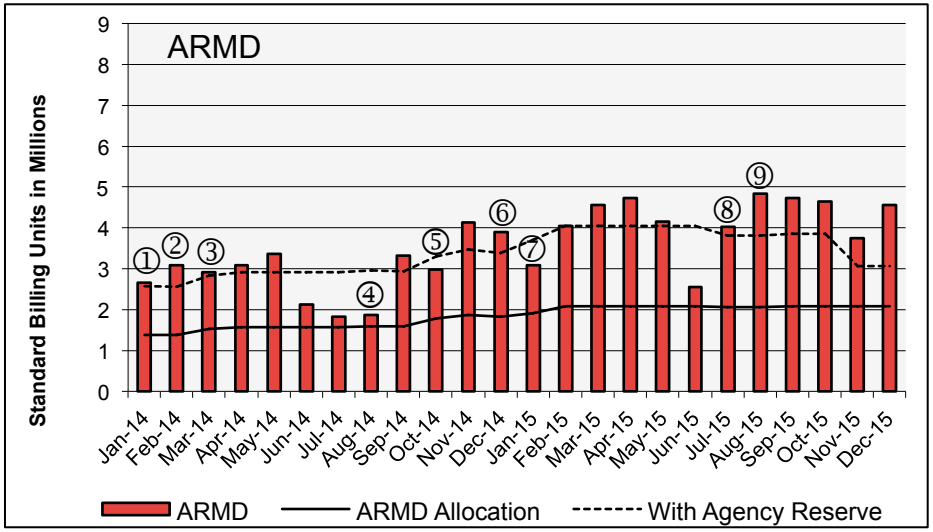


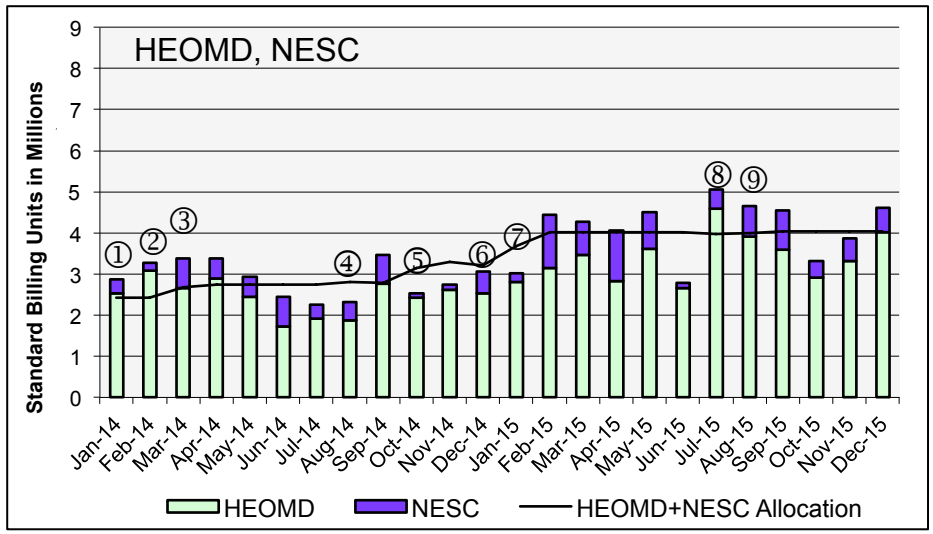
HECC Utilization Normalized to 30-Day Month



HECC Utilization Normalized to 30-Day Month







① 6 Ivy Bridge Racks added; 20 Nehalem, 12 Westmere Racks Retired from Pleiades

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

③ 4 Ivy Bridge Racks added mid-March to Pleaides

④ 6 Westmere Racks added to Merope, Merope Harpertown retired

⑤ 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

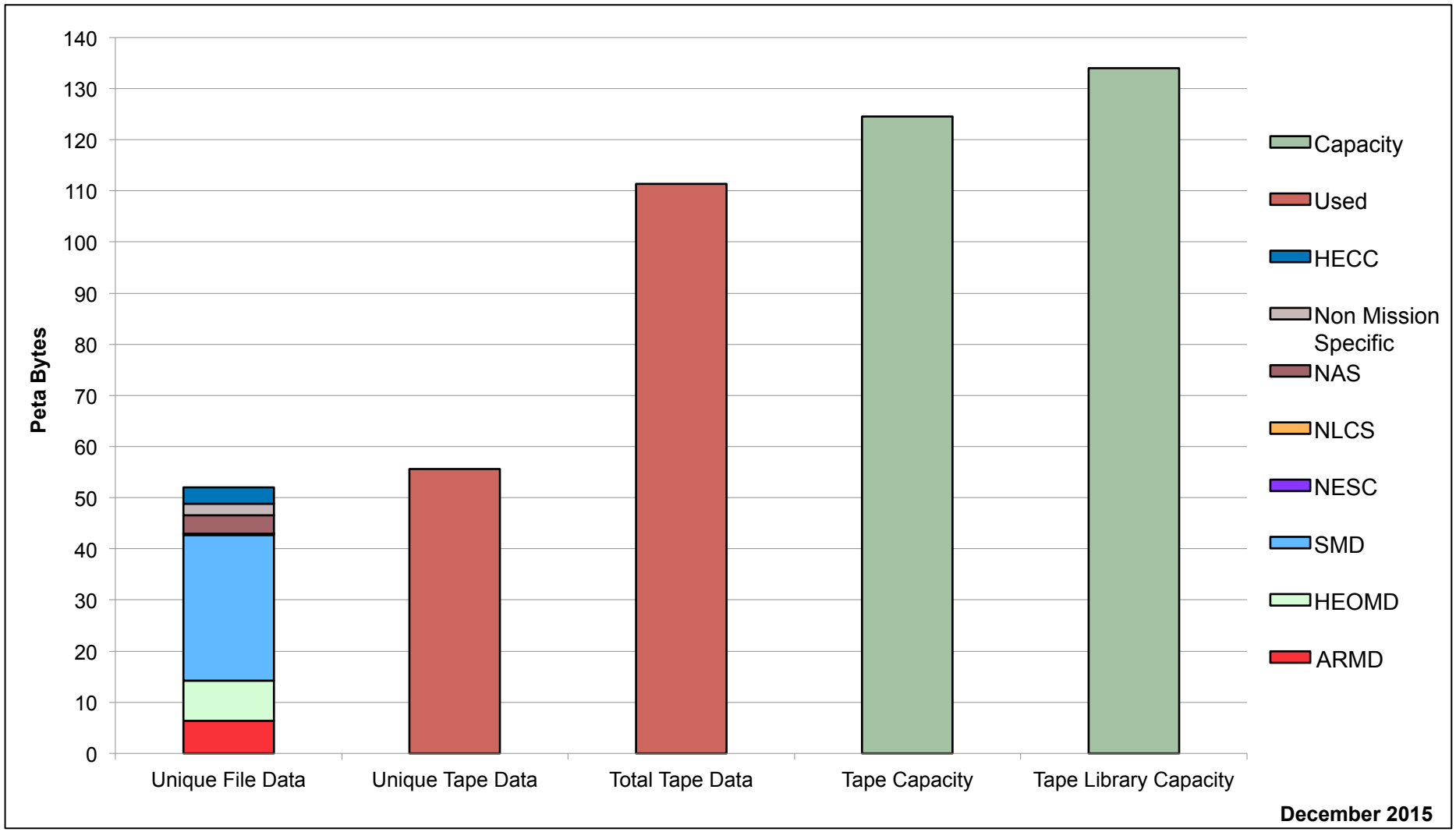
⑥ 16 Westmere Racks retired from Pleiades

⑦ 14 Haswell racks added to Pleiades

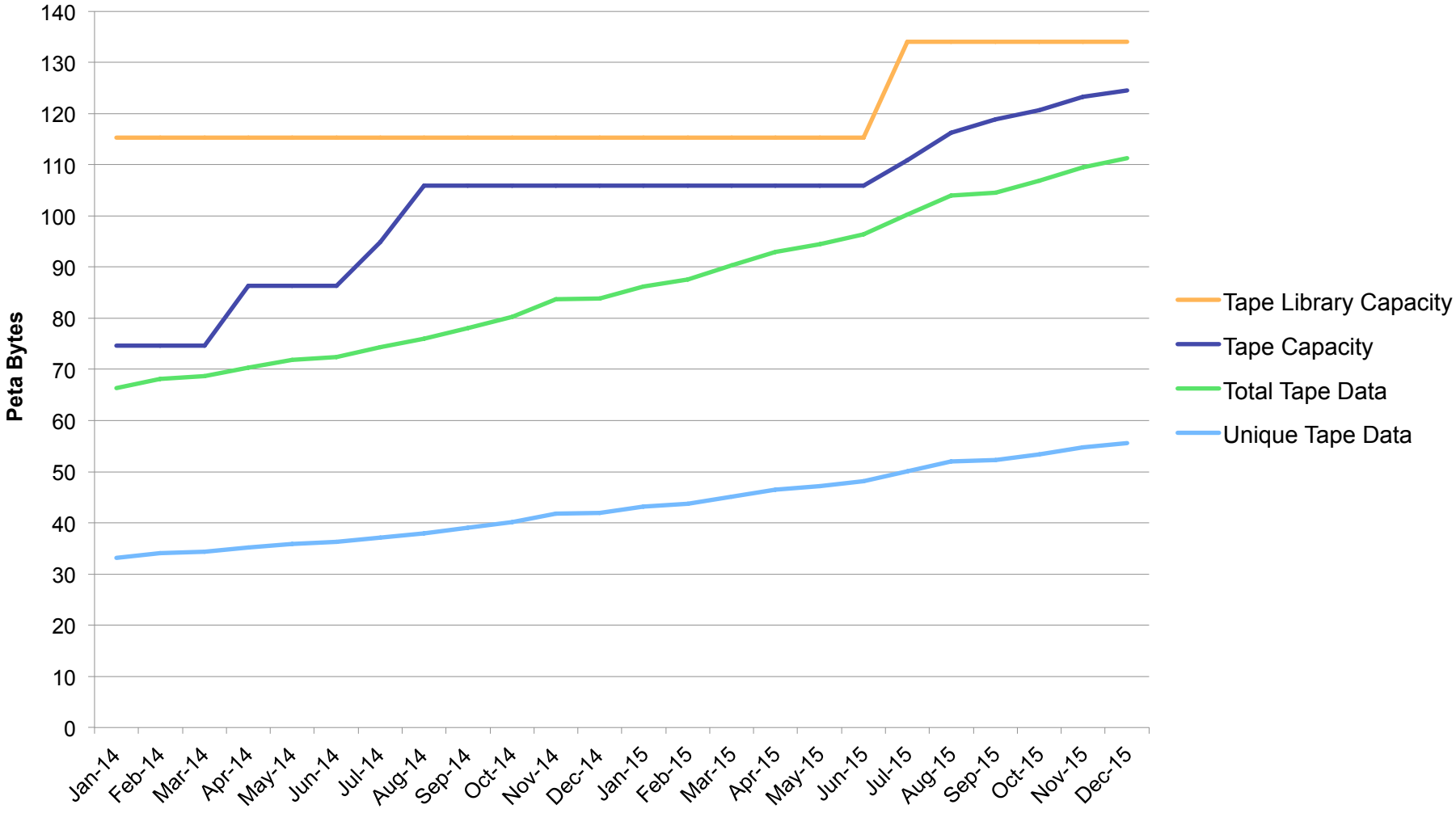
⑧ 7 Merope Nehalem Racks removed from Merope

⑨ 7 Merope Westmere Racks added from Merope

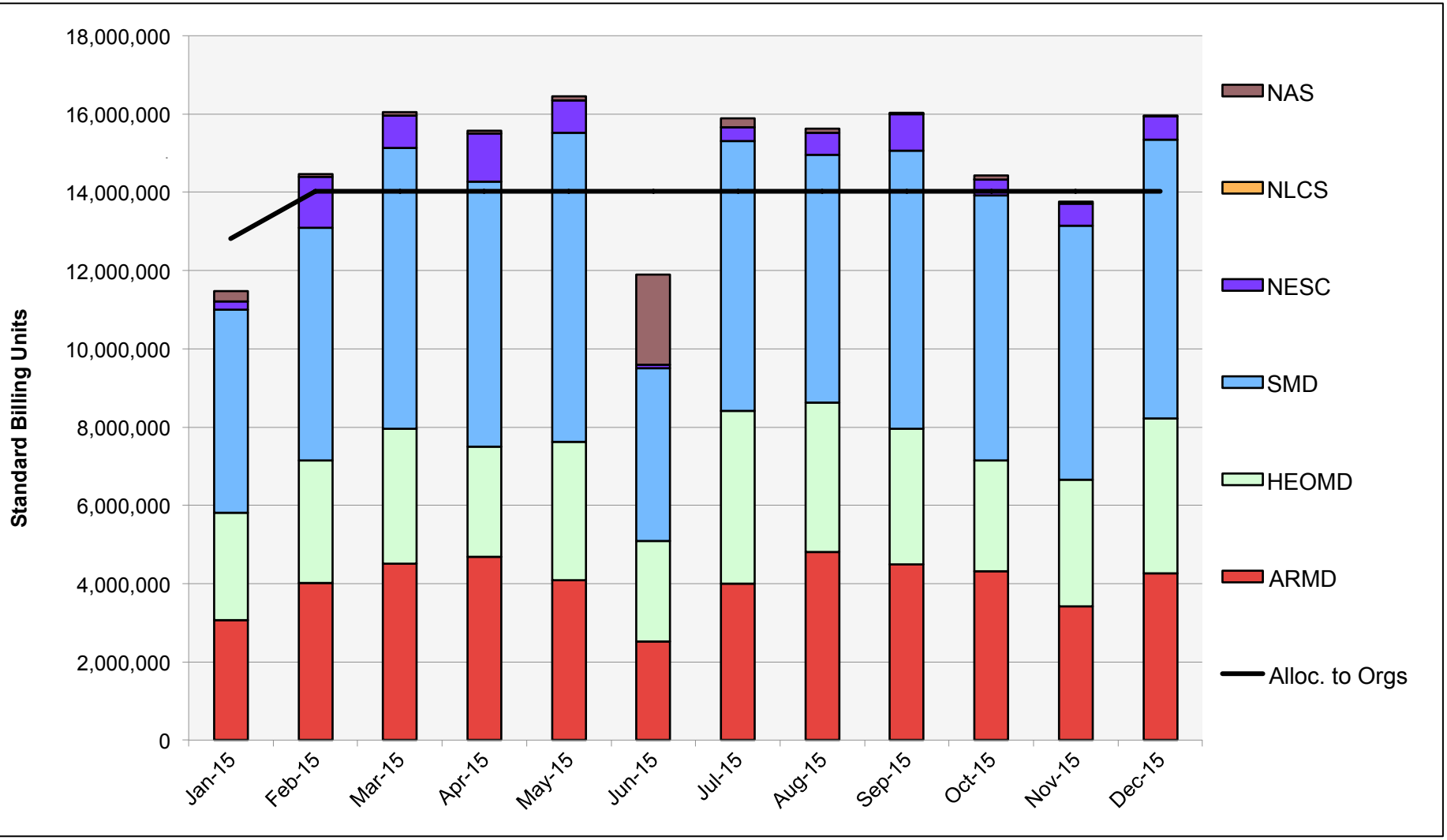
Tape Archive Status



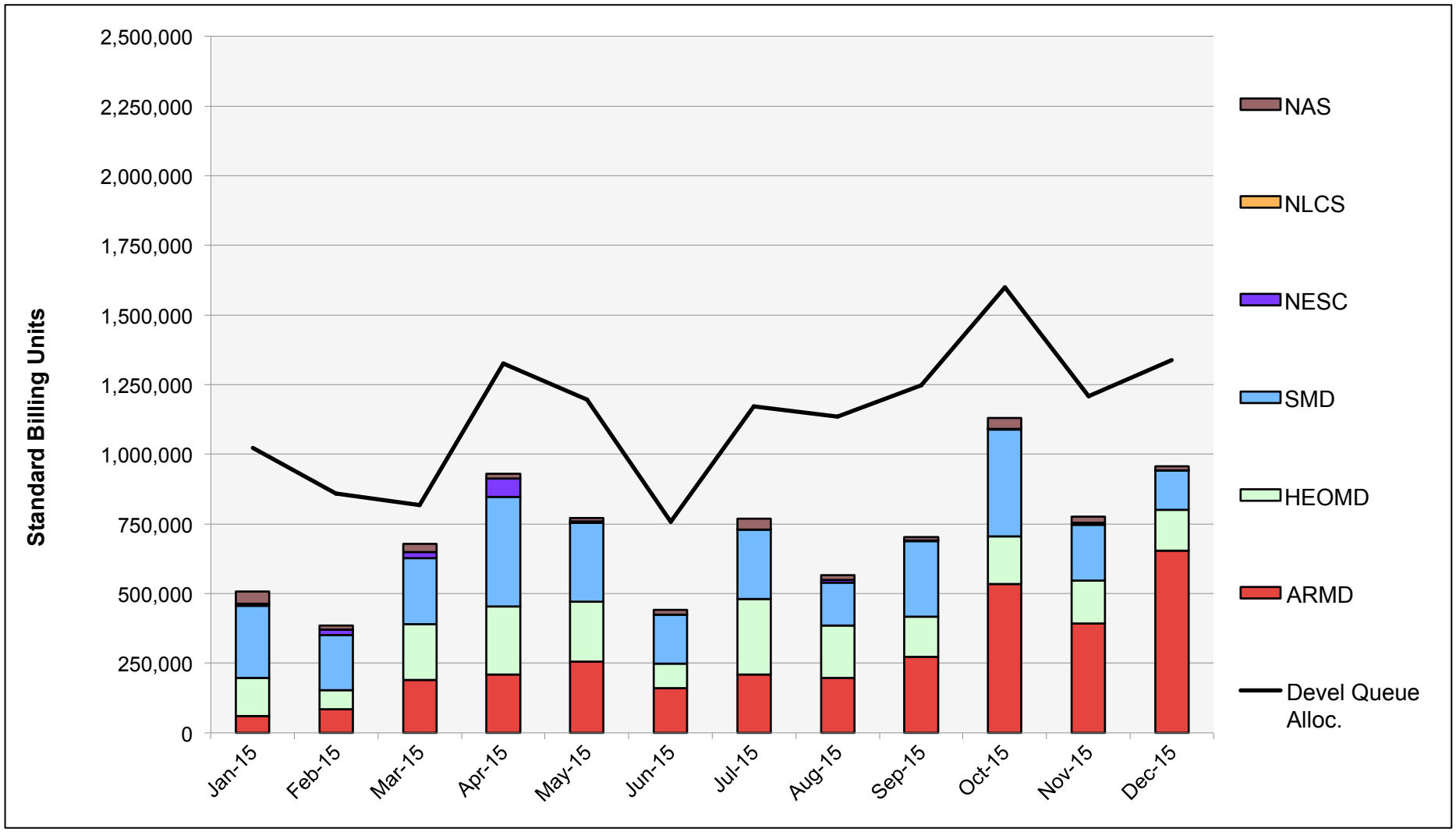
Tape Archive Status



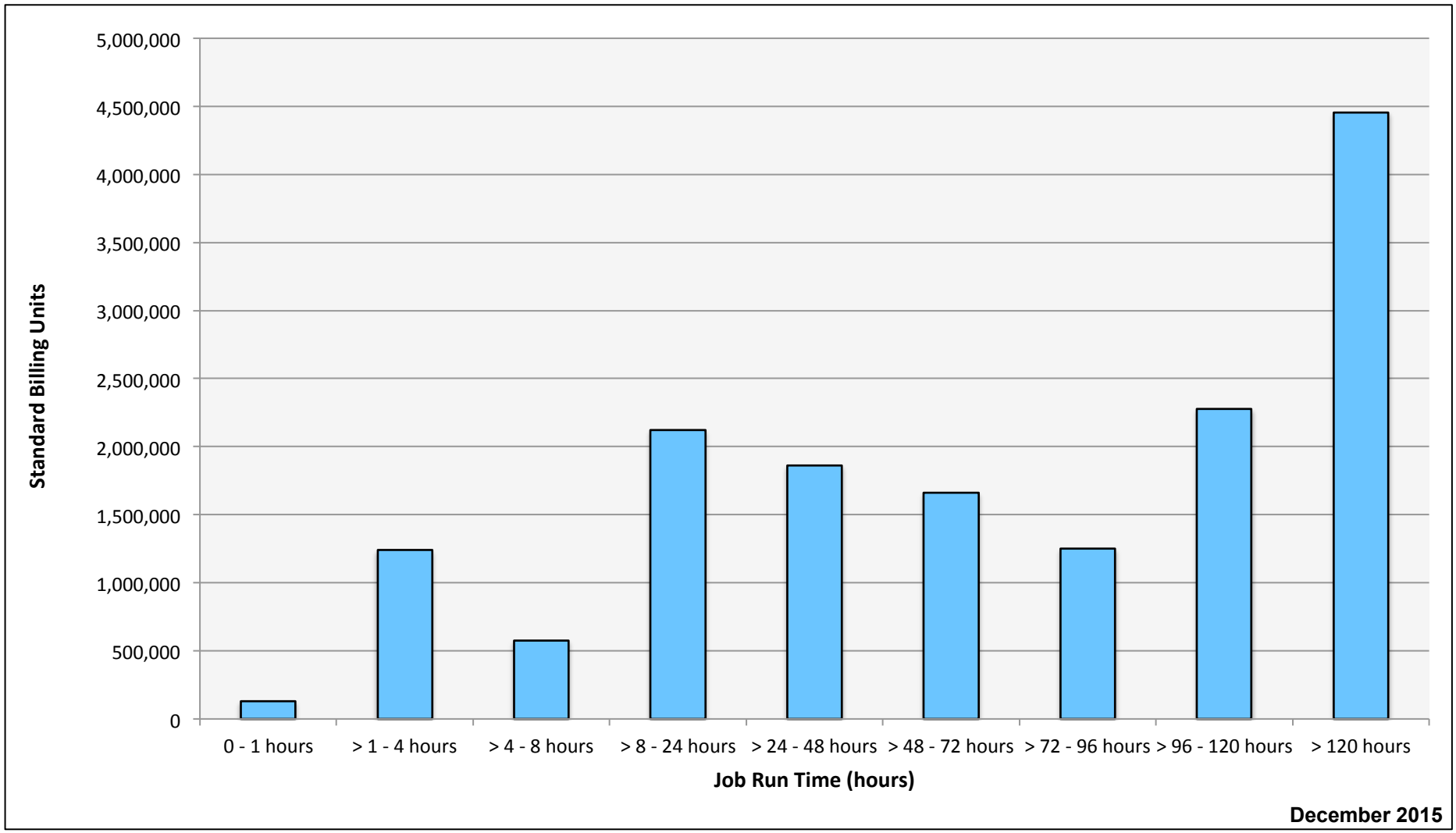
Pleiades:
SBUs Reported, Normalized to 30-Day Month



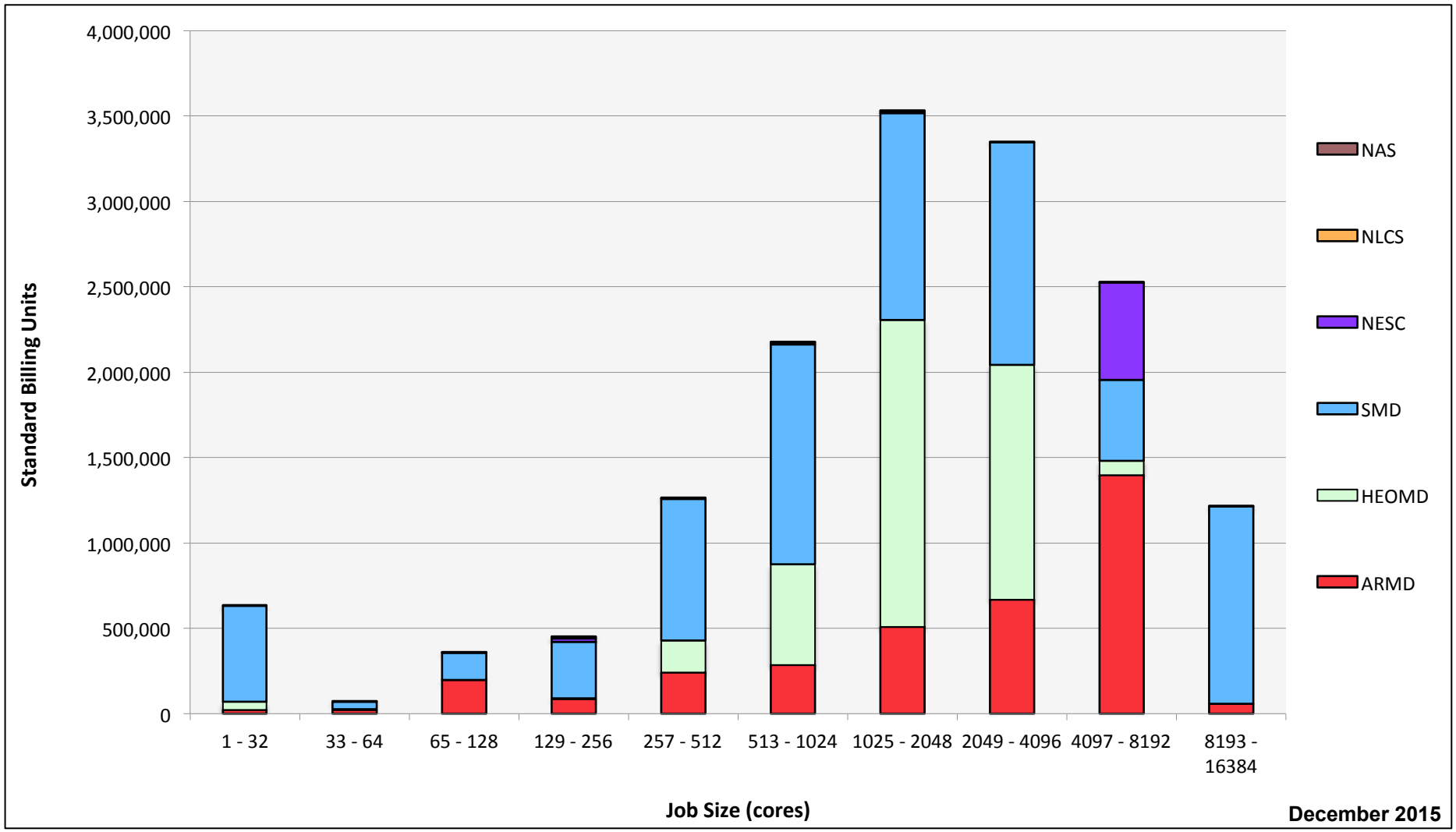
Pleiades:
Devel Queue Utilization



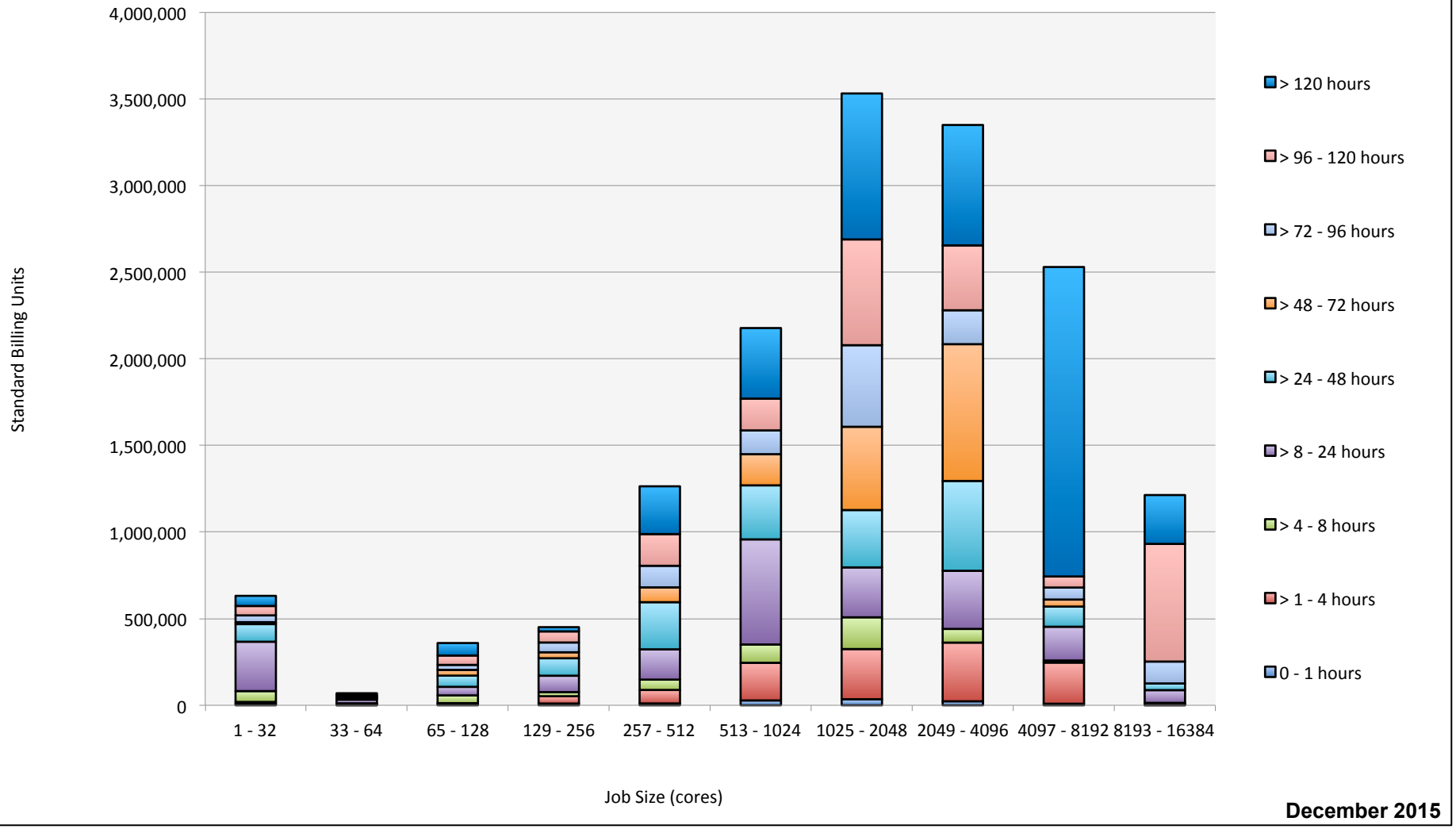
Pleiades:
Monthly Utilization by Job Length



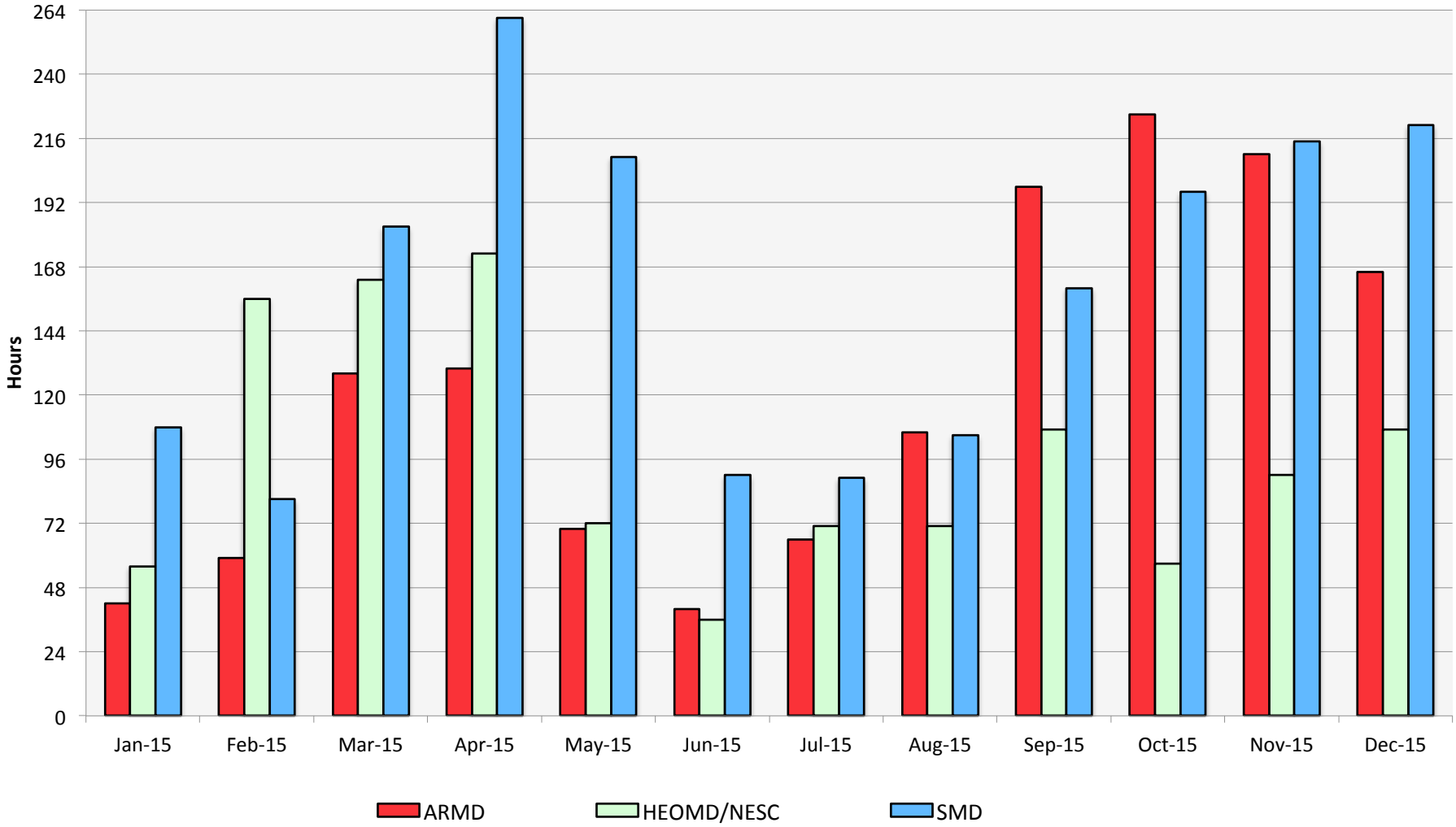
Pleiades:
Monthly Utilization by Size and Mission



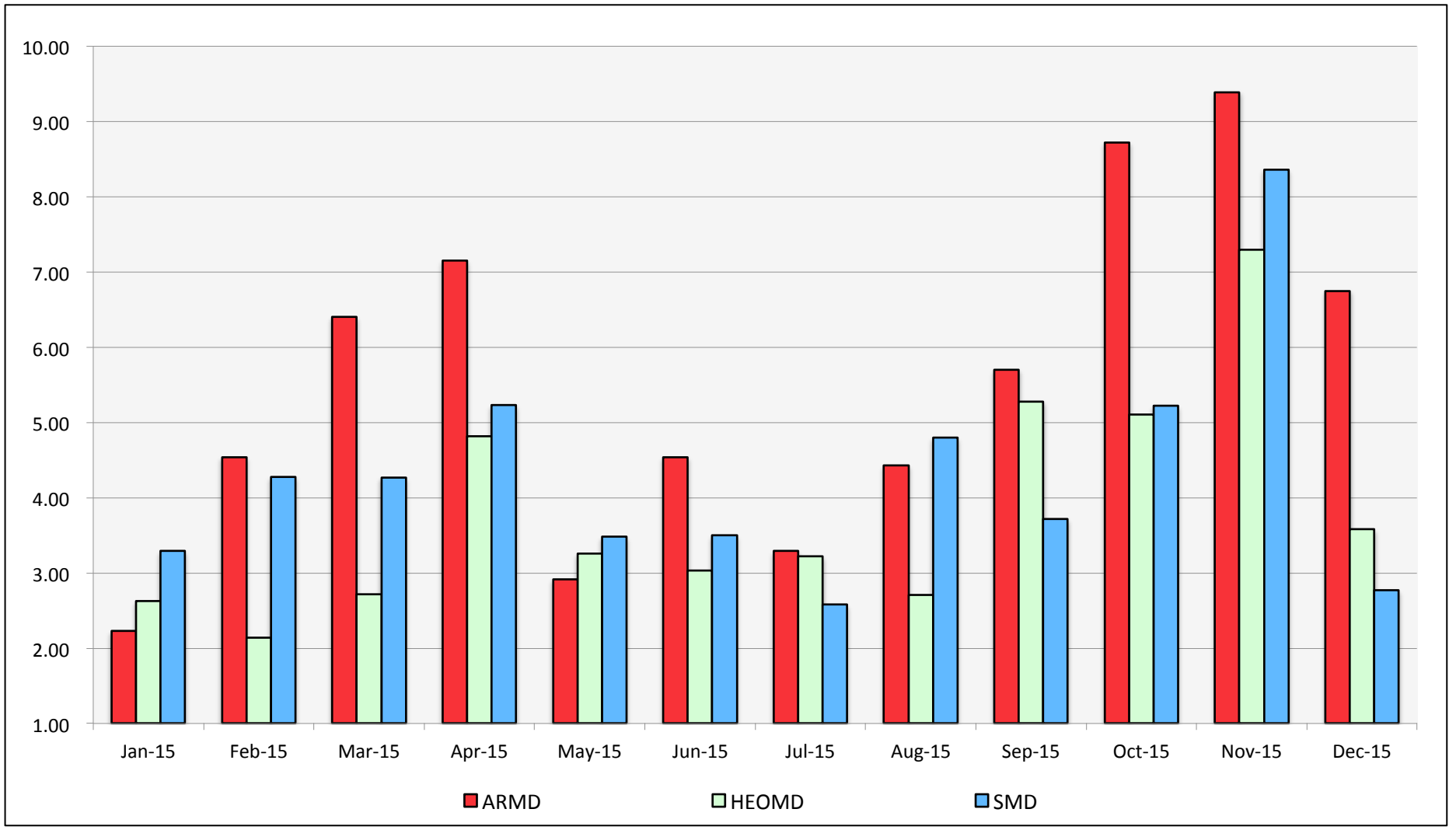
Pleiades:
Monthly Utilization by Size and Length



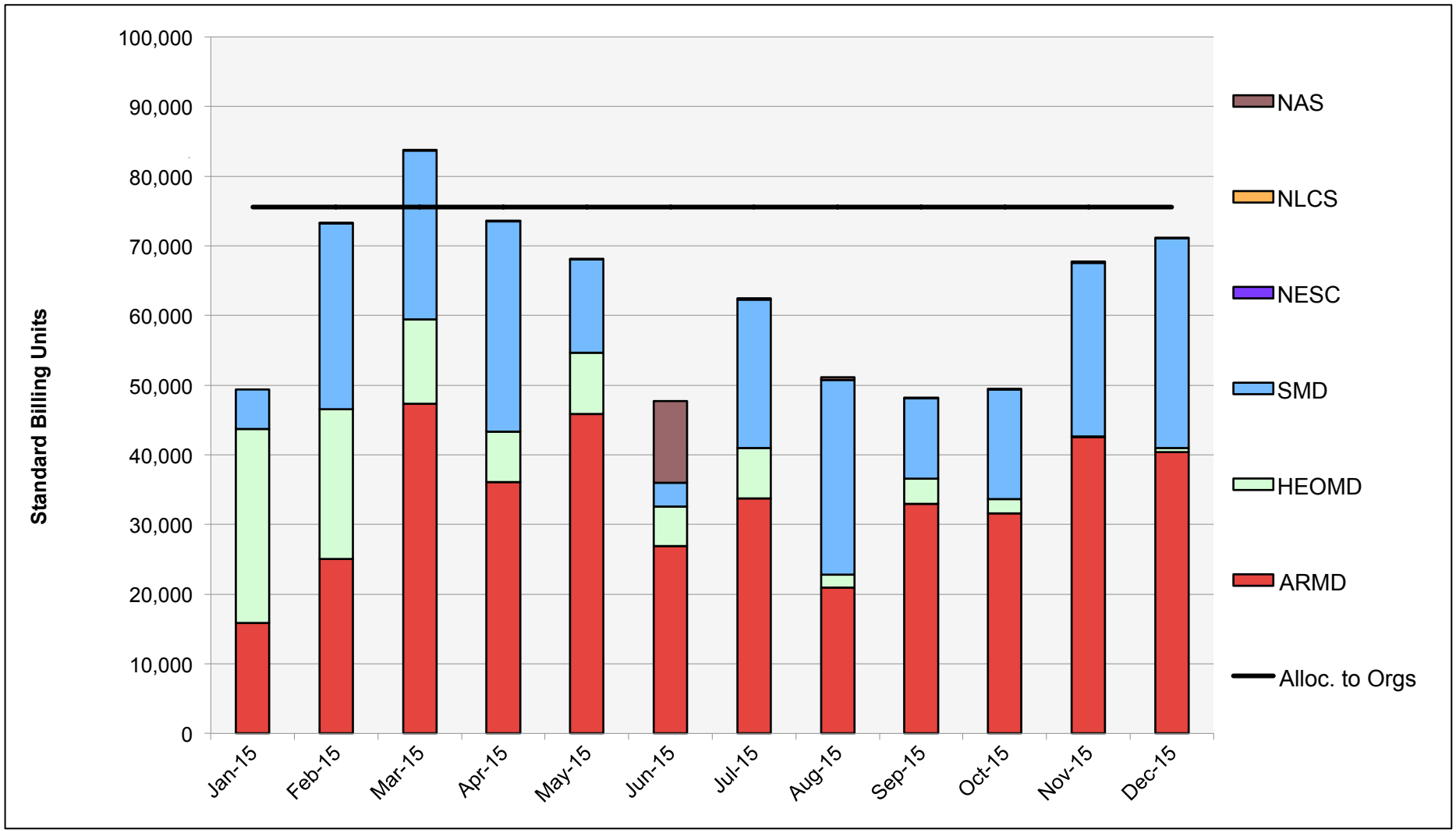
Pleiades:
Average Time to Clear All Jobs



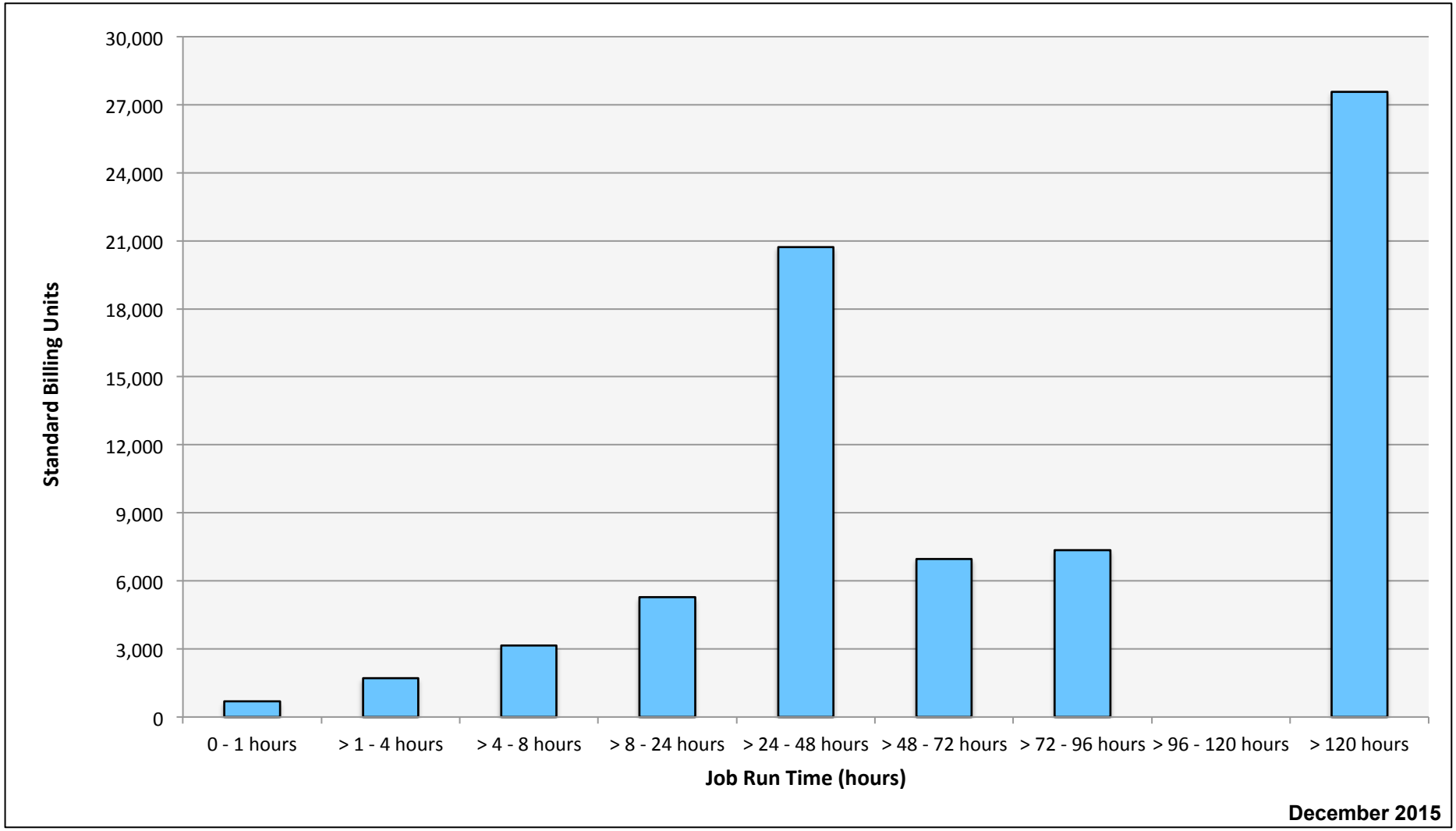
Pleiades:
Average Expansion Factor



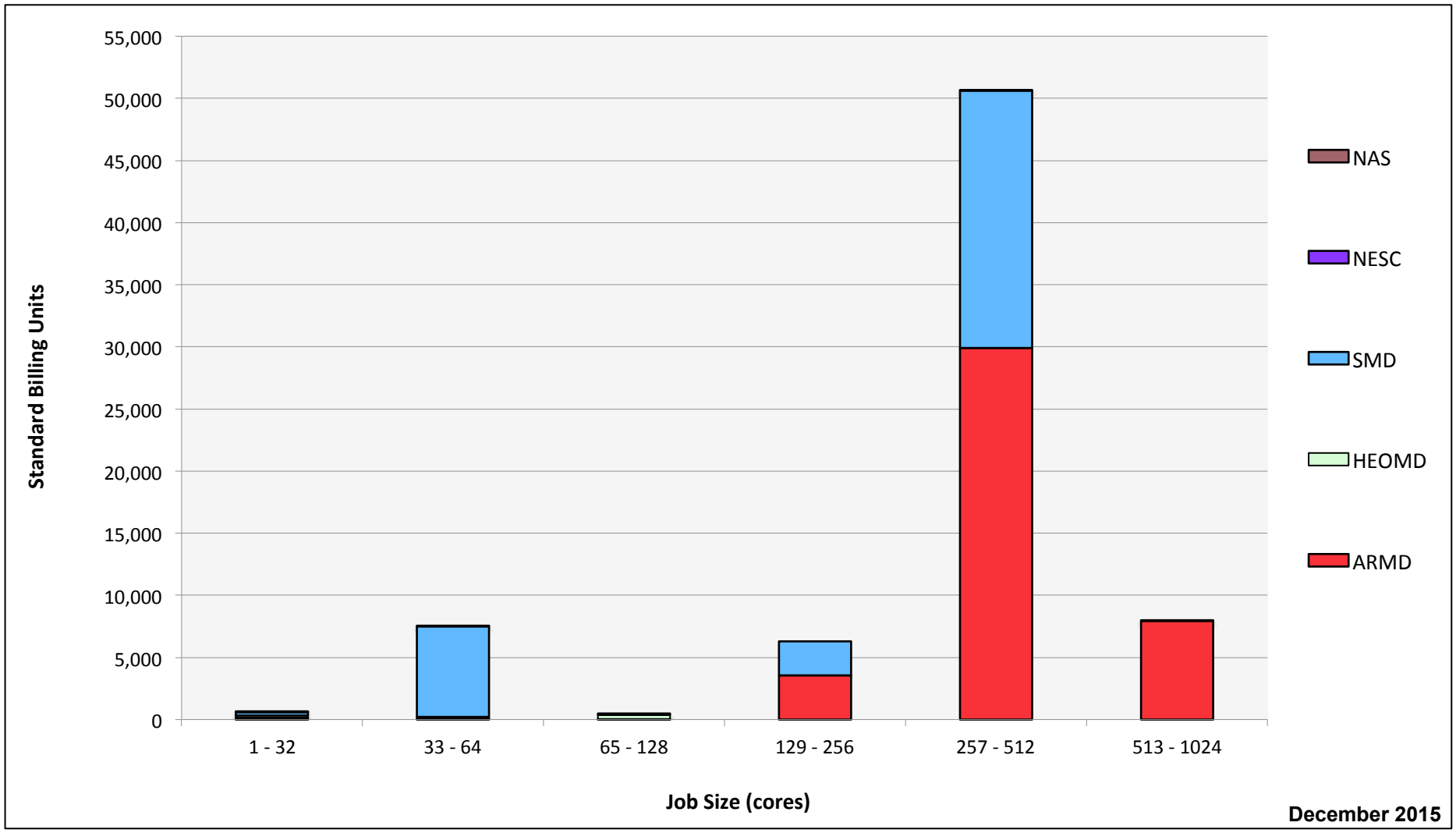
Endeavour:
SBUs Reported, Normalized to 30-Day Month



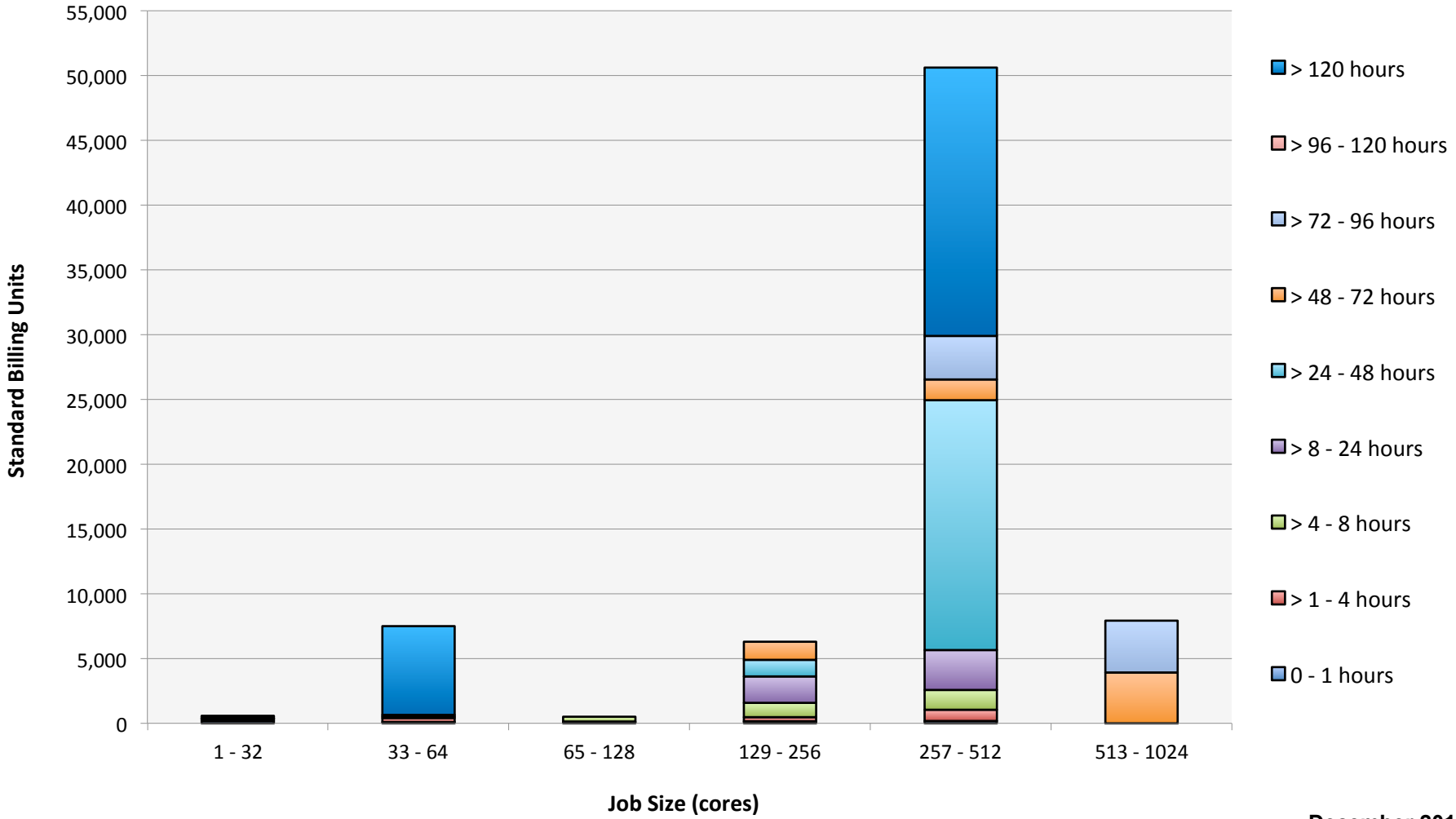
Endeavour:
Monthly Utilization by Job Length



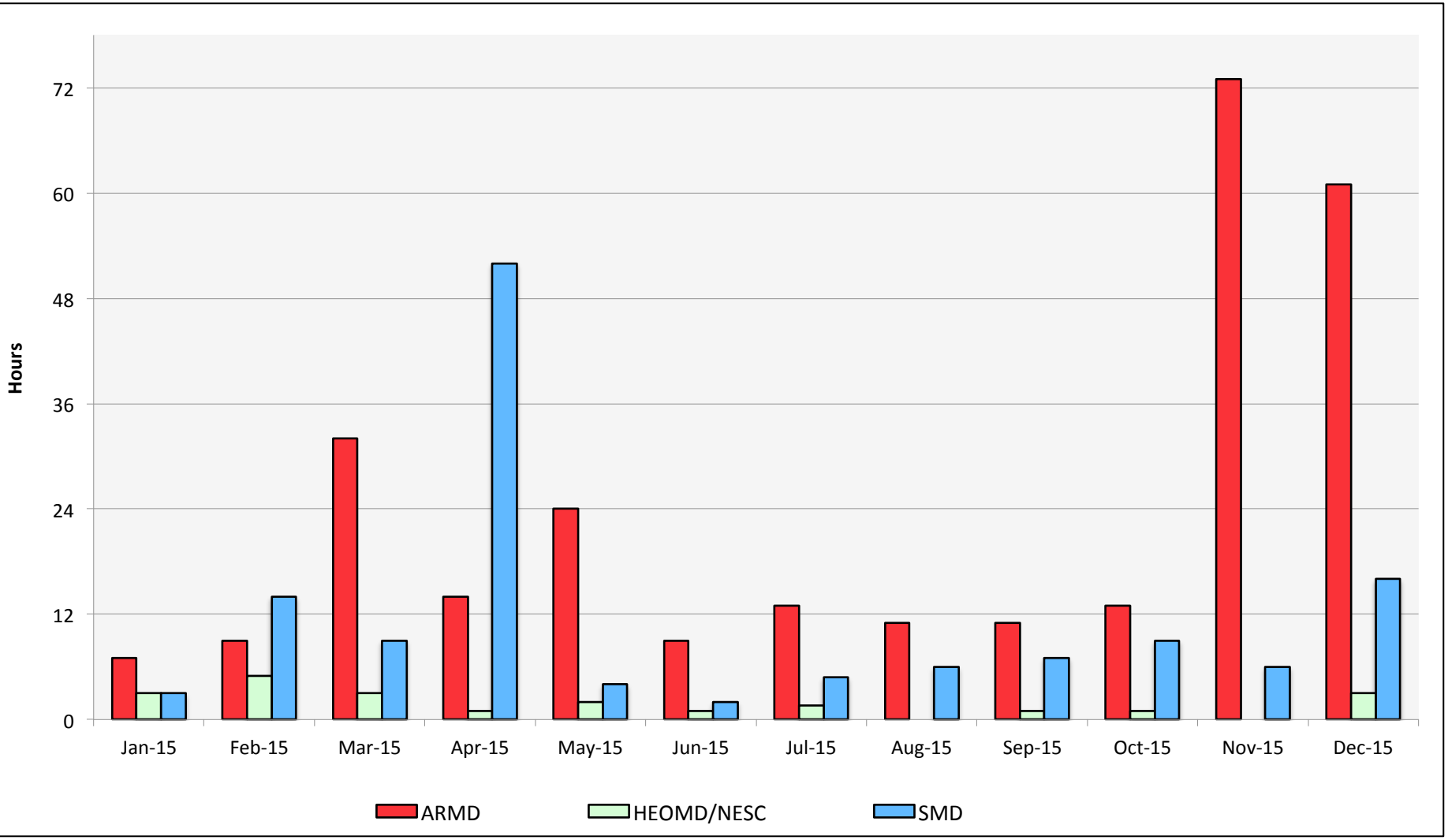
Endeavour:
Monthly Utilization by Size and Mission



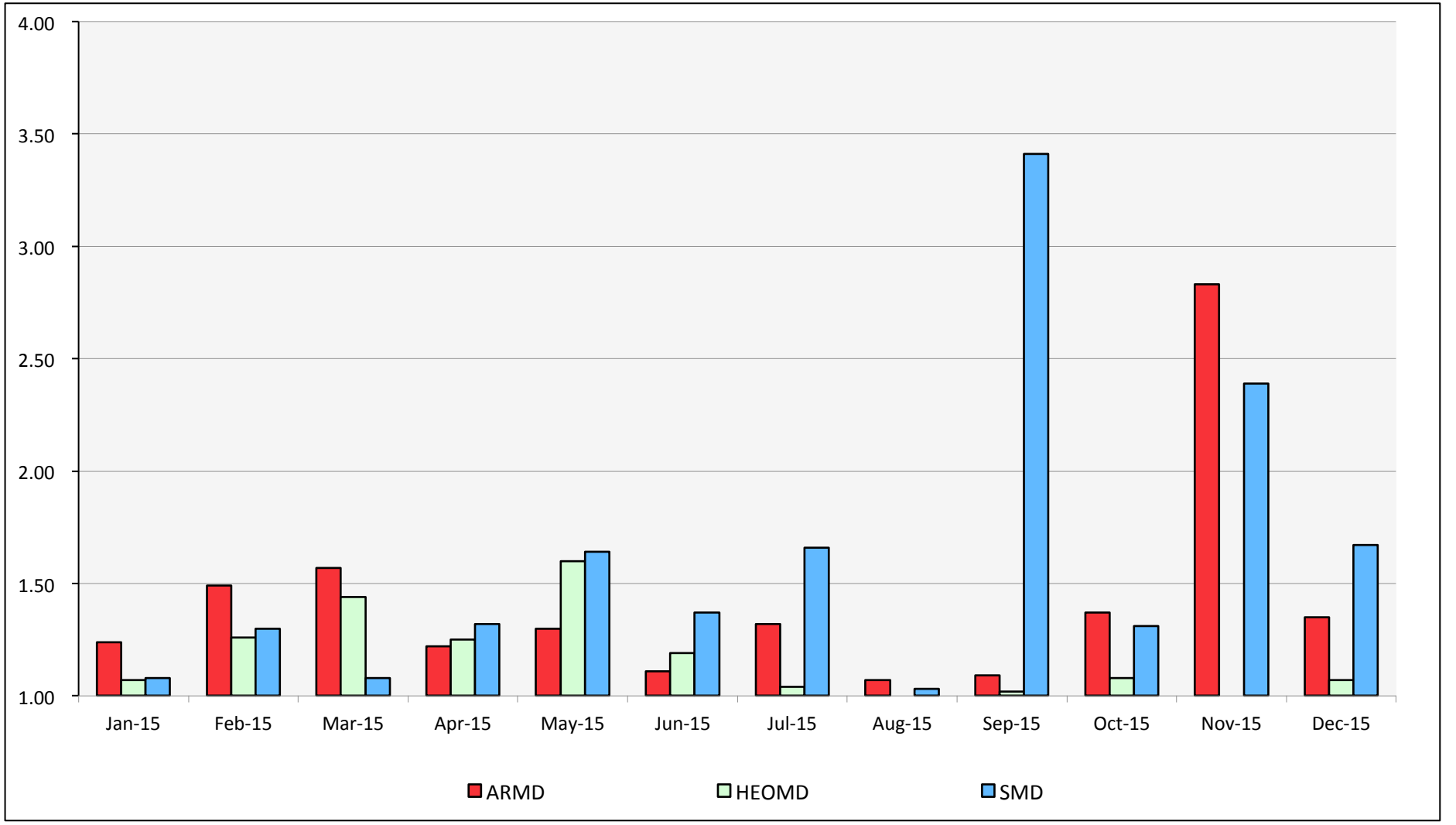
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Monthly Utilization by Size and Length



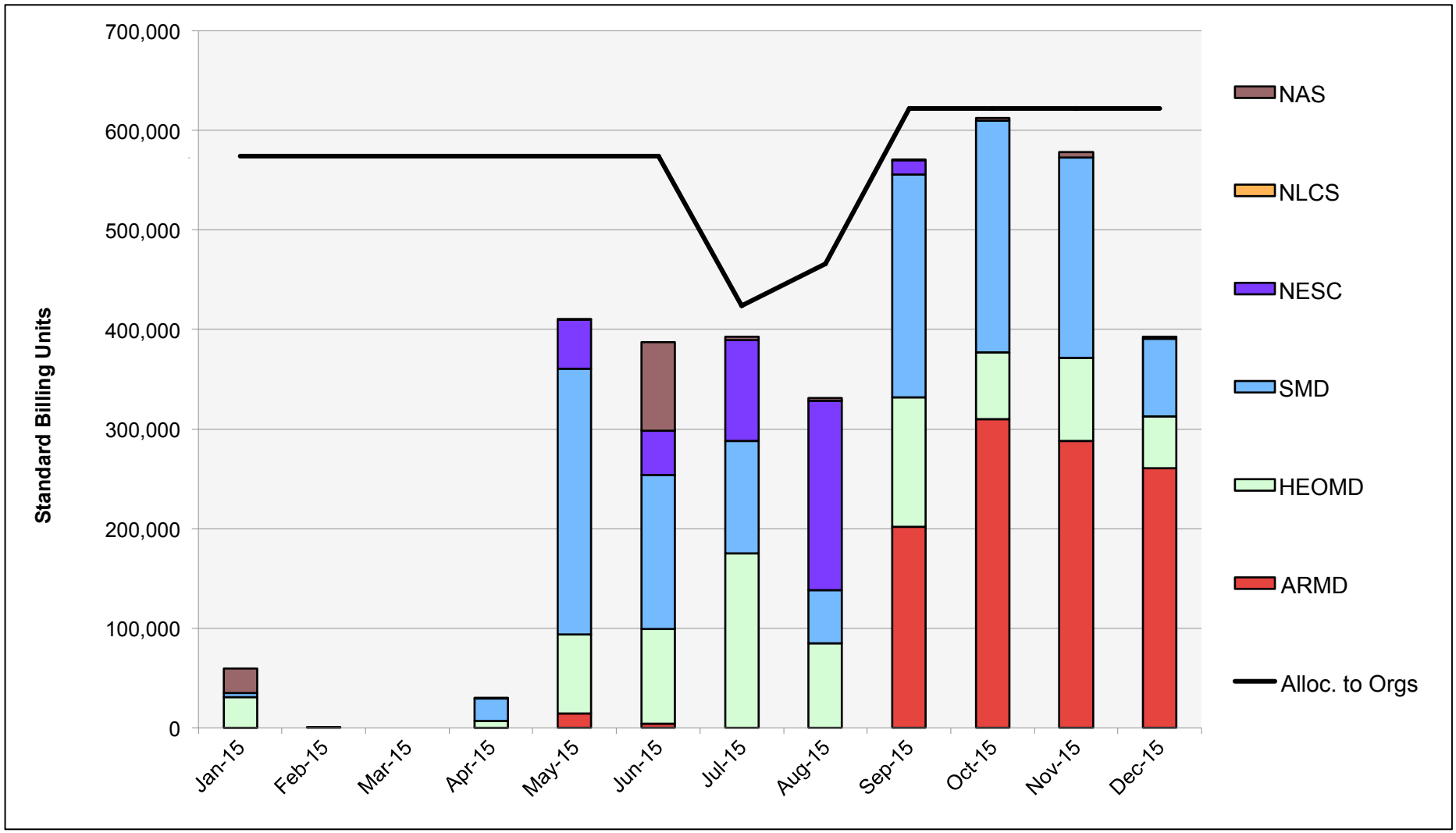
Endeavour:
Average Time to Clear All Jobs



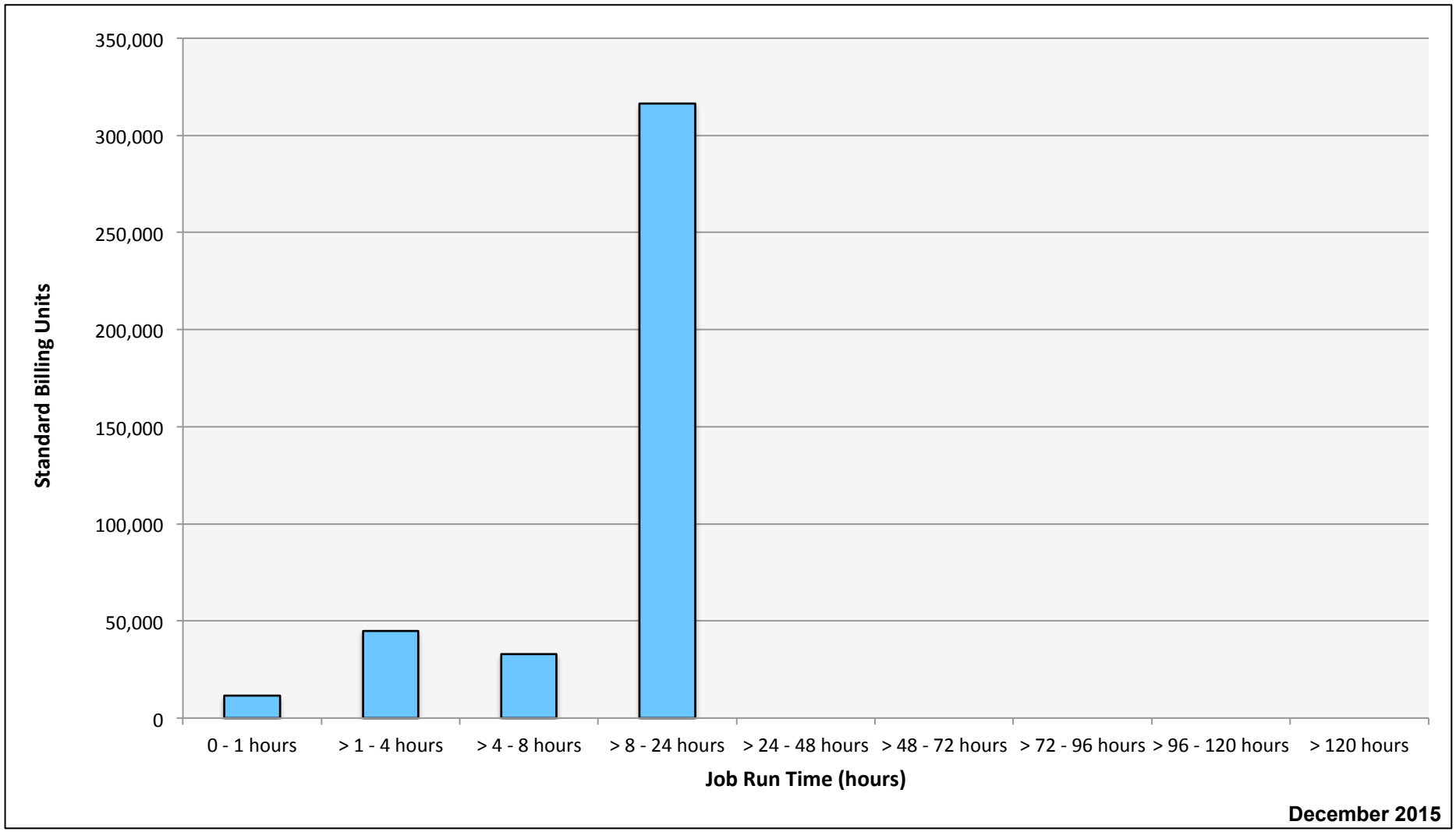
Endeavour:
Average Expansion Factor



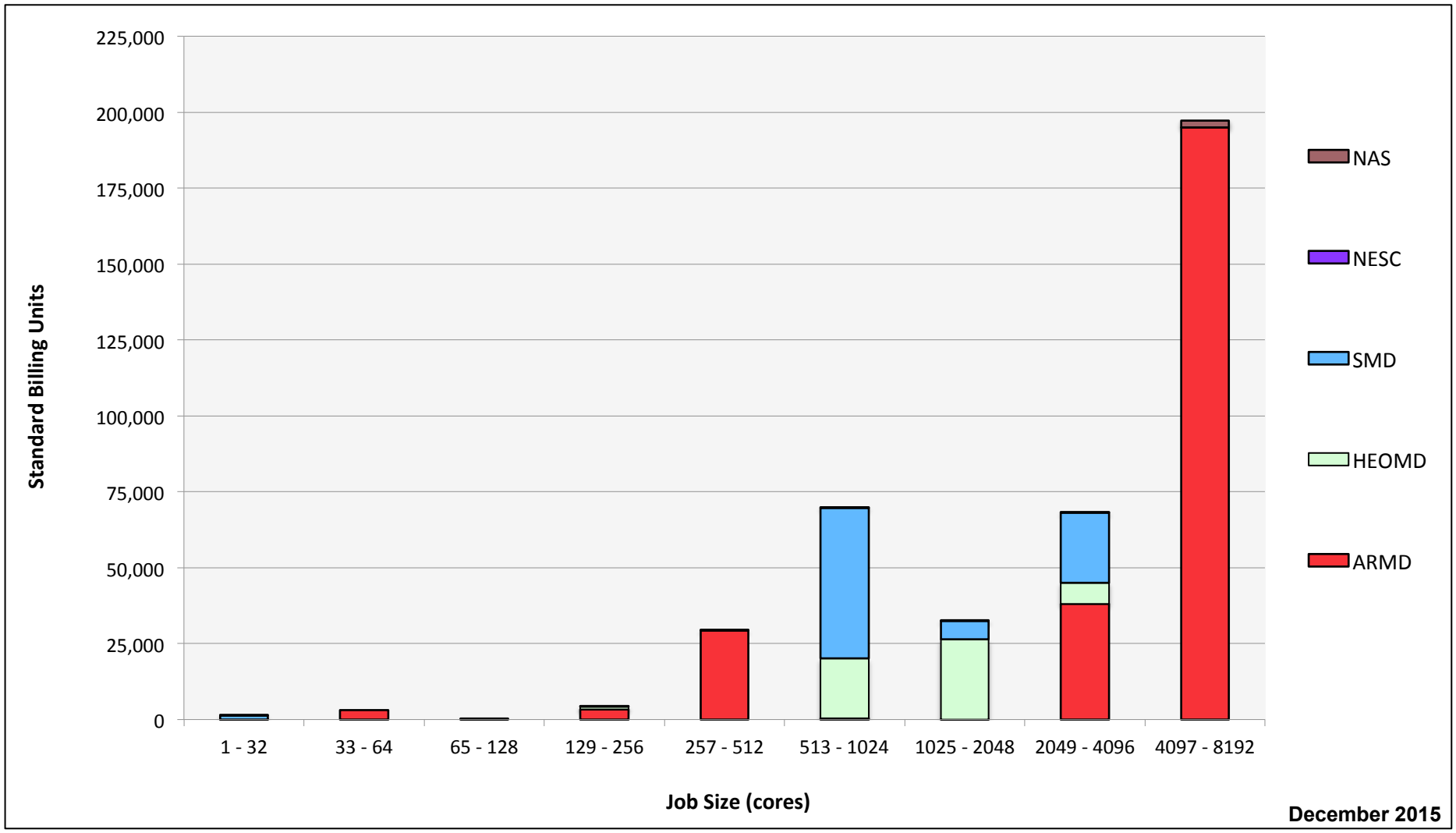
Merope:
SBUs Reported, Normalized to 30-Day Month



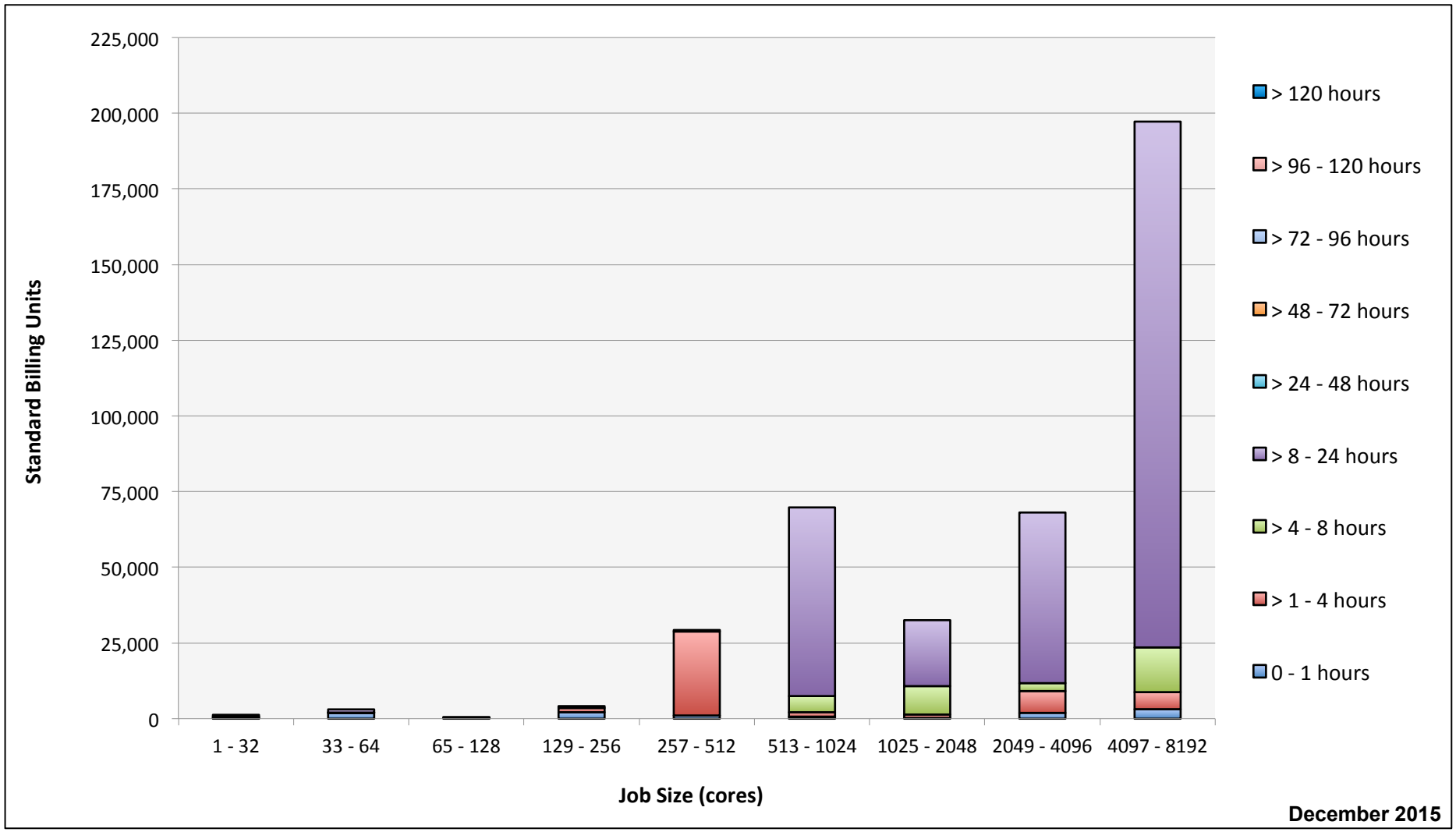
Merope:
Monthly Utilization by Job Length



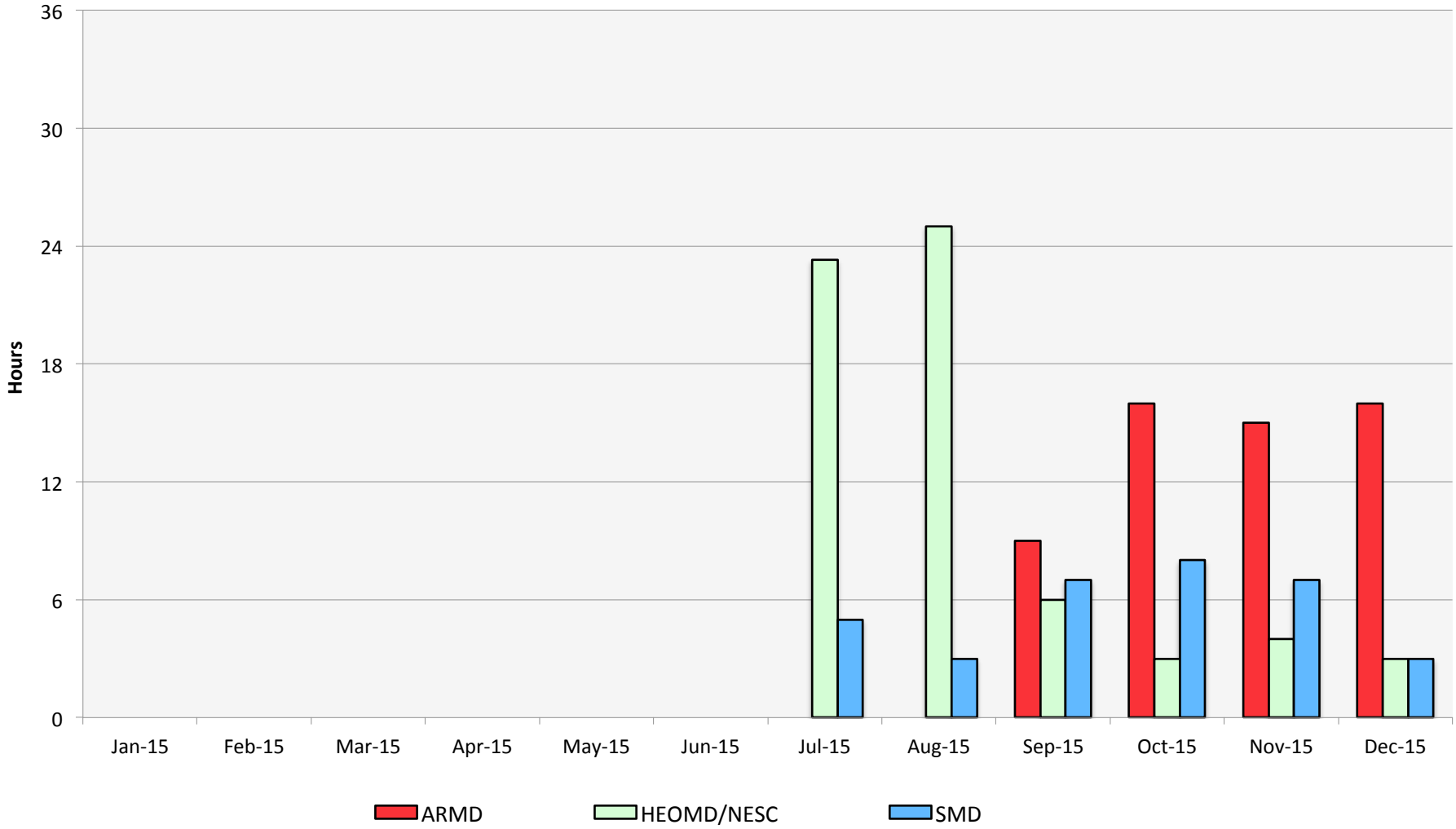
Merope:
Monthly Utilization by Size and Mission



Merope:
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Merope:
Average Time to Clear All Jobs



Merope:
Average Expansion Factor

