Project Status Report

High End Computing Capability
Strategic Capabilities Assets Program

January 10, 2018

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Modular Supercomputing Facility Attains World Class Power Usage Effectiveness

- HECC's Modular Supercomputing Facility (MSF) houses and cools the 4.78-petaflop Electra supercomputer using state-of-the-art technology.
- The MSF's Power Usage Effectiveness (PUE) for FY18 Q1 was 1.029—reported averages for data centers around the world range from 1.8-2.5 PUE.
  - PUE, an established metric for computer center power efficiency is calculated as the (Total Facility Power) ÷ (IT Systems Power).
  - In comparison, the PUE for the primary HECC facility in Building N258 is 1.33; average for other NASA data centers is approximately 1.9.
- The MSF's two modules use different types of cooling technologies.
- Module 1 cools compute nodes directly with outside air. It needs 8 kW of fan power to cool 350 kW of IT, regardless of the outside temperature. Its PUE was 1.026 in the year since deployment (1.024 for FY18 Q1).
- Module 2 cools compute nodes with water cooled by heat exchanger coils on the roof. It averages 14 kW of fan/pump power to cool 440 kW of IT since its deployment in October 2017. Its PUE was 1.032 for FY18 Q1.
- 97% of the power used by the MSF is consumed by the compute nodes (only 3% is needed for housing/cooling).

Mission Impact: The MSF adds computer resources for users and saves energy and money that can be spent on additional resources. Installing computers in the MSF results in $144K in energy savings each year over installing the same resources in the primary supercomputing facility at NASA Ames.

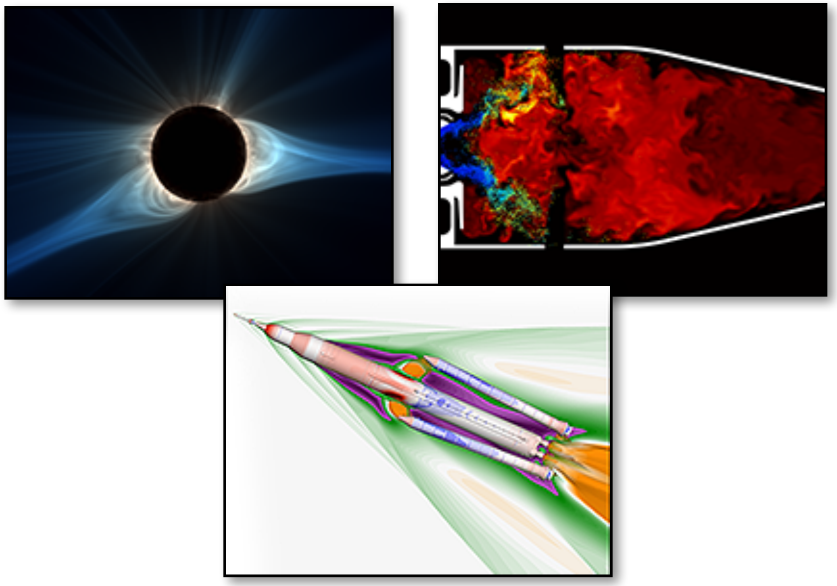
Modules 1 and 2 of the Modular Supercomputing Facility (MSF) are located near the primary HECC facility. The compute nodes in Module 1 are cooled directly with outside air. Adiabatic coolers on the roof of the Module 2 efficiently provide cooling water, via a closed loop, to its compute nodes. - *Photo by Derek Shaw, NASA/Ames*

POC: Chris Tanner, christopher.tanner@nasa.gov, (650) 604-6754, NASA Advanced Supercomputing Division, CSRA LLC

HECC Supercomputer Usage in December 2017 Sets New Record

- In December, the combined usage on HECC supercomputers set a new record of 28,161,309 Standard Billing Units (SBUs*).
- The usage by 310 of NASA's science and engineering groups exceeded the previous record of 28,142,305 SBUs set in Oct. 2017 by 19,004 SBUs.
- The record was unexpected because it was set in spite of relatively light usage (except by the Human Exploration and Operations Mission Directorate) over the holiday season.
- Usage of Pleiades, Electra, Merope, and Endeavour contributed to this record.
- The top 10 projects used between 521,988 and 4,376,411 SBUs, and together accounted for over 43% of the total usage.
- The HECC Project continues to plan and evaluate ways to address the future requirements of NASA's users.

Mission Impact: The increasing capacity of HECC systems provides mission directorates with more resources to accomplish their goals and objectives.



Examples of work done on HECC systems, clockwise from top left: 1) Prediction of the solar corona during the total solar eclipse on Aug. 21, 2017. *C. Downs, Z. Mikić, Predictive Science Inc.;* 2) Snapshot of a model jet engine simulation, highlighting the temperatures (black-red-yellow) within the combustion chamber and the liquid fuel droplets (small dots). *J. Labahn, M. Ihme, Stanford University;* 3) Simulation of SLS Block 1B booster separation flowfield. *J. Meeroff, H. Lee, NASA/Ames*

POC: Catherine Schulbach, catherine.h.schulbach@nasa.gov, (650) 604-3180, NASA Advanced Supercomputing Division

** 1 SBU equals 1 hour of a Pleiades Westmere 12-core node.*

HECC Enhances PBS to Improve Broadwell Scheduling for Pleiades and Electra

- HECC system administrators developed and deployed an enhancement to PBS Pro, the software used to schedule batch jobs on HECC resources, to improve efficiency in scheduling jobs requesting Broadwell processors.
- The new feature enables PBS to automatically select Broadwell nodes on either Pleiades or Electra, depending on which system has the nodes available and can start the job sooner—resulting in faster turnaround time for users.
- Previously, users had to submit jobs requesting Broadwell processors to either Pleiades or Electra specifically, leading to an inefficient distribution of resources that left idle nodes on one system while creating a backlog of jobs on the other.
- Users can still specify either Pleiades or Electra if they choose to.
- With this enhancement, users will no longer need to spend time analyzing the queues on Electra and Pleaides to figure out where they can get the best turnaround time for their jobs.

Mission Impact: Enhancing HECC batch scheduling software improves utilization of NASA's high-performance computing resources and decreases turnaround time for engineers and scientists working on agency missions.

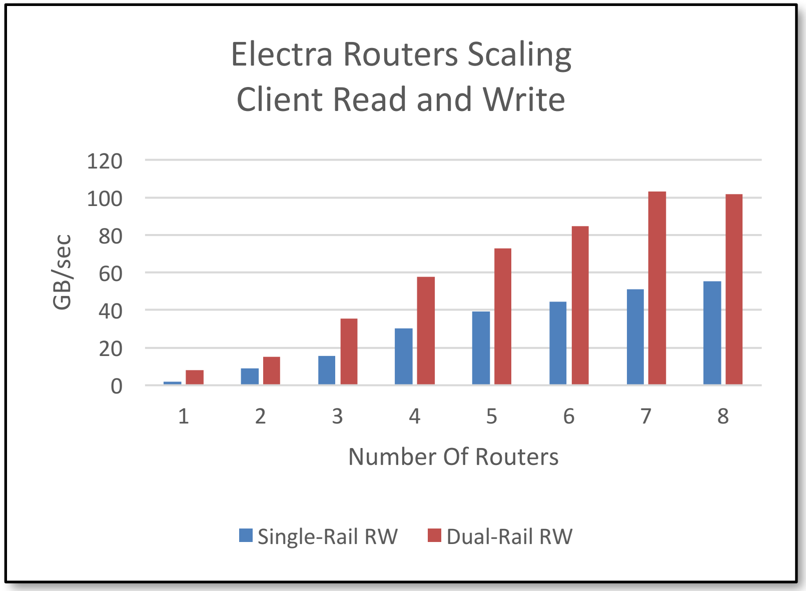
Improvements to the batch job scheduler used by HECC resources increase efficient utilization of NASA's Pleiades (shown) and Electra supercomputers.

POCs: Bob Ciotti, bob.ciotti@nasa.gov, (650) 604-4408, NASA Advanced Supercomputing (NAS) Division;
Davin Chan, davin.chan@nasa.gov, (650) 604-3613, NAS Division, CSRA LLC

Supercomputer Systems Team Deploys Multi-Rail Lustre Routers to Increase Performance For Users

- HECC system administrators recently deployed multi-rail Lustre routers for the Electra supercomputer in order to increase the I/O bandwidth and resiliency of HECC's Lustre filesystems.
- Multi-rail networking is a new feature that allows the use of multiple InfiniBand cards to increase available bandwidth, with the intent to improve the performance of Lustre clients with multiple interfaces.
- HECC administrators developed an innovative way to utilize this feature to improve the bandwidth of Lustre routers without actually increasing the number of routers required.
- Another benefit of using the multi-rail configuration is that it makes connectivity between Electra, housed in the MSF, and the I/O subsystem, located in building N258, more resilient to failures that may occur with the long-distance InfiniBand connections.

Mission Impact: Through an innovative use of Lustre features, HECC teams increased the I/O bandwidth between Electra and the HECC Lustre filesystems, improving performance for scientists and engineers working on NASA projects.



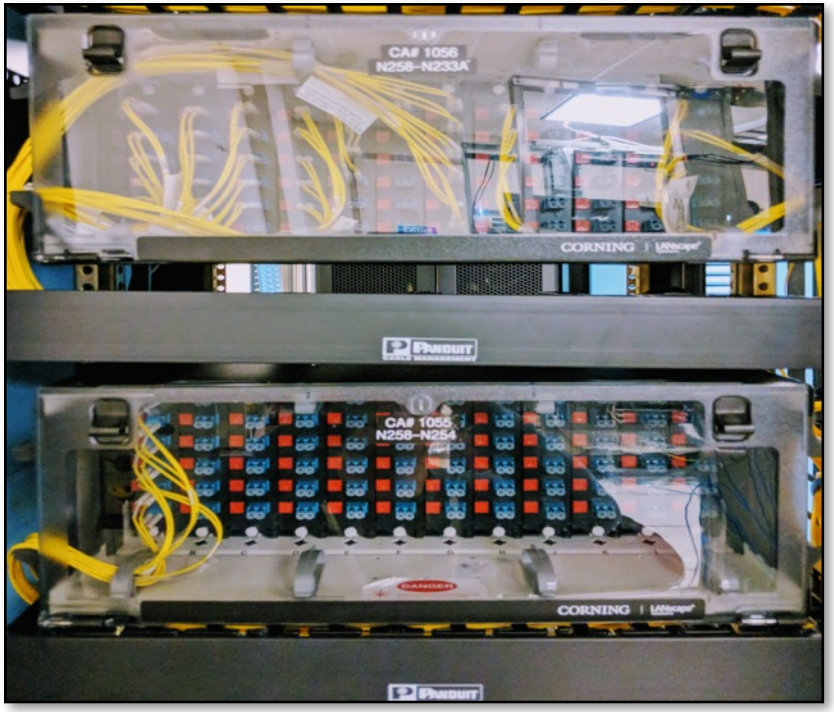
Using dual-rail networking (two InfiniBand interfaces) doubles the available bandwidth when compared to a single-rail configuration.

POCs: Bob Ciotti, bob.ciotti@nasa.gov, (650) 604-4408, NASA Advanced Supercomputing (NAS) Division;
Davin Chan, davin.chan@nasa.gov, (650) 604-3613, NAS Division, CSRA LLC

Networking Team Completes Major Fiber Migration Project

- The HECC Networking team coordinated with NASA Ames network engineers to complete a major fiber migration to a new Ames inter-building cable plant.
- The network fiber connects three different HECC buildings on the Ames campus. Work included:
  - Transitioned to two new 144-strand, single-mode fiber cables that connect N258 to N254.
  - Transitioned to one new 144-strand, single-mode fiber cable that connects N258 to N233A.
- The primary purpose for the transition was to address cables running across the property that Google leases from NASA through a man-hole scheduled for demolition.
- The Ames cable plant team pulled replacement cables, each carrying 144 strands, through a new conduit system to each building.
- The Networking team worked with the HECC Supercomputer Systems team to migrate all single-mode fiber links from the old to new fiber patch panels, with minimal impact to HECC users.

Mission Impact: Through extensive planning and pre-work, the HECC Networking team completed a transition of virtually all inter-building fiber connections with minimal impact to users.



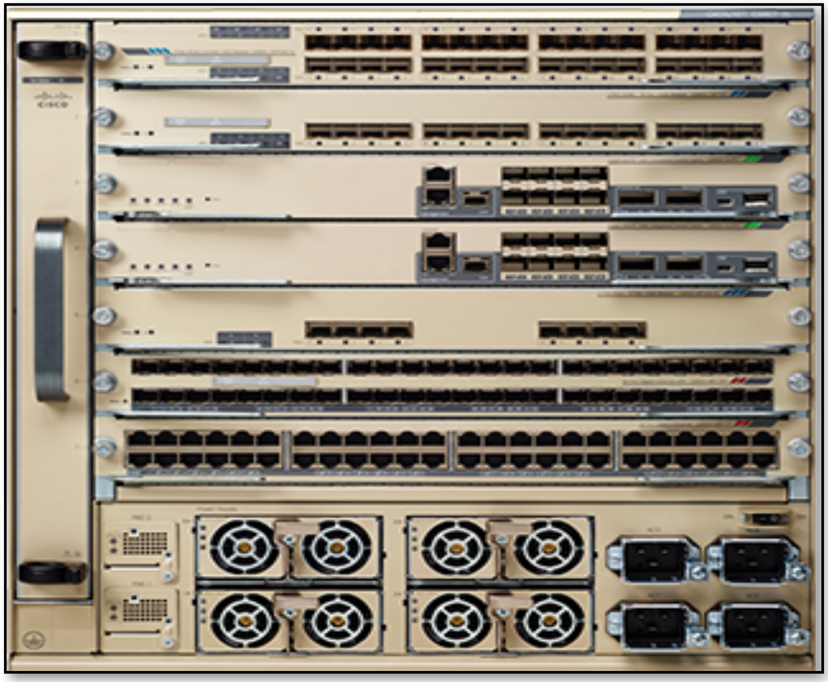
Two new patch panels in building N258 connecting the new NAS network infrastructure to buildings N254 and N233A at Ames.

POC: Chris Buchanan, chris.buchanan@nasa.gov, (650) 604-4308, NASA Advanced Supercomputing Division, CSRA LLC

Networking Team Completes Cisco IOS Upgrades in Key Areas of NASLAN

- The Networking team completed Cisco IOS upgrades to the NASLAN border, DMZ, and two core switches.
- The upgrades applied bug fixes and security patches to critical components of the NASLAN infrastructure.
- Networking team engineers coordinated with HECC Supercomputer Systems engineers, desktop support staff, and the User Services and Security teams to ensure the upgrade had minimal impact on overall operations.
- Prior to the upgrade, the team completed planning and testing of the new IOS to ensure it was stable.
- The Networking team is now investigating improvements to the NASLAN infrastructure to reduce and/or eliminate user impact during future maintenance work.

Mission Impact: HECC Networking team engineers coordinated with all affected groups to ensure these upgrades were completed with minimal impact to the HECC user community.



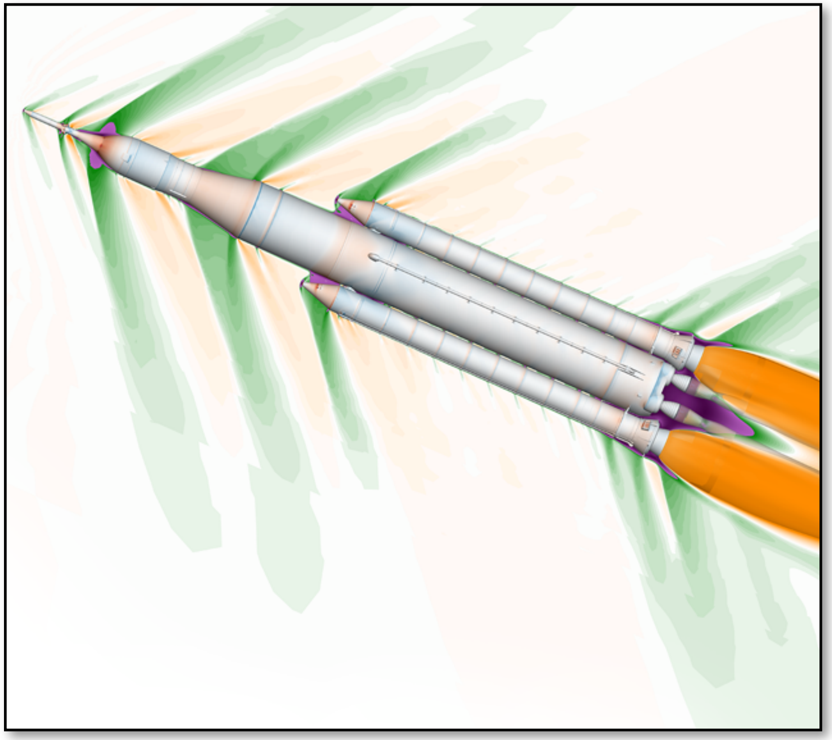
A Cisco 6807, which we use at the border, DMZ, and core of HECCC/NASLAN.

POCs: Ray Gilstrap, ray.gilstrap@nasa.gov, (650)-604-3844, NASA Advanced Supercomputing (NAS) Division;
Chris Buchanan, chris.buchanan@nasa.gov, (650) 604-4308, NAS Division, CSRA LLC

HECC Experts Improve Throughput for Space Launch System Simulations

- HECC performance engineering experts actively monitor the efficiency of large, ongoing computational projects on HECC systems to help improve job performance.
- Recently, when monitoring the output for scientists using NASA's OVERFLOW code to build a database for the Space Launch System—in a particular series of calculations using the adaptive feature of OVERFLOW—our experts detected that the adaption process was very time-consuming.
- They suggested decreasing the frequency of adaption, and the implementation resulted in at least a factor of 2 speedup, saving the project between 3 and 4 million SBUs over a two-month period alone.
- This savings is significant: over the life of the project, scientists have created and will continue to create aerodynamic databases to analyze different SLS vehicle designs (see slide 12.)

Mission Impact: HECC workflow optimization experts enable faster development of a critical CFD database for design of the Space Launch System.



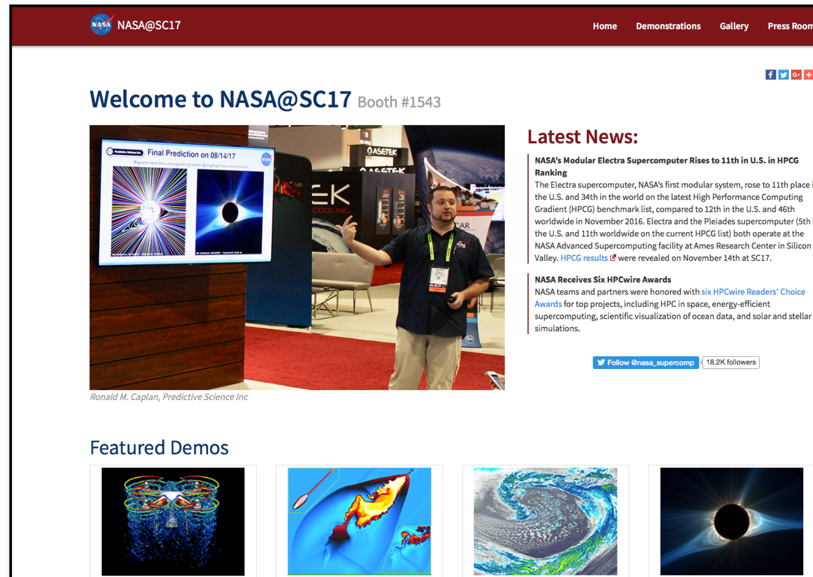
SLS Block 1 ascent flowfield simulated using NASA's OVERFLOW code.
Derek Dalle, Henry Lee, NASA/Ames

POC: Dennis Jespersen, dennis.jespersen@nasa.gov, (650) 604-6742, NASA Advanced Supercomputing (NAS) Division

Tools Team Provides Support and Automation for HECC Applications and Websites

- The HECC Tools team develops and supports applications, web tools, and databases that help to automate processes for our HECC team and users. Recent work includes:
  - Continued improvements to the HECC and HEC monthly accounting reports, by automating the ongoing setup of the report files and streamlining the addition and deletion of processors and nodes used in calculations.
  - Development and maintenance of the SC17 website for NASA.
  - Continued development of and enhancements to the myNAS website to provide new user features.
  - Upgrade of Oracle Enterprise Manager to improve ongoing maintenance of HECC databases.
- New developments in progress include:
  - MicroStrategy upgrade to provide better performance and new features.
  - Special Access website for requesting elevated privileges based on HECC systems.
  - Remedy upgrade to include Smart IT for simpler incident management.
  - Acctdb software update to improve performance.
  - Remedy workflow for travel request approval.

Mission Impact: Automating important aspects of HECC applications, web tools, and reports provides NASA users with enhanced HECC accounting and processes on the myNAS website, and more time for mission-specific work.



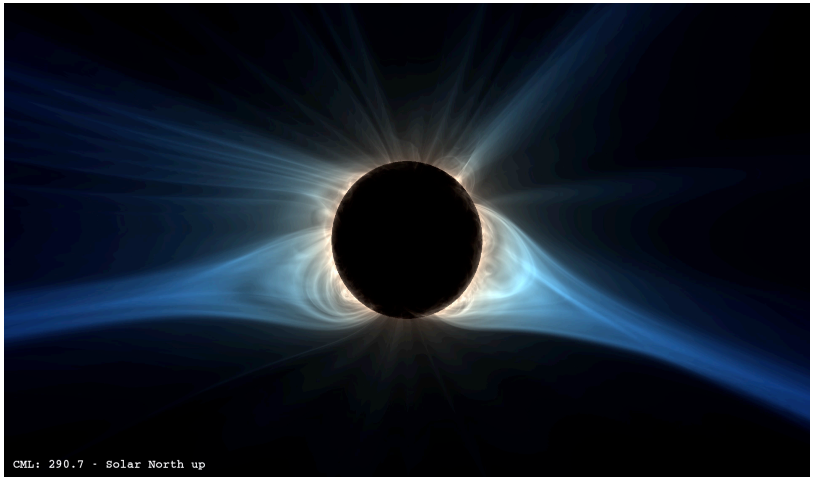
The NASA@SC17 website showcased the agency's latest supercomputing-enabled science and engineering results presented in the NASA booth, along with news announcements and a gallery of spectacular scientific images and videos.

POC: Mi Young Koo, mi.y.koo@nasa.gov, (650) 604-4528, NASA Supercomputing Division, CSRA LLC

Using Modeling and Simulation to Predict the Corona of the 2017 Total Solar Eclipse

- Scientists successfully predicted how the Sun's corona would look during the August 21, 2017 total solar eclipse, by using innovative modeling and computational methods on Pleiades.
- The prediction represents one of the largest and most ambitious global corona simulations to date.
  - Resistive, thermodynamic, magnetohydrodynamic equations were used to simulate the global corona, with observations of the solar surface magnetic field as a boundary condition.
  - The researchers implemented new methods, including a wave-turbulence-driven coronal heating model and energization of the magnetic field via inserted flux ropes along filament channels.
  - The simulation ran for 60 wall-clock hours—about as long as the time period simulated. This ability to run in near-real-time paves the way for continually running models that routinely ingest observations.
- The scientists are collaborating with others to quantitatively compare the simulation with observations, which will help interpret the complex data obtained during the eclipse.

Mission Impact: Made possible by HECC resources, this work helps pave the way for the development of continually running models that routinely ingest observations—highly beneficial for solar modeling and space weather studies. The prediction was used for observational planning purposes prior to the eclipse by some NASA-supported experiments.



Prediction of the solar corona during the August 21, 2017 total solar eclipse. This video is a from a composite volume rendering of the magnetic squashing factor (with radial and sky-plane weightings). The squashing factor is sensitive to non-uniformities in the magnetic field and highlights the inherent complexity of the corona.

POCs: Ronald Caplan, caplanr@predsci.com, (858) 225-2314, Cooper Downs, cdowns@predsci.com, (858) 225-2312, Predictive Science Inc.

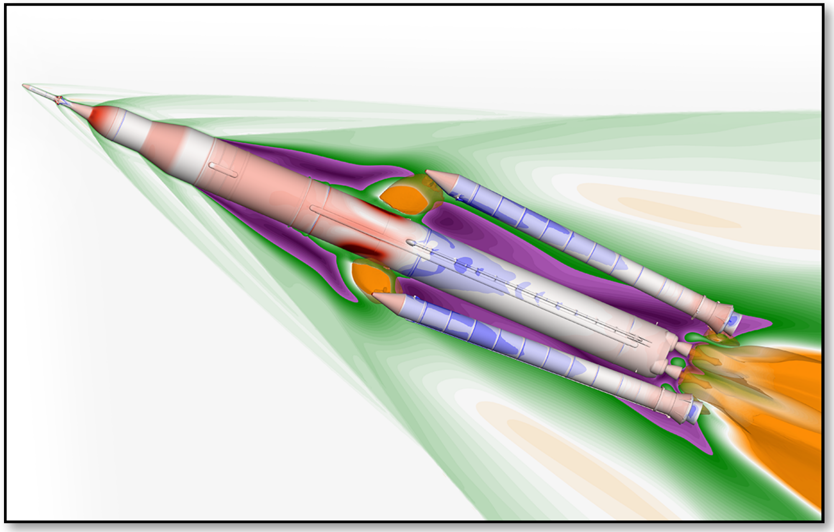
HECC provided supercomputing resources and services in support of this work.

Progress in Building Aerodynamic Databases to Support the SLS Design Process

- Researchers at NASA Ames use CFD simulations to build aerodynamic databases supporting the SLS design process, to quantify aerodynamic forces on the vehicle from ascent through booster separation.
- The team has created multiple aerodynamic databases that engineers require during the SLS design process, including:
  - Distributed line loads used in structural analysis: surface pressures used in venting and other dynamic analysis.
  - Protuberance aerodynamic loads used in the design.
  - Forces and moments on the vehicle during booster separation used to verify the booster-separation system.
- The team also succeeded in verifying the accuracy of the computational aerodynamic simulations for the uncrewed Exploration Mission-1 vehicle.
- About 8,100 FUN3D simulations and 900 OVERFLOW simulations (total of 55 million core hours) were used to build the various databases.
- In the coming year, the team expects to produce an unprecedented amount of aerodynamic data for the Block 1B crew and cargo vehicles, and to produce eight separate aerodynamic databases.

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

Mission Impact: The continued growth of HECC computational resources and capabilities makes it feasible to use more CFD simulations and rely less on data from expensive wind tunnel tests for aerodynamic databases that are critical in ensuring a successful SLS launch.



SLS Block 1B booster separation flowfield simulated using NASA's FUN3D code. The vehicle surface is colored by pressure contours (blue is low, red is high.) The background slice shows local velocity and highlights shockwaves (green); the isosurface show the engine and booster separation motor plumes (orange). *Jamie Meeroff, Henry Lee, NASA/Ames*

POCs: Henry Lee, henry.c.lee@nasa.gov, (650) 604-3689;
Stuart Rogers, stuart.rogers@nasa.gov, (650) 604-4481, NASA Advanced Supercomputing Division

HECC Facility Hosts Several Visitors and Tours in December 2017

- HECC hosted 5 tour groups in December; guests learned about the agency-wide missions being supported by HECC assets, and some groups also viewed the D-Wave 2X quantum computer system. Visitors this month included:
  - A group of corporate leaders from the Haas School of Business, at the University of California, Berkeley.
  - Horst Simon, Deputy Director for Research at the Lawrence Berkeley National Laboratory.
  - Cheolho Lim and Kwanghyeok Ju from the Korea Aerospace Research Institute.
  - A small group from the Vinnova Silicon Valley Office, located at Stanford University, visited Ames for a site tour; guests included Anne Lidgard, Director; Henric Johnson, Professor in Computer Science and Senior Vinnova Wallenberg Fellow; and Anders Nilsson and Jakob Broman, Senior Vinnova Wallenberg Fellows.
  - A large group of NASA Early Career Program attendees from NASA Jet Propulsion Laboratory and SpaceX, who visited Ames for a site tour.

NAS Division Computational Aerosciences Branch Chief Cetin Kiris gave a hyperwall presentation and tour of the supercomputing facility to a group of corporate leaders from the Haas School of Business, at the University of California Berkeley.

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

Papers

- "**A JavaScript API for the Ice Sheet System Model (ISSM) 4.11: Towards and Online Interactive Model for the Cryospheric Community**," E. Larour, et al., Geoscientific Model Development, December 4, 2017. *
  https://www.geosci-model-dev.net/10/4393/2017/gmd-10-4393-2017.pdf
- "**Three-Dimensional General-Relativistic Magnetohydrodynamic Simulations of Remnant Accretion Disks from Neutron Star Mergers: Outflows and r-Process Nucleosynthesis**," D. Siegel, B. Metzger, Physical Review Letters, 119, December 6, 2017. *
  https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.119.231102
- "**Numerical Analysis on Mixing Processes for Transcritical Real-Fluid Simulations**," P. Ma, H. Wu, D. Banuti, M. Ihme, arXiv:1712.02431 [physics.flu-dyn], December 6, 2017. *
  https://arxiv.org/abs/1712.02431
- "**Direct Numerical Simulations of Turbulent Channel Flow Under Transcritical Conditions**," P. Ma, X.Yang, M. Ihme, arXiv:1712.02430 [physics.flu-dyn], December 6, 2017. *
  https://arxiv.org/abs/1712.02430
- "**The Importance of Vertical Resolution in the Free Troposphere for Modeling Intercontinental Plumes**," J. Zhuang, D. Jacob, S. Eastham, Atmospheric Chemistry and Physics: Discussions, December 8, 2017. *
  https://www.atmos-chem-phys-discuss.net/acp-2017-1124/acp-2017-1124.pdf
- "**Probability Density Function Characterization for Conditional Source-term Estimation in High-Pressure Combustion**," N. Christopher, et al., German Aerospace Center (DLR) Electronic Library, December 8, 2017. *

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

Papers (cont.)

- “**Electron Heating in Low Mach Number Perpendicular Shocks. II. Dependence on Pre-Shock Conditions**,” X. Guo, et al., arXiv:1712.03239 [astro-ph.HE], December 8, 2017. *
  https://arxiv.org/abs/1712.03239
- “**SCORCH. II. Radiation-Hydrodynamic Simulations of Reionization with Varying Radiation Escape Fractions**,” A. Doussot, et al., arXiv:1712.04464 [astro-ph.CO], December 12, 2017. *
  https://arxiv.org/abs/1712.04464
- “**Influence of Stellar Radiation Pressure on Flow Structure in the Envelope of Hot-Jupiter HD 209458b**,” A. Cherenkov, et al., Monthly Notices of the Royal Astronomical Society, December 14, 2017. *
  https://academic.oup.com/mnras/advance-article-abstract/doi/10.1093/mnras/stx3230/4743747
- “**A Joint Probability Density-Based Decomposition of Turbulence in the Atmospheric Boundary Layer**,” M. Chinita, et al., AMS Monthly Weather Review, December 15, 2017. *
  http://journals.ametsoc.org/doi/abs/10.1175/MWR-D-17-0166.1
- “**The Vertical Dust Profile Over Gale Crater, Mars**,” S. Guzewich, et al., Journal of Geophysical Research: Plants, December 19, 2017. *
  http://onlinelibrary.wiley.com/doi/10.1002/2017JE005420/full
- “**Recovery Schemes for Primitive Variables in General-Relativistic Magnetohydrodynamics**,” D. Siegel, P. Mösta, D. Desai, S. Wu, arXiv:1712.07538 [astro-ph.HE], December 20, 2017. *
  https://arxiv.org/abs/1712.07538
- “**Dynamics of Trees of Fragmenting Granules in the Quiet Sun: Hinode/SOT Observations Compared to Numerical Simulation**,” J.-M. Malherbe, et al., Solar Physics, December 21, 2017. *
  https://link.springer.com/article/10.1007/s11207-017-1225-x

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

Papers (cont.)

- "**Mesoscopic Modeling of Structural Self-Organization of Carbon Nanotubes into Vertically Aligned Networks of Nanotube Bundles**," B. Wittmaack, et al., Carbon, December 20, 2017. *
  https://www.sciencedirect.com/science/article/pii/S0008622317313118
- "**Simulation-Based Height of Burst Map for Asteroid Airburst Damage Prediction**," M. Aftosmis, D. Matthias, A. Tarano, Acta Astronautica, December 23, 2017. *
  https://www.sciencedirect.com/science/article/pii/S0094576517315229

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

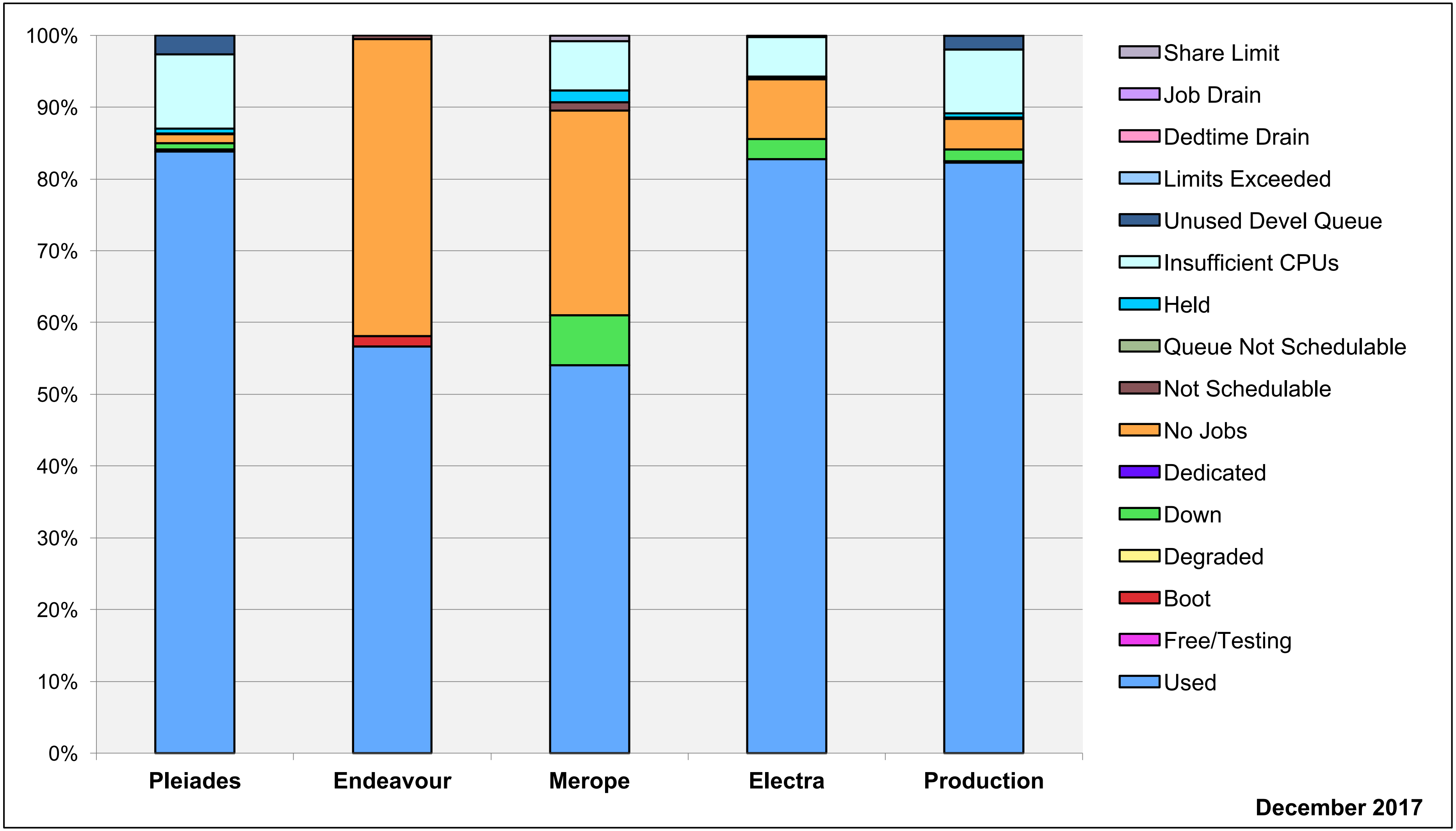
Presentations

- **AGU Fall Meeting, New Orleans, LA, December 11-15, 2017.**
  - “**Advances in Observations, Data-Constrained Modeling, and Predictions of Solar Activity from the Deep Interior to the Corona I-II**,” I. Kitiashvili, et al.
  - ”**Solar Activity Across the Scales: From Small-Scale Quiet-Sun Dynamics to Magnetic Activity Cycles**,” I. Kitiashvili, A Wray, N. Mansour, et al.
  - “**Very High Resolution Tree Cover Mapping for Continental United States Using Deep Convolutional Neural Networks**,” S. Ganguly, R. Nemani, et al.
  - “**Land Monitoring from a New Generation of Geostationary Satellite Sensors**,” R. Nemani, et al.
  - “**Evaluation of Terrestrial Carbon Cycle with the Land Use Harmonization Dataset**,” T. Sasai, R. Nemani.
  - “**DeepSAT’s CloudCNN: A Deep Neural Network for Rapid Cloud Detection from Geostationary Satellites**,” S. Kalia, S. Ganguly, R. Nemani, et al.
  - “**Linear Subpixel Learning Algorithm for Land Cover Classification from WELD Using High Performance Computing**,” U. Kumar, S. Ganguly, R. Nemani, et al.

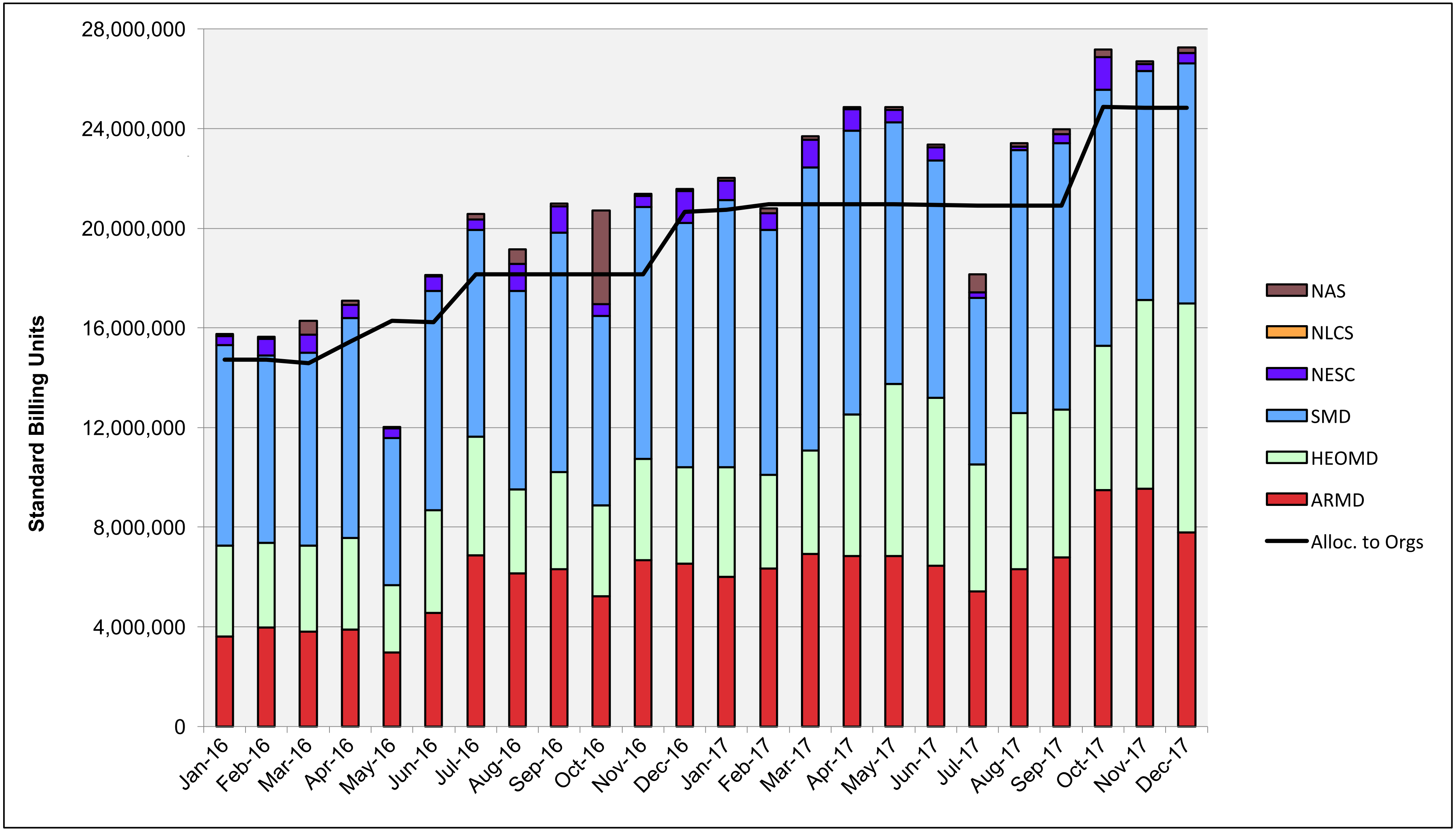
News

- **Massive, 3-Mile-Wide ‘Potentially Hazardous Asteroid’ will Zoom Past Earth Tomorrow**, *Fox News*, December 15, 2017. Coverage of 3200 Phaethon, the space rock that orbits the Sun, with quotes from NASA and information on the work “being done by experts on the Asteroid Threat Assessment Project at the NASA Advanced Supercomputing facility at Ames Research Center in California’s Silicon Valley" in conjunction with NASA’s Planetary Defense Coordination Office.

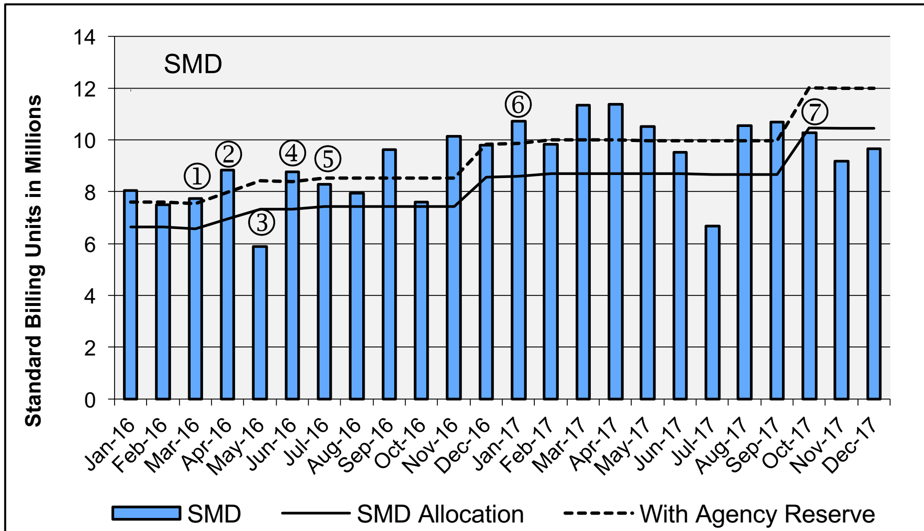
HECC Utilization

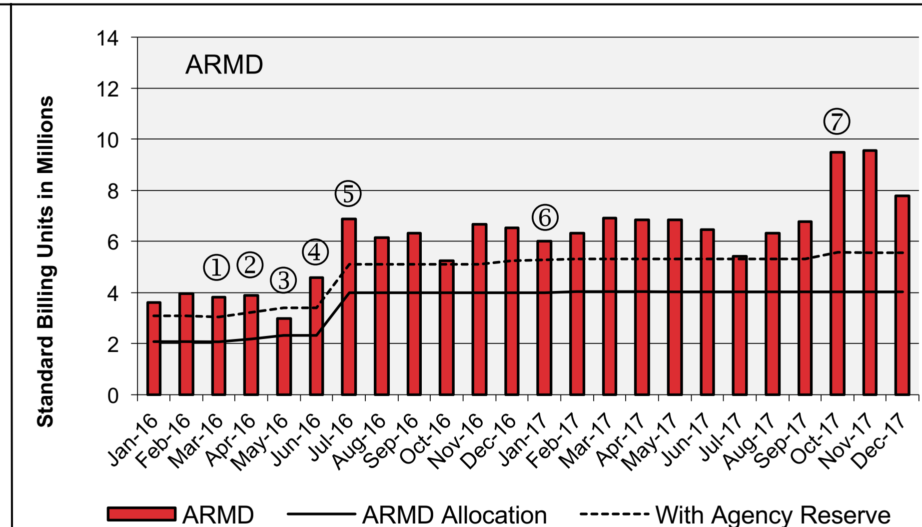


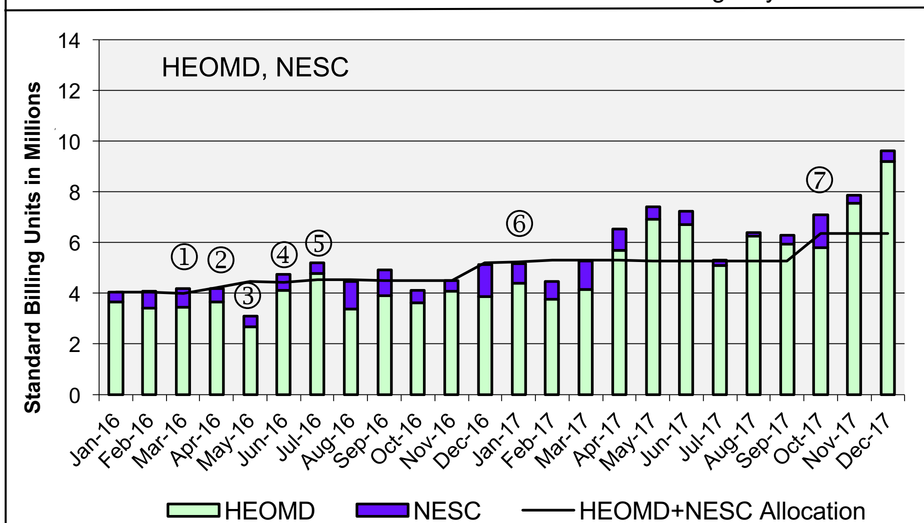
HECC Utilization Normalized to 30-Day Month



HECC Utilization Normalized to 30-Day Month

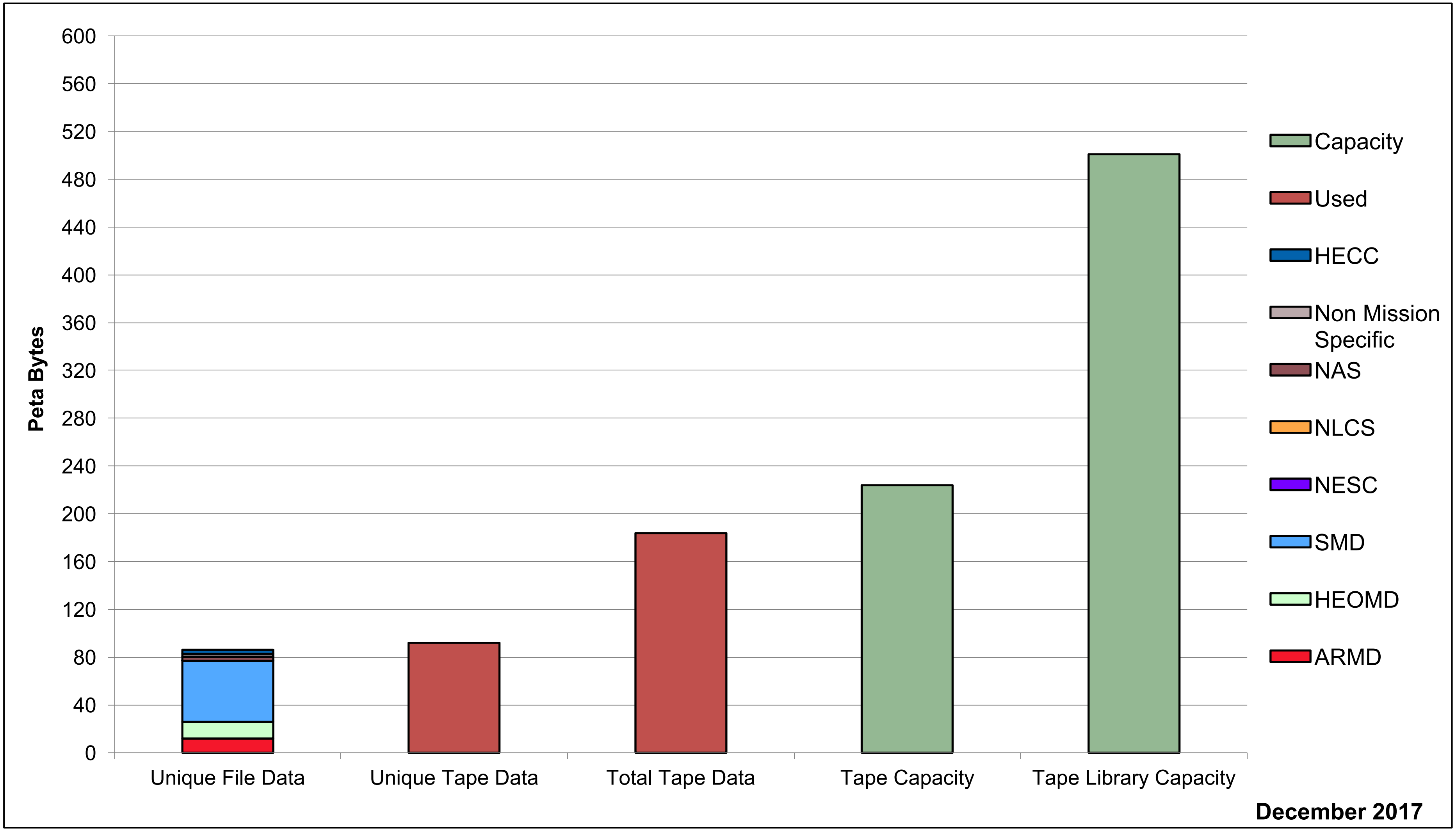






① 16 Westmere racks retired from Pleiades
② 10 Broadwell racks added to Pleiades
③ 4 Broadwell racks added to Pleiades
④ 14 (All) Westmere racks retired from Pleiades
⑤ 14 Broadwell Racks added to Pleiades
⑥ 16 Electra Broadwell Racks in Production, 20 Westmere 1/2 racks added to Merope
⑦ 4 Skylake E Cells (16 D rack equivalents) added to Electra

Tape Archive Status



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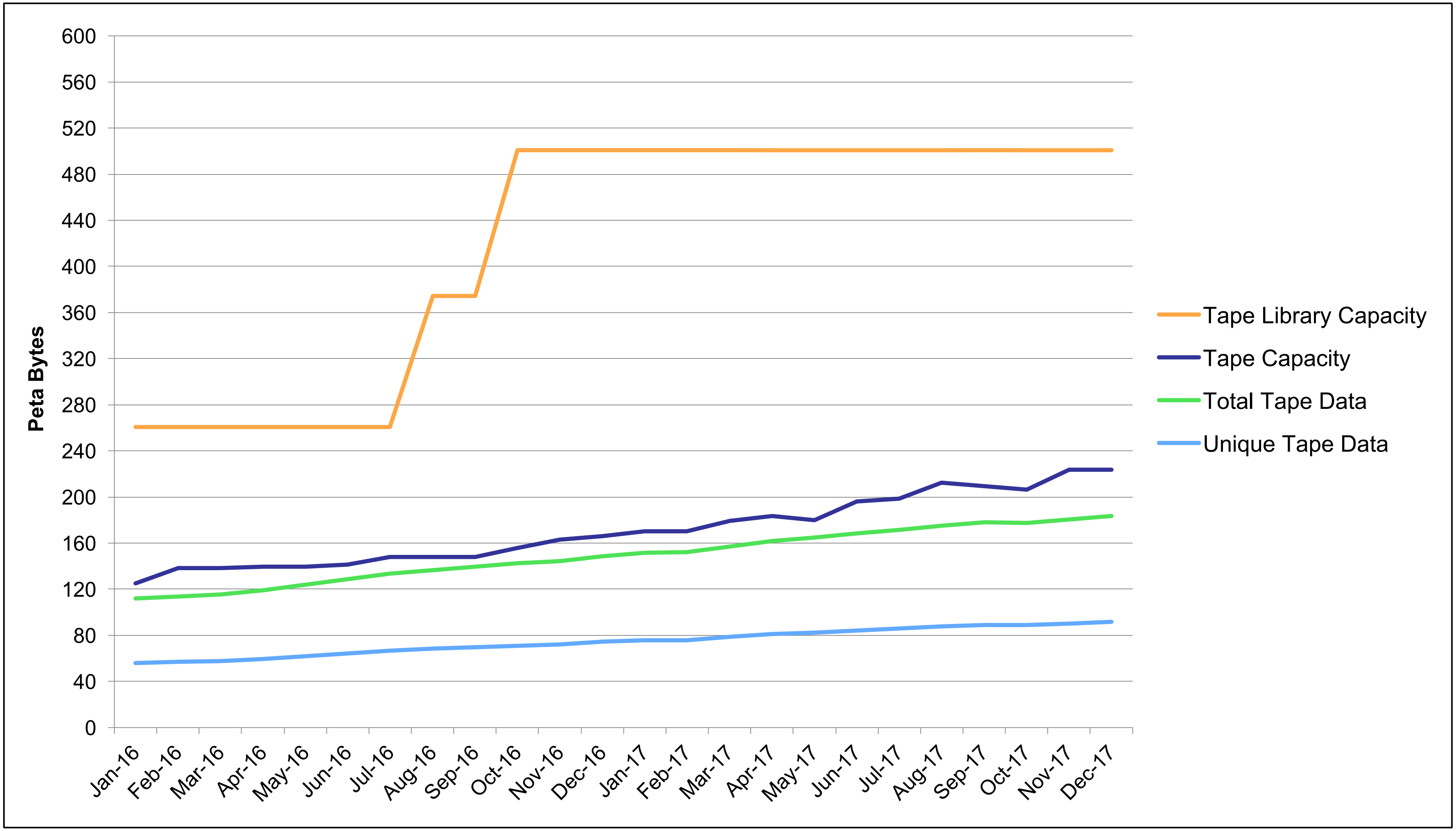
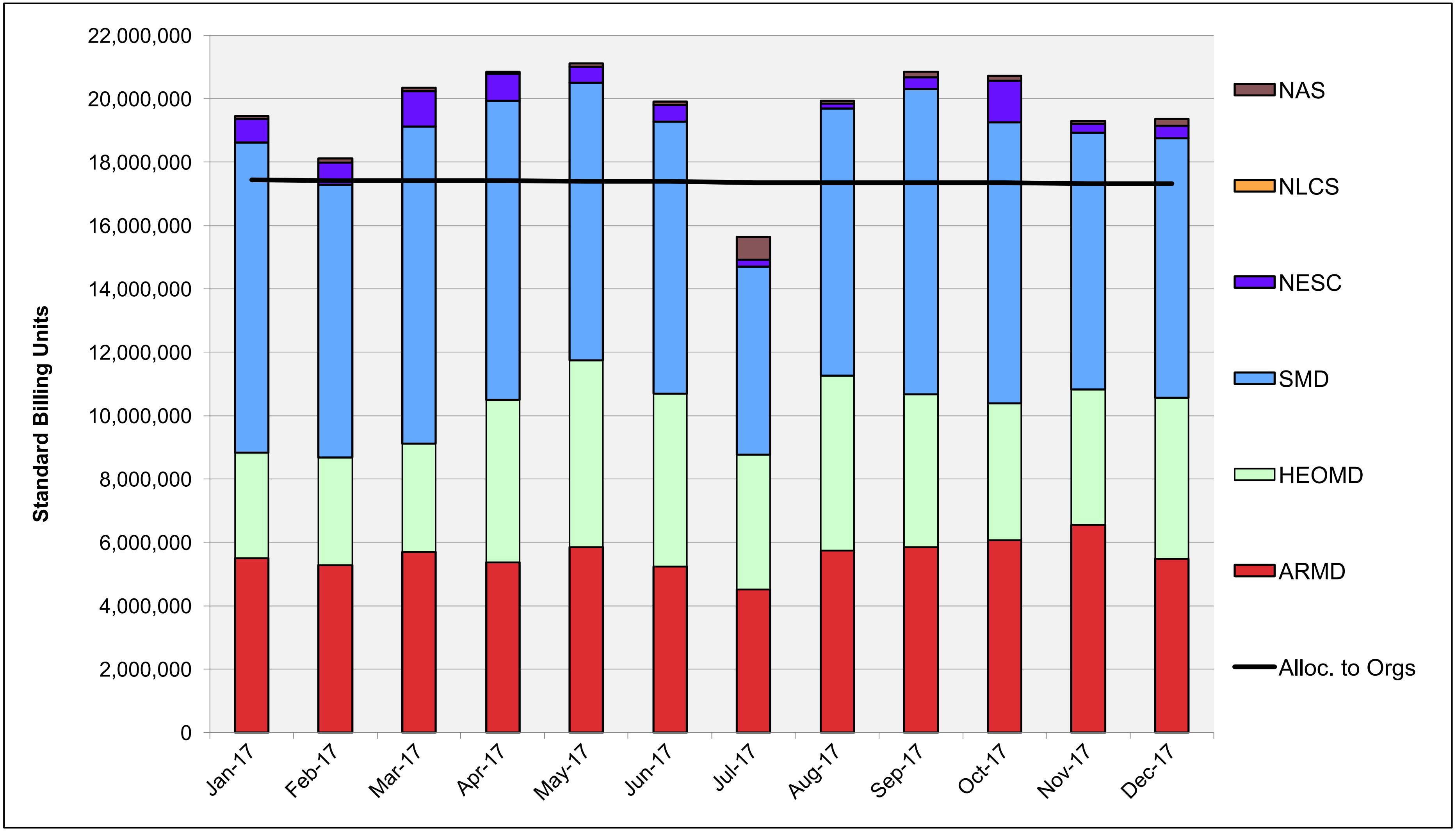
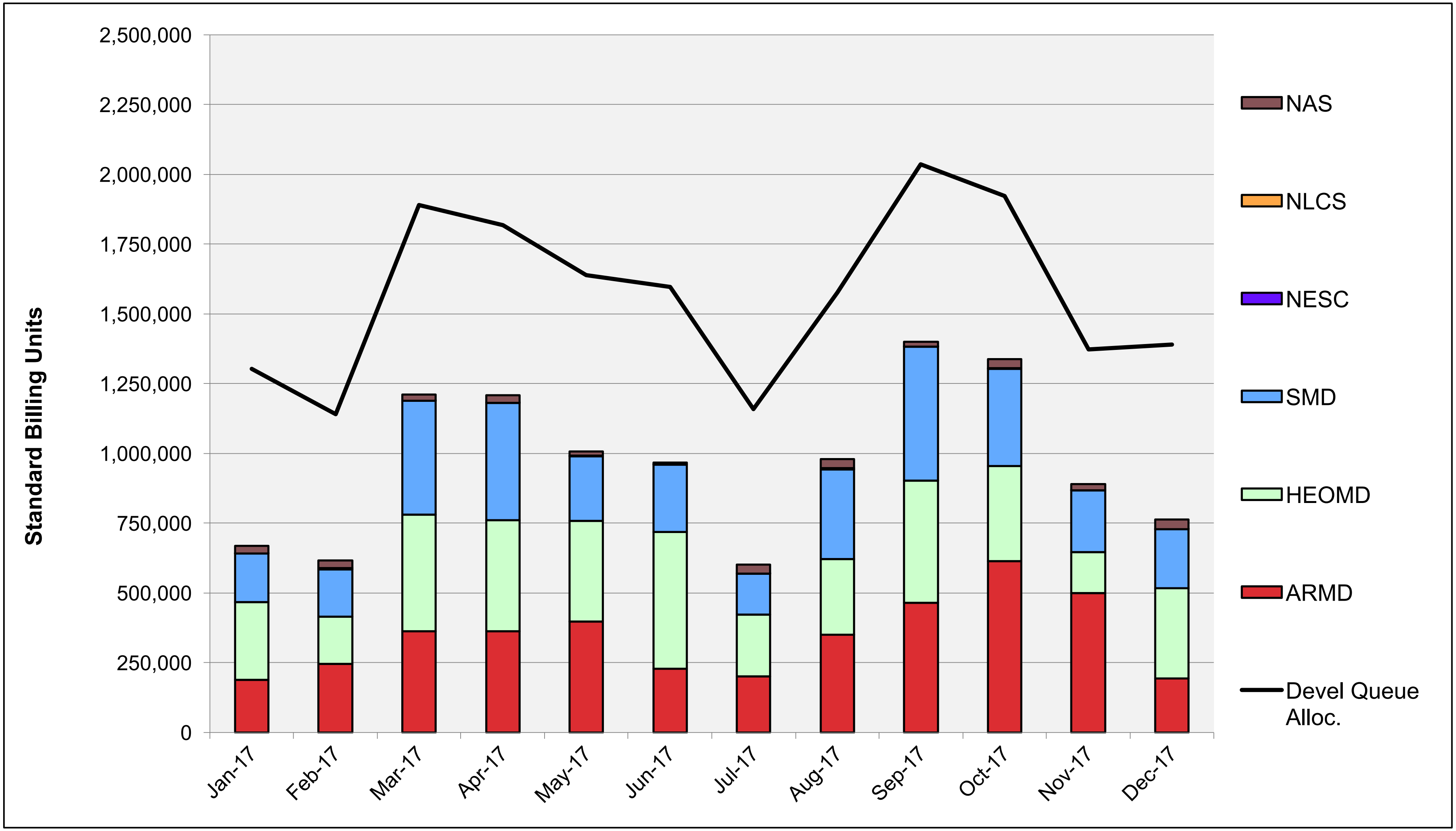


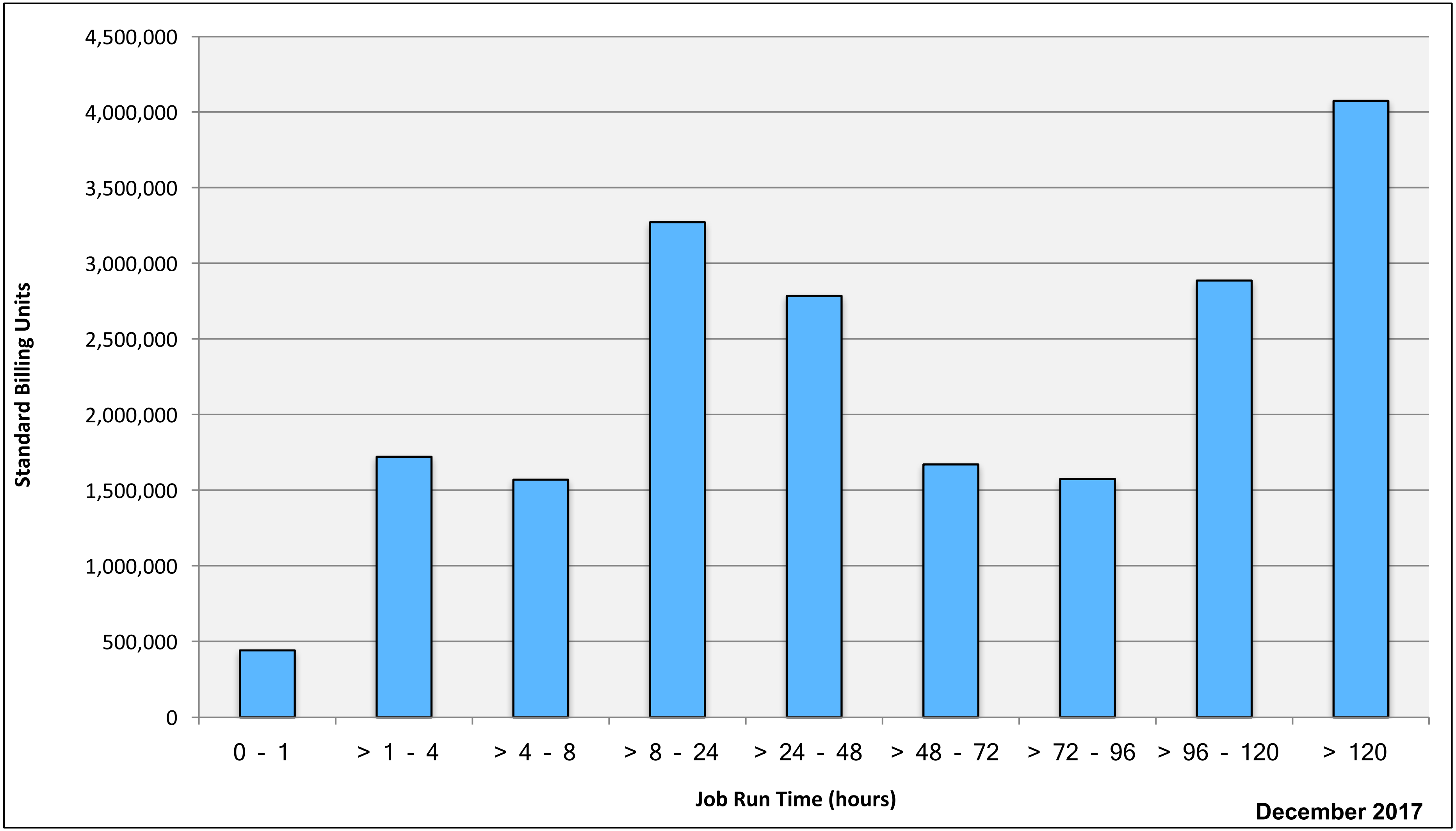
Pleiades: SBUs Reported, Normalized to 30-Day Month



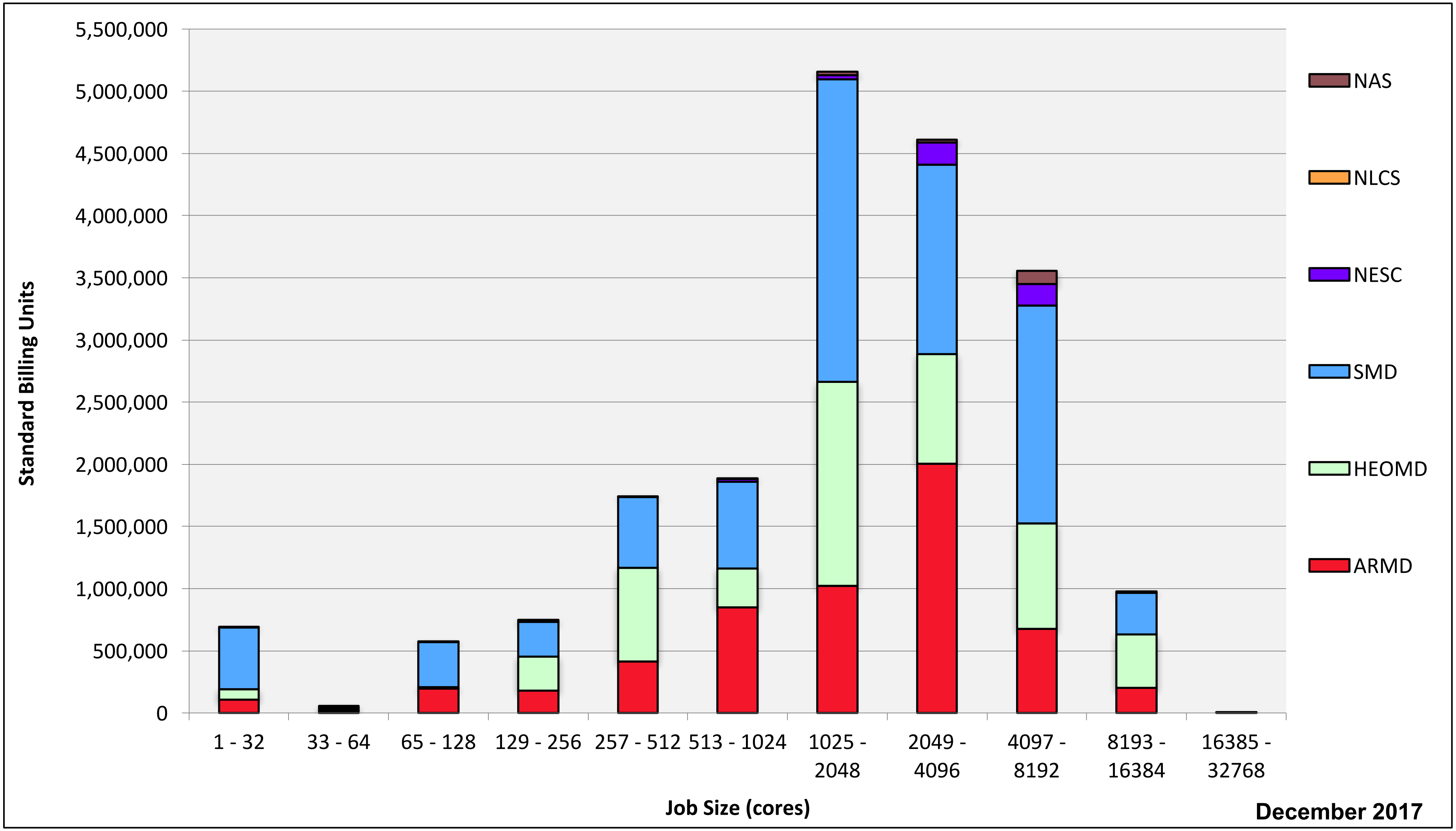
Pleiades:
Devel Queue Utilization



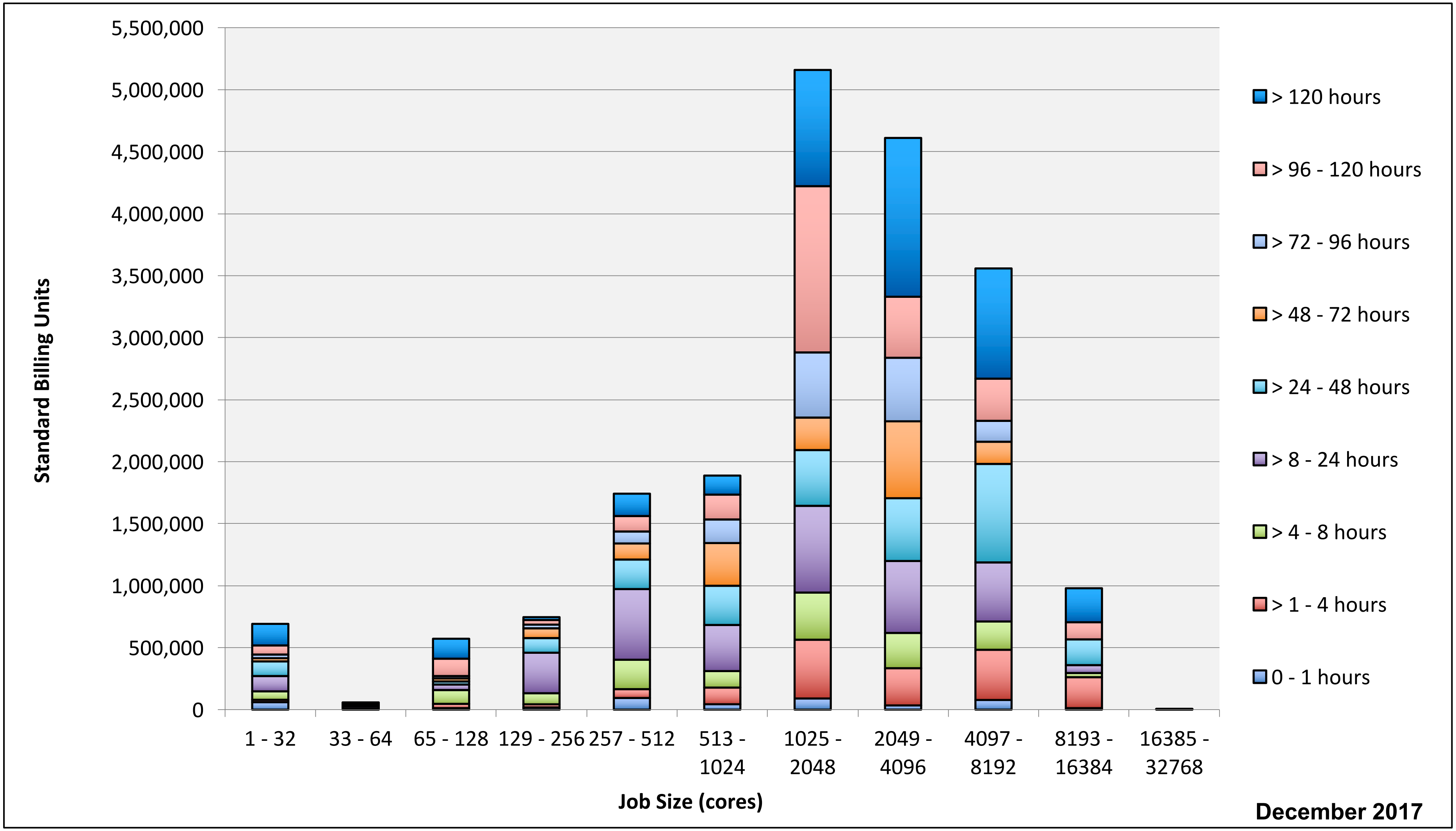
Pleiades: Monthly Utilization by Job Length



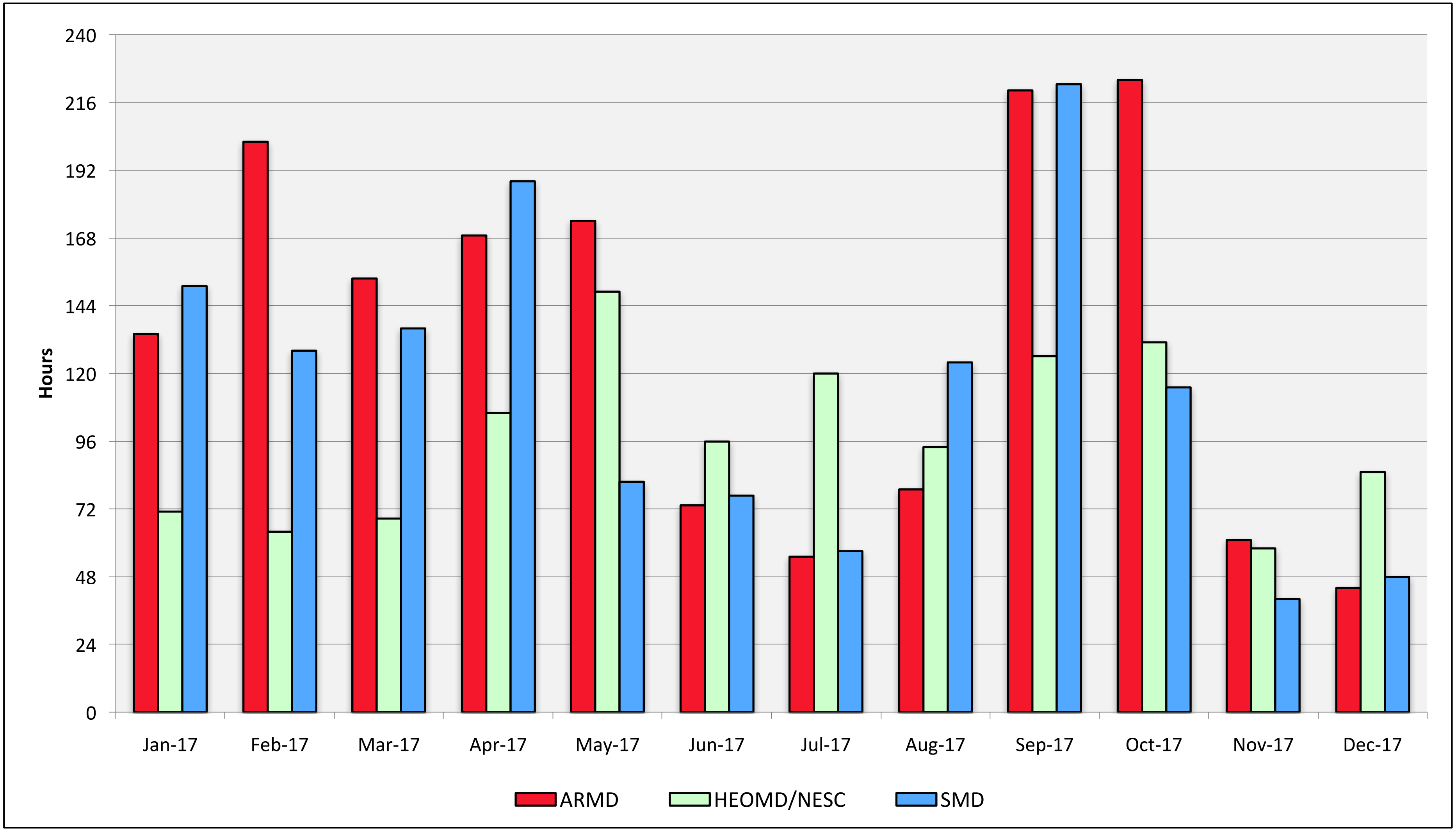
Pleiades: Monthly Utilization by Size and Mission



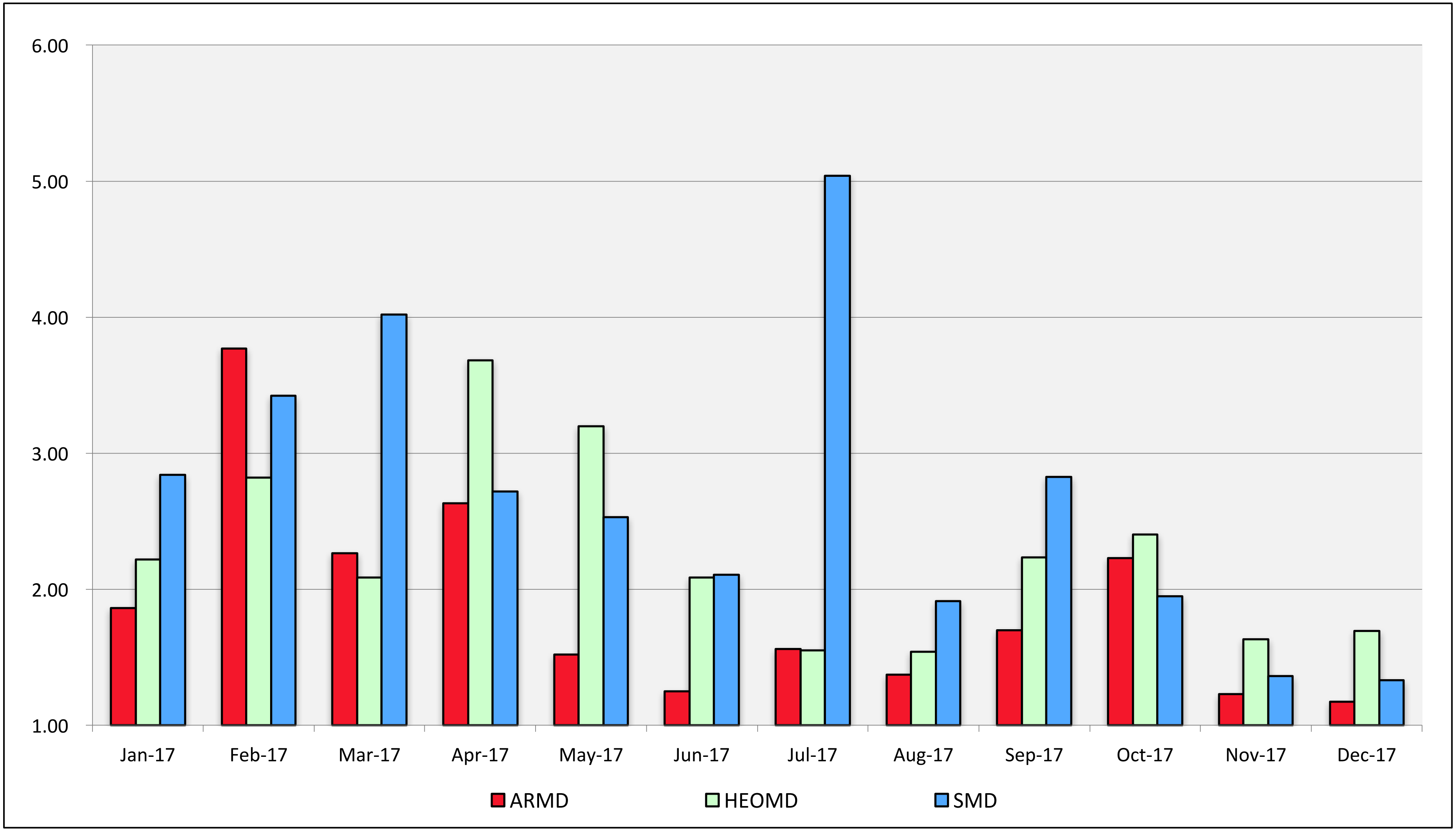
Pleiades: Monthly Utilization by Size and Length



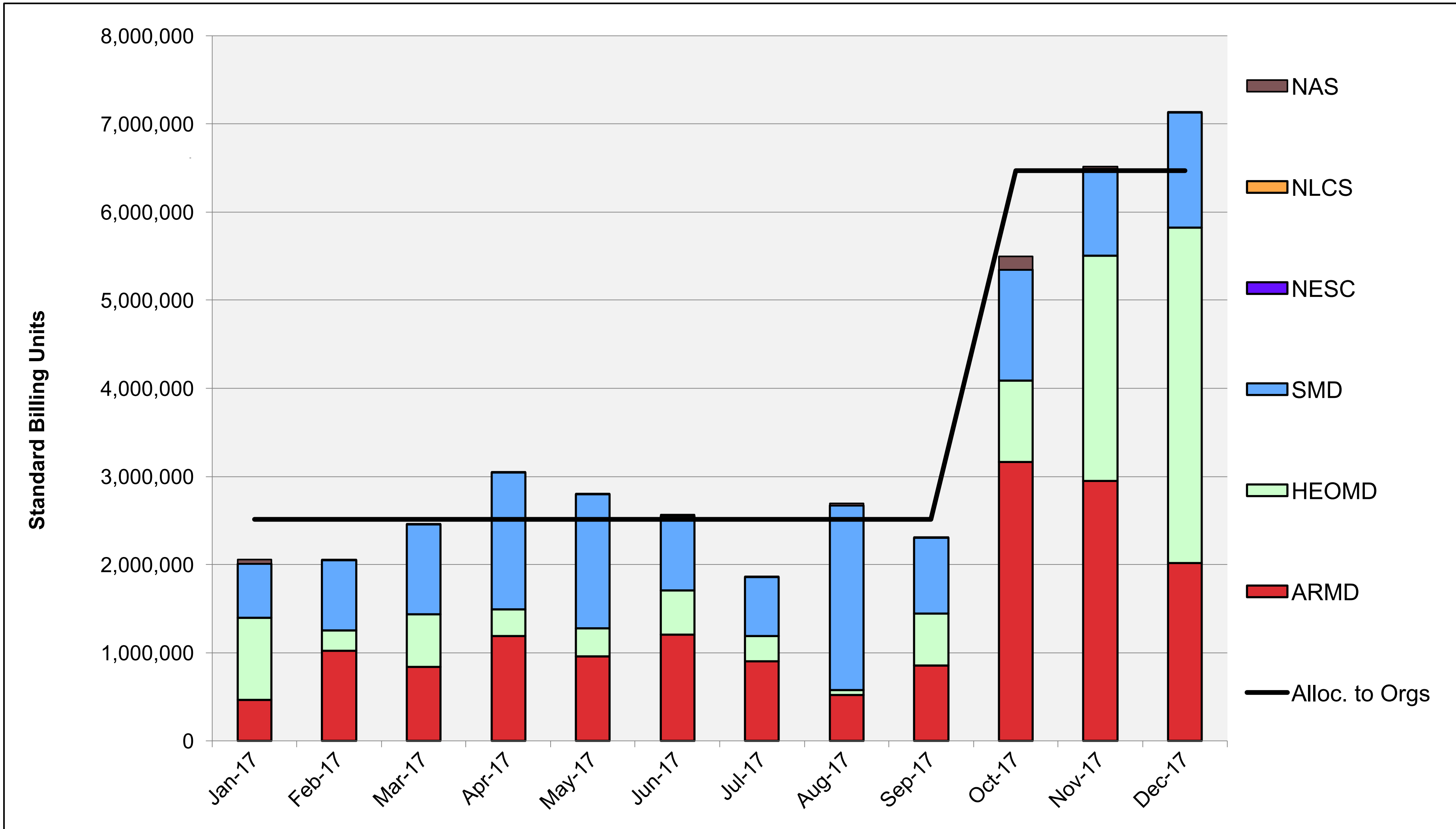
Pleiades:
Average Time to Clear All Jobs



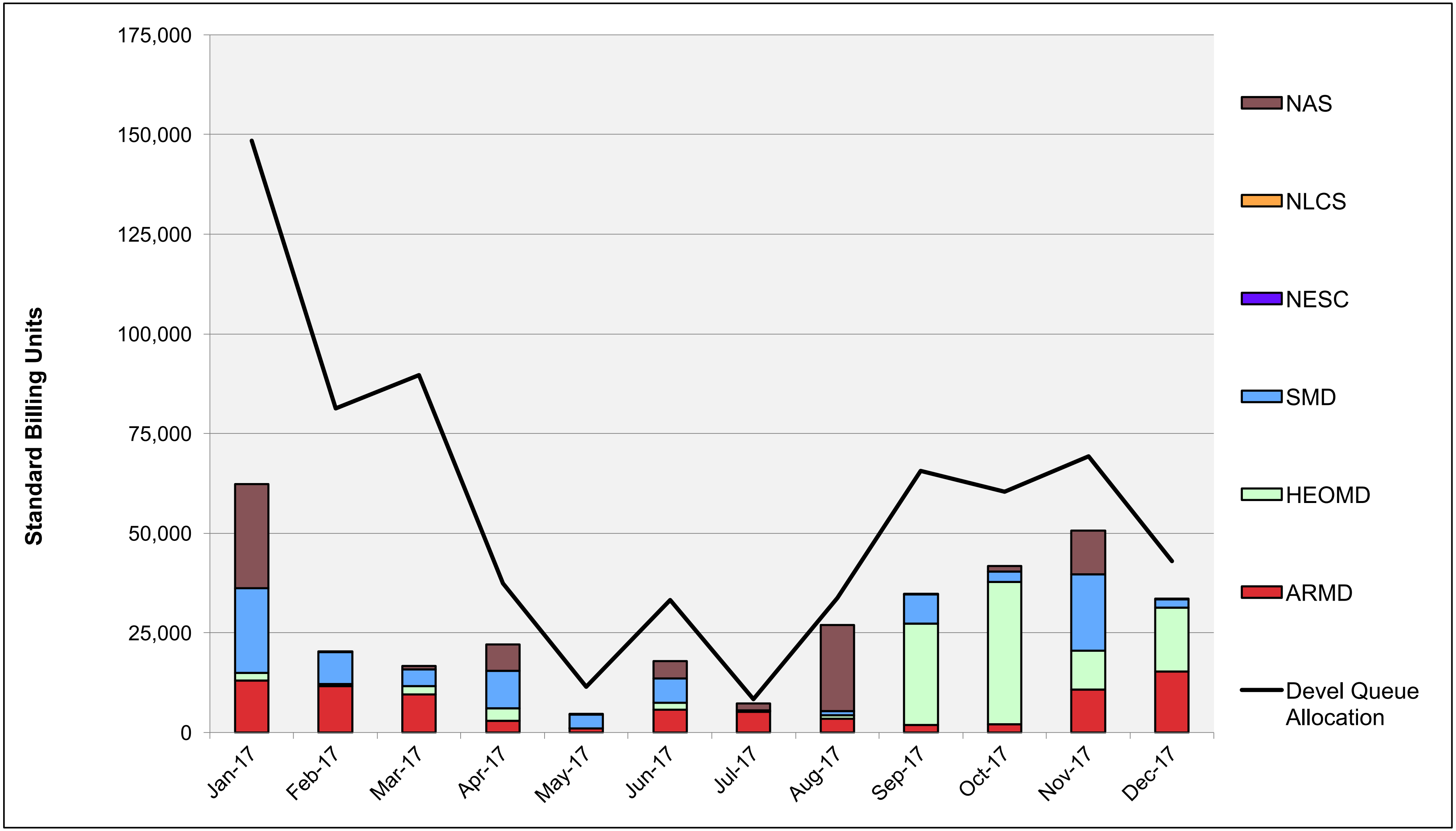
Pleiades: Average Expansion Factor



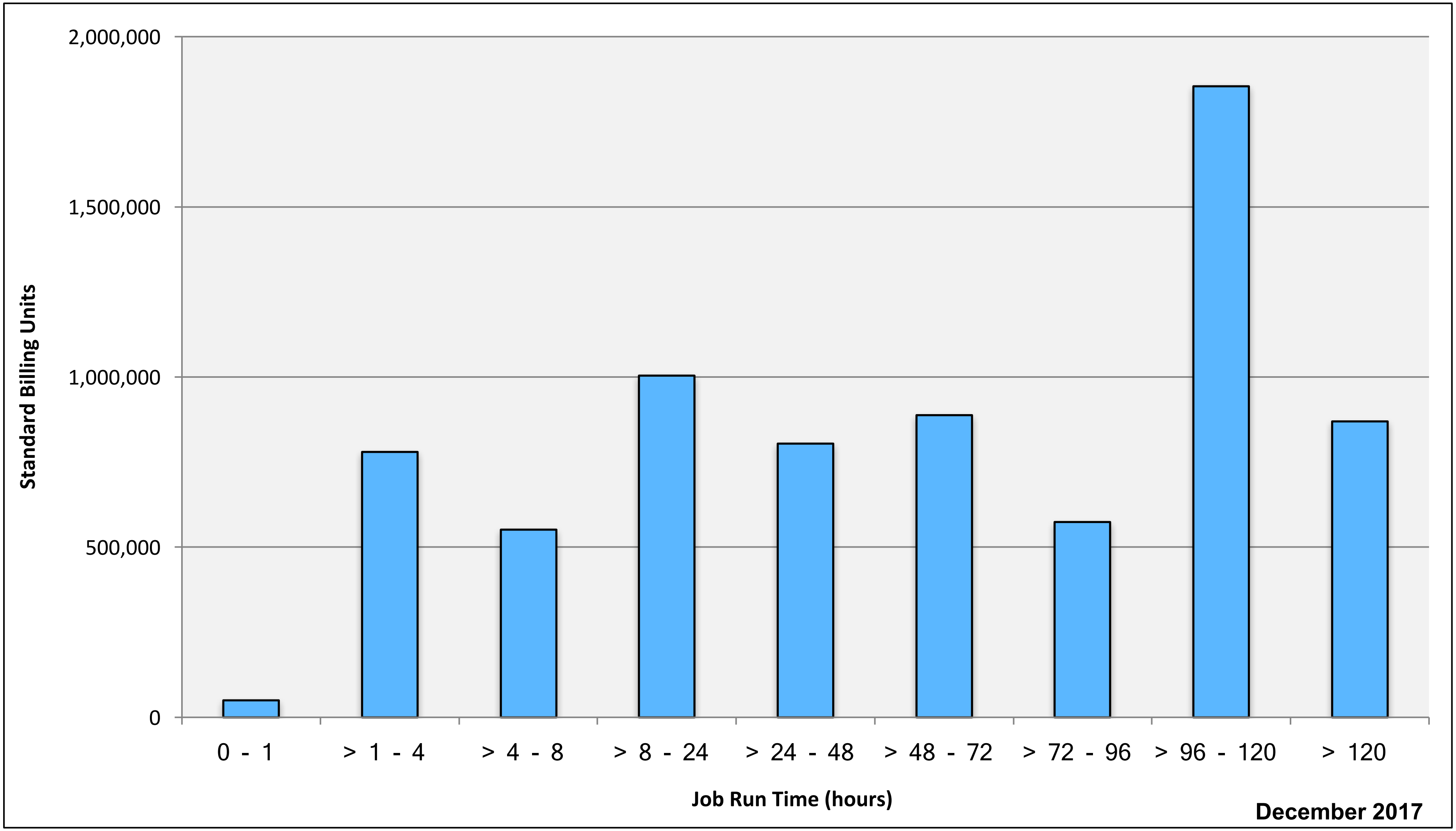
Electra: SBUs Reported, Normalized to 30-Day Month



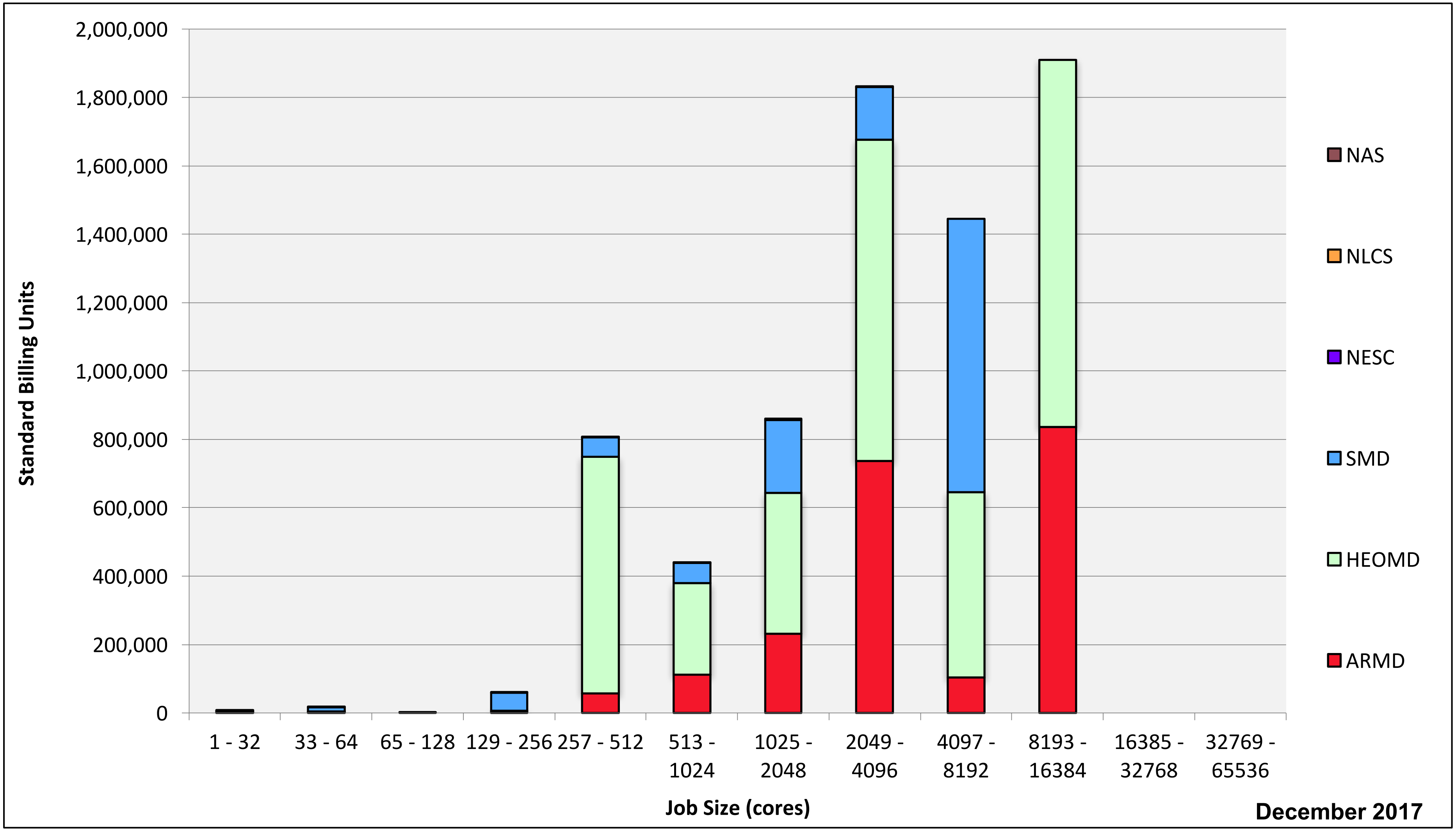
Electra:
Devel Queue Utilization



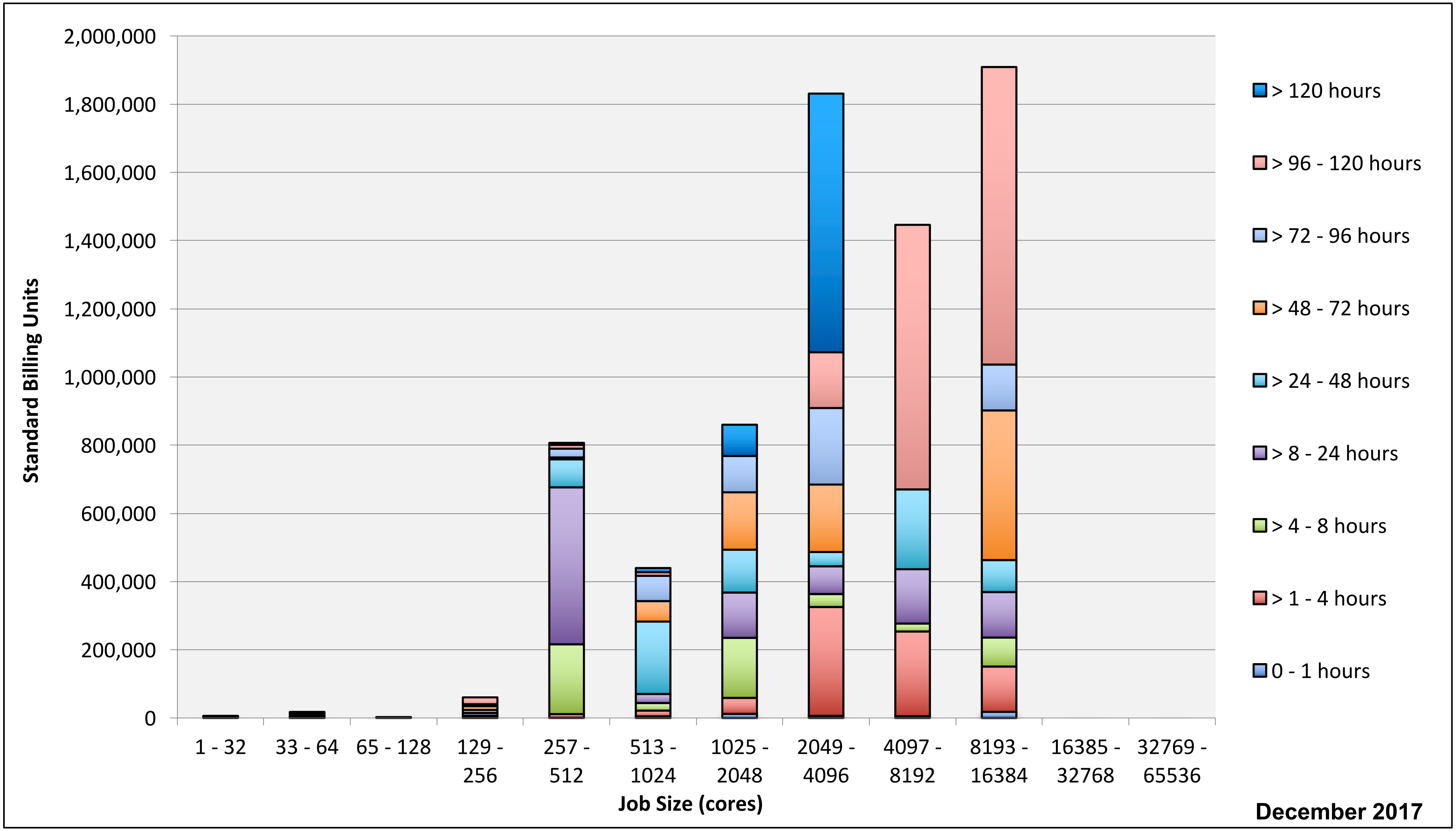
Electra:
Monthly Utilization by Job Length



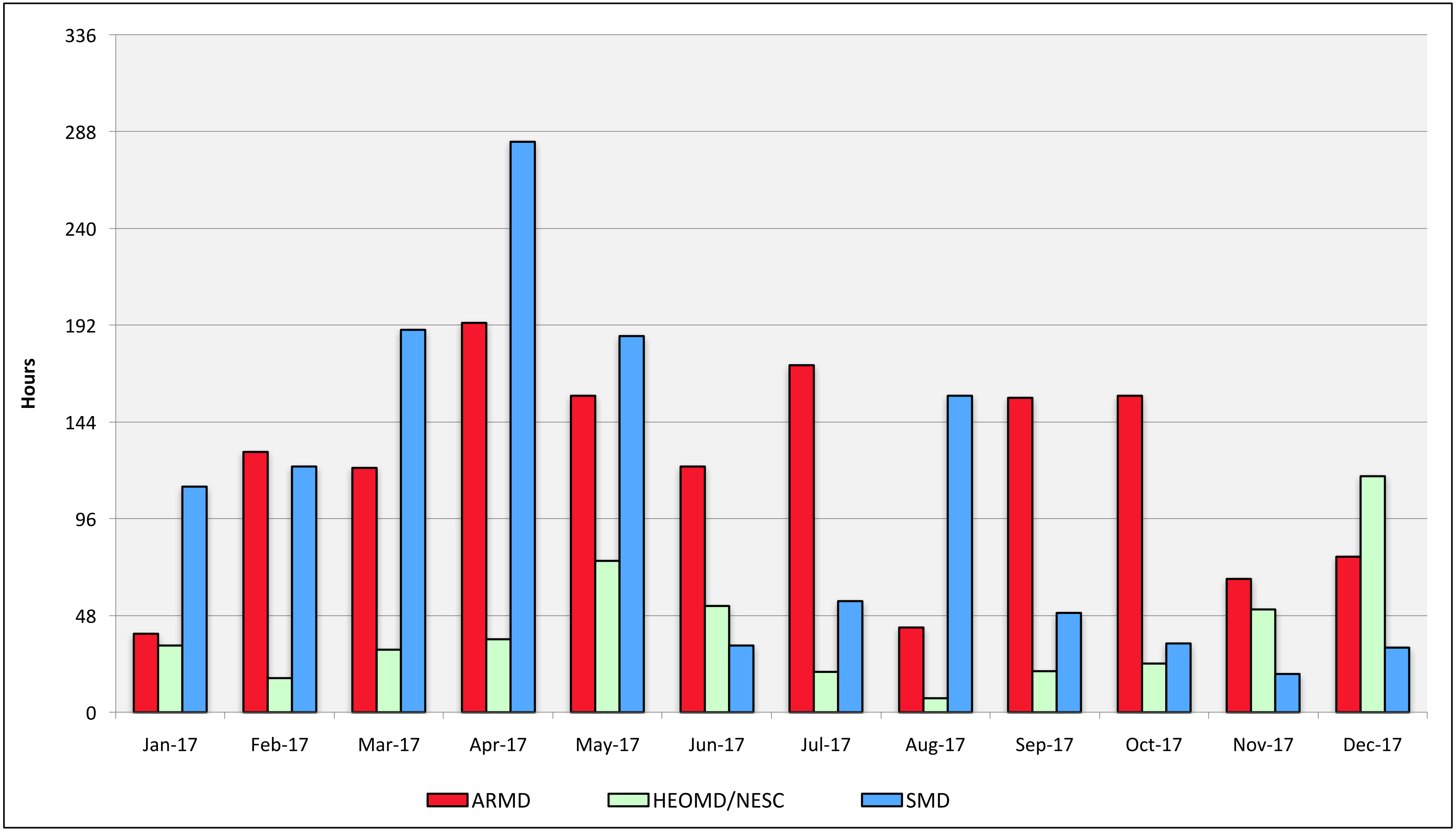
Electra:
Monthly Utilization by Size and Mission



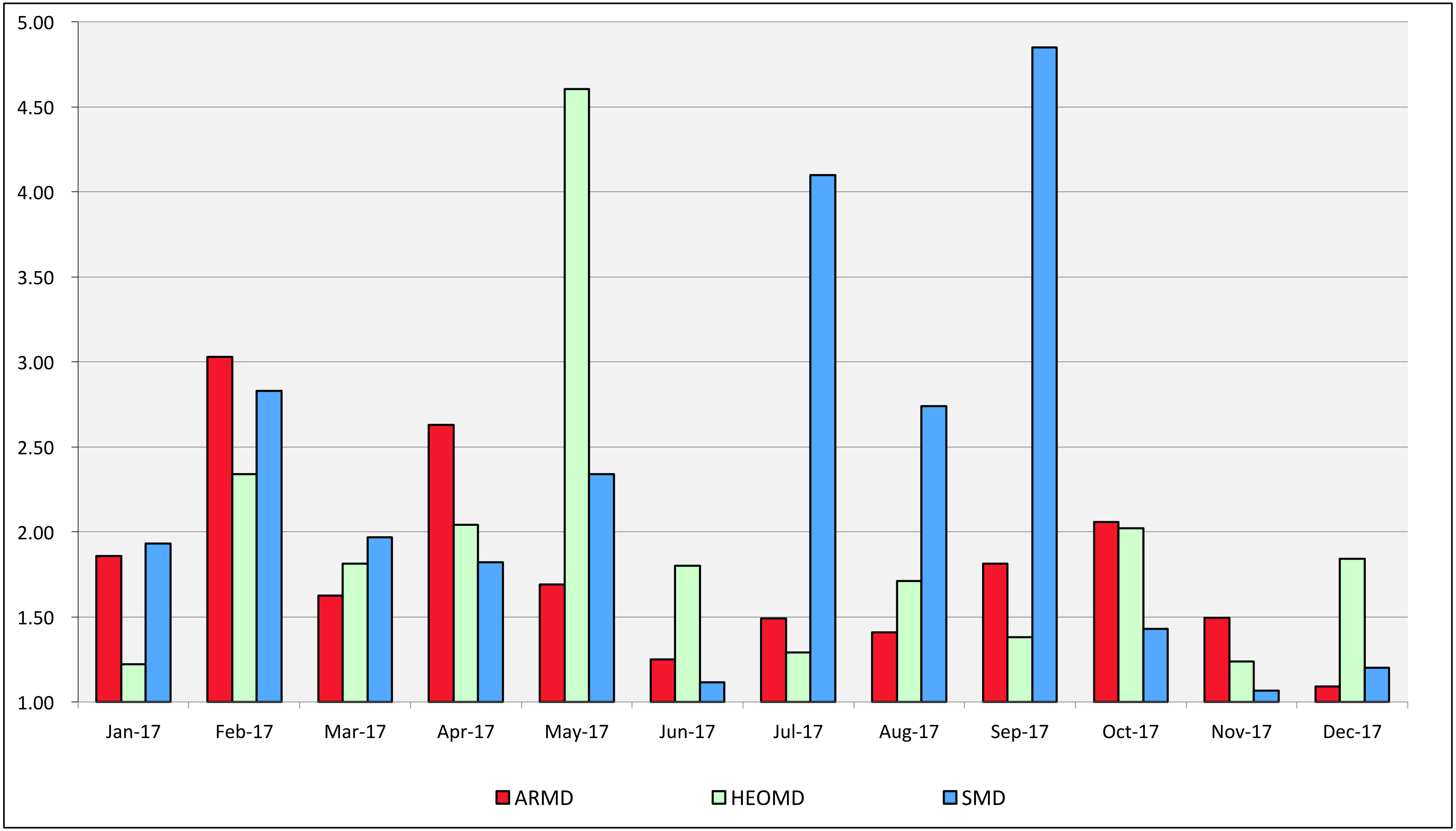
Electra: Monthly Utilization by Size and Length



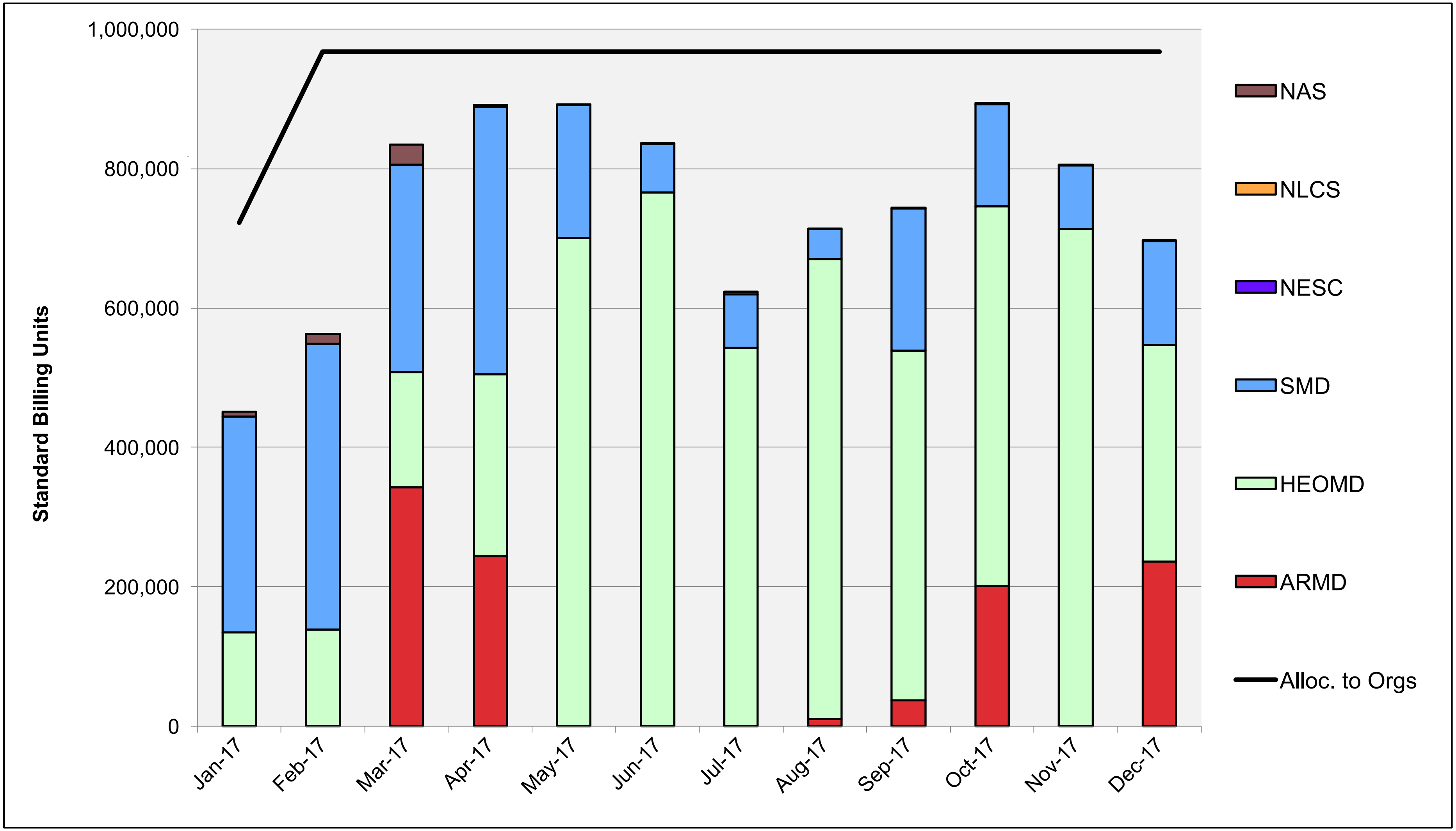
Electra:
Average Time to Clear All Jobs



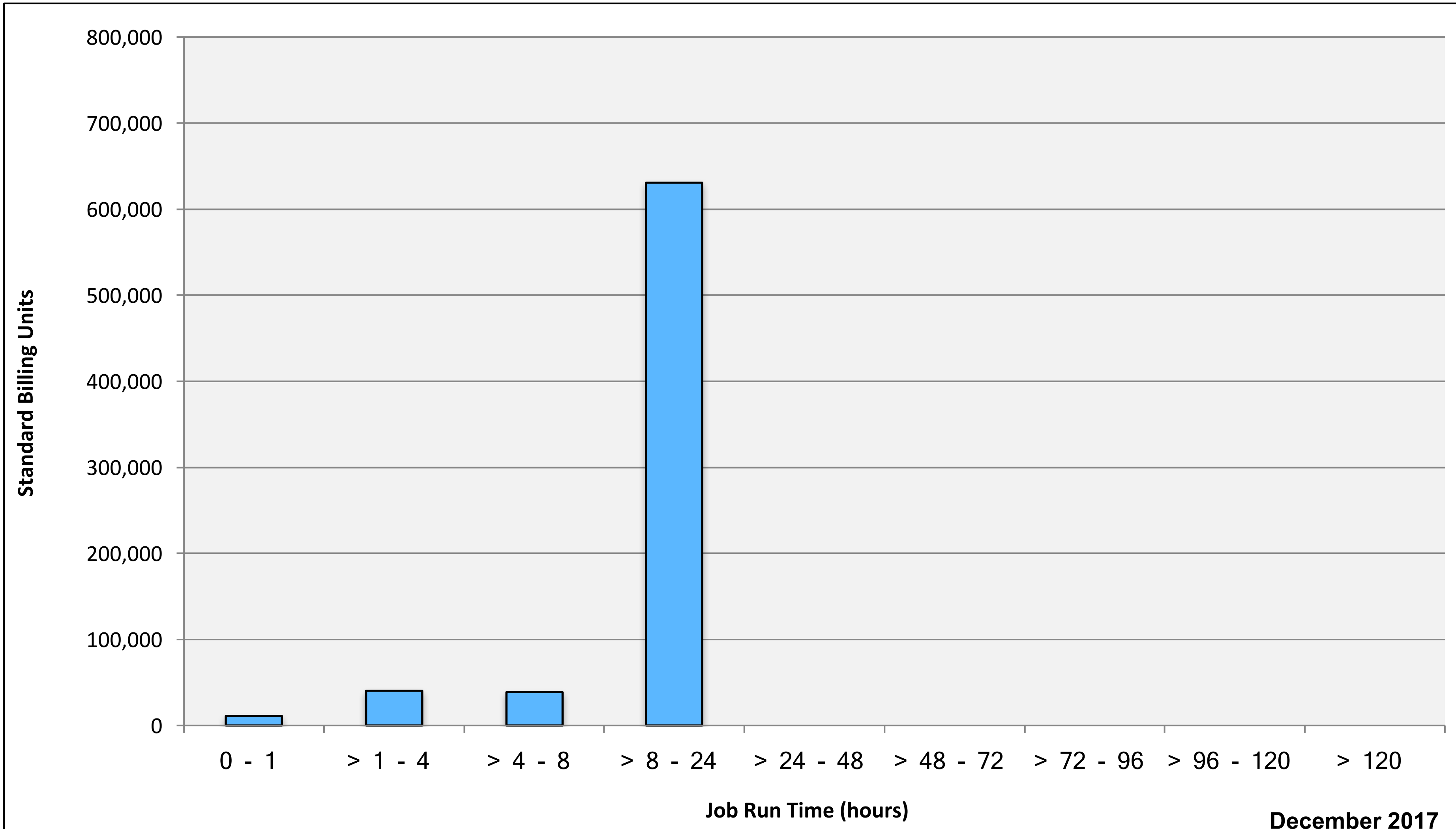
Electra: Average Expansion Factor



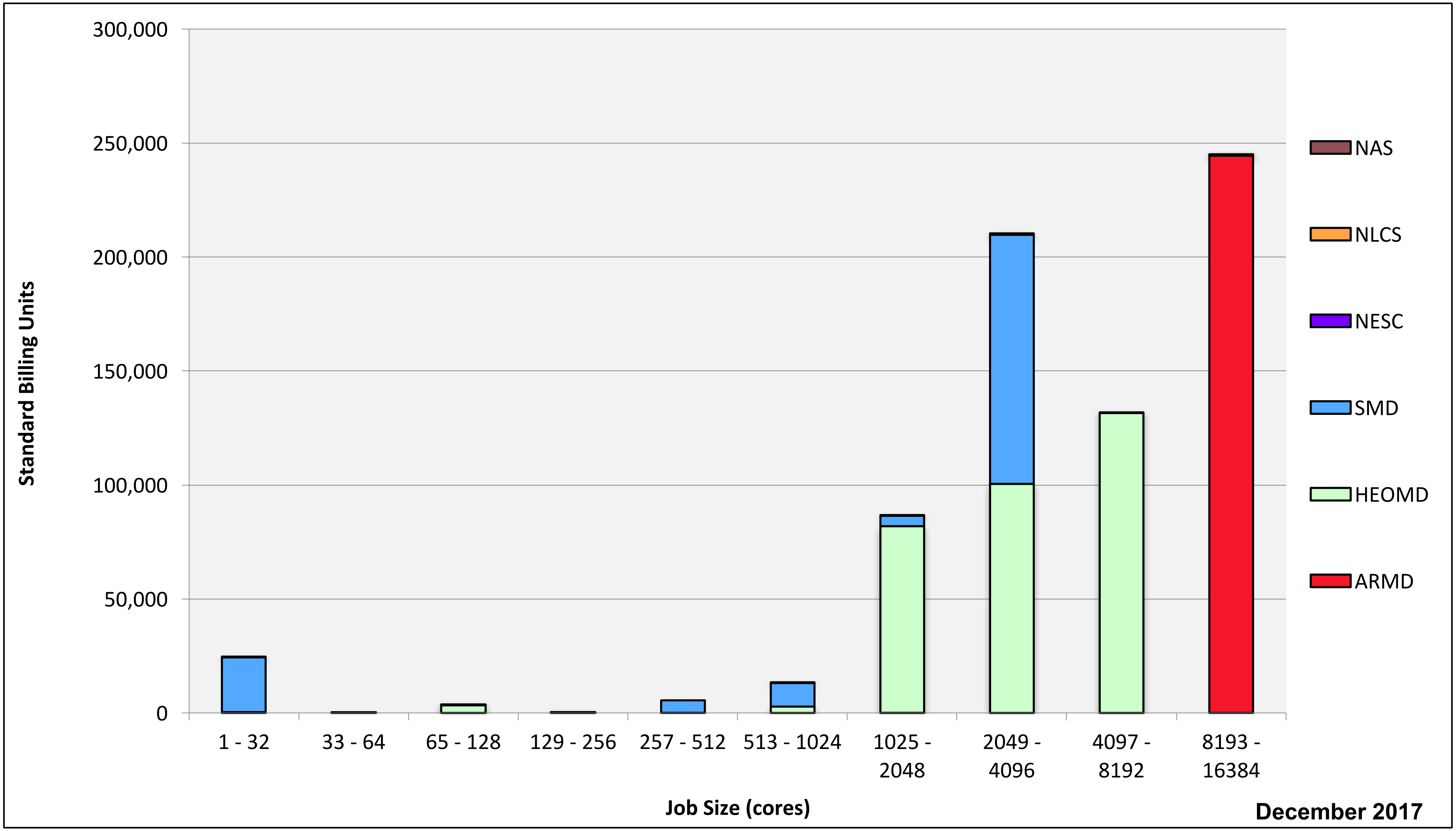
Merope: SBUs Reported, Normalized to 30-Day Month



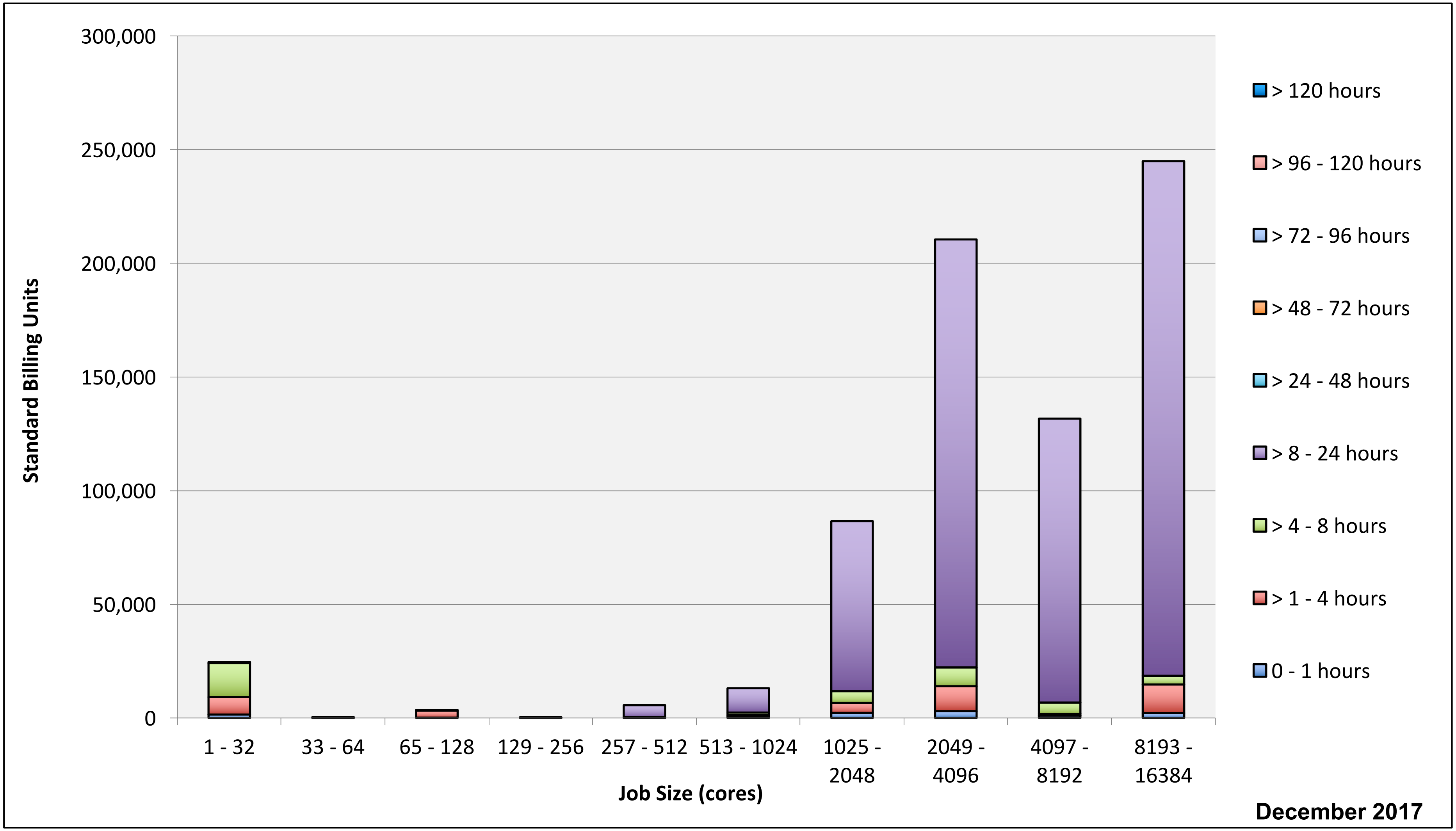
Merope: Monthly Utilization by Job Length



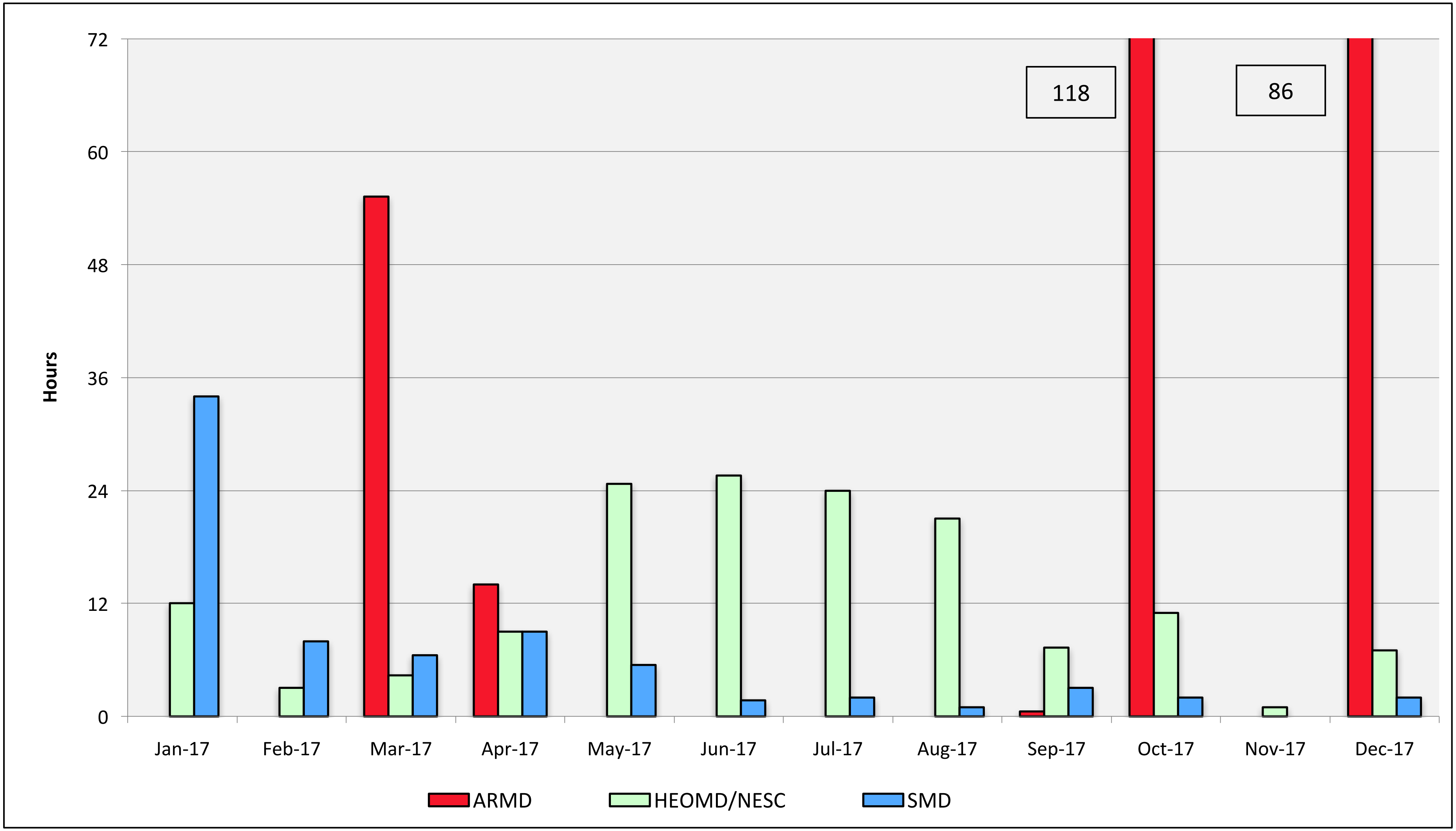
Merope:
Monthly Utilization by Size and Mission



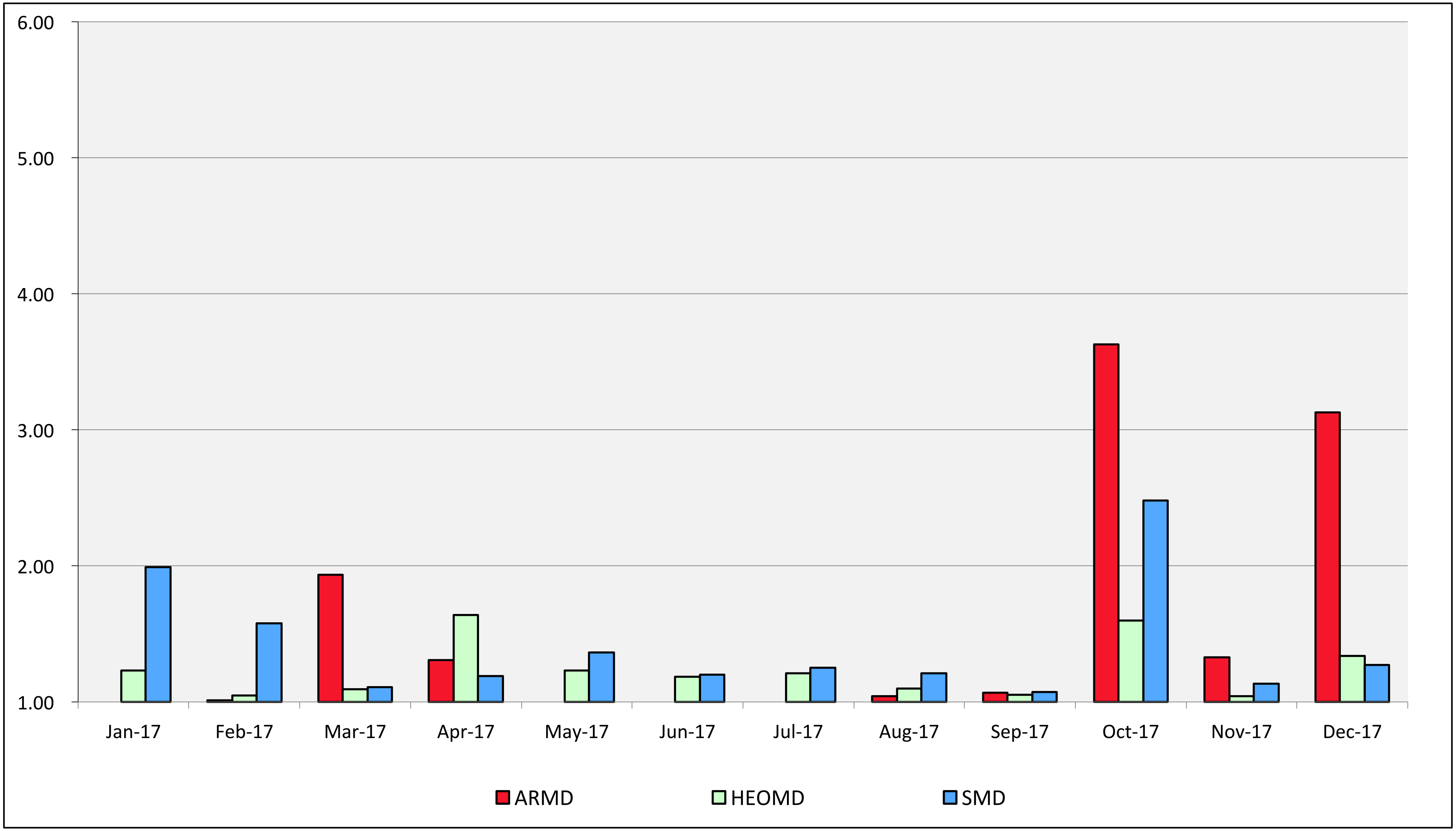
Merope: Monthly Utilization by Size and Length



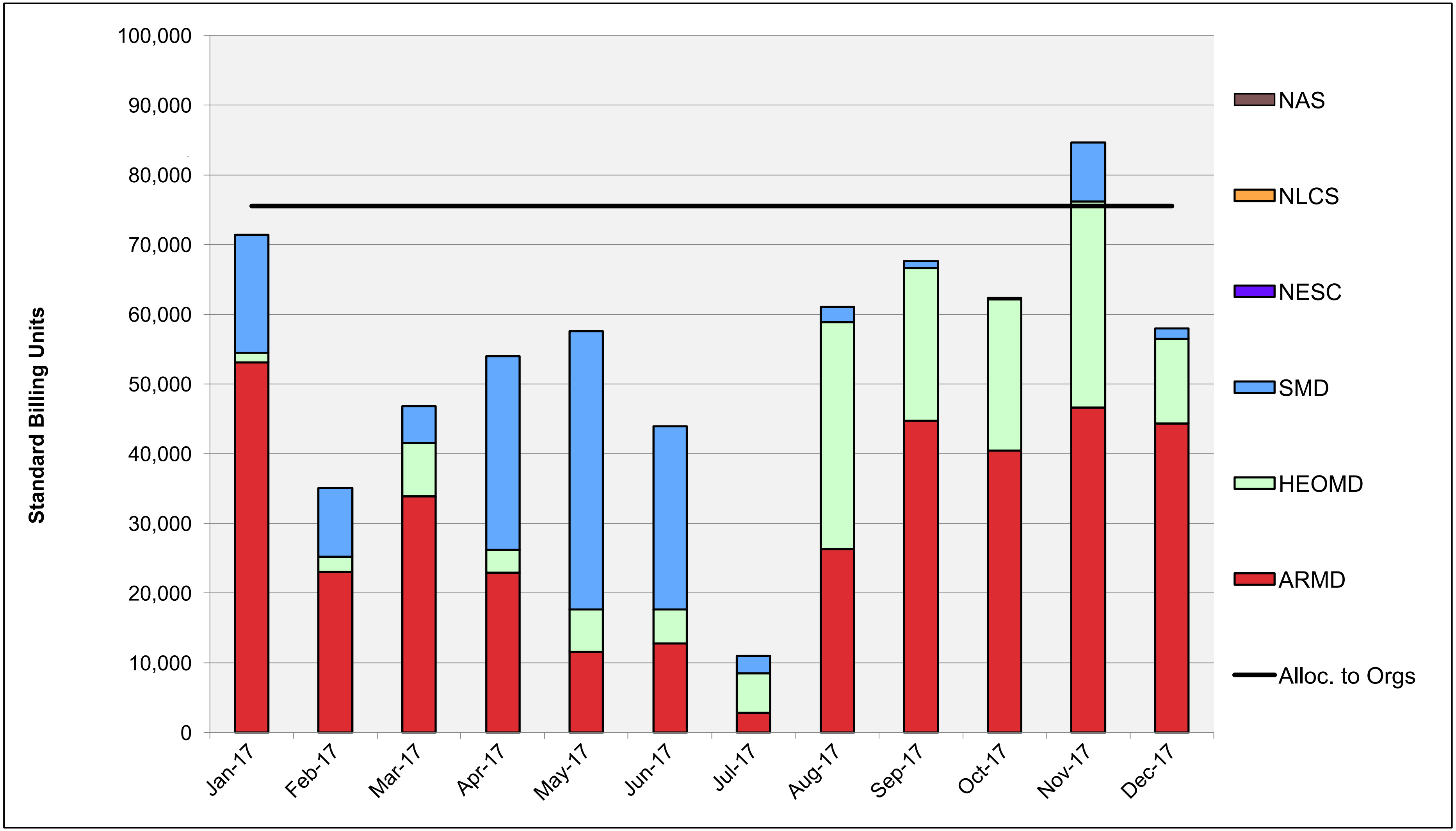
Merope:
Average Time to Clear All Jobs



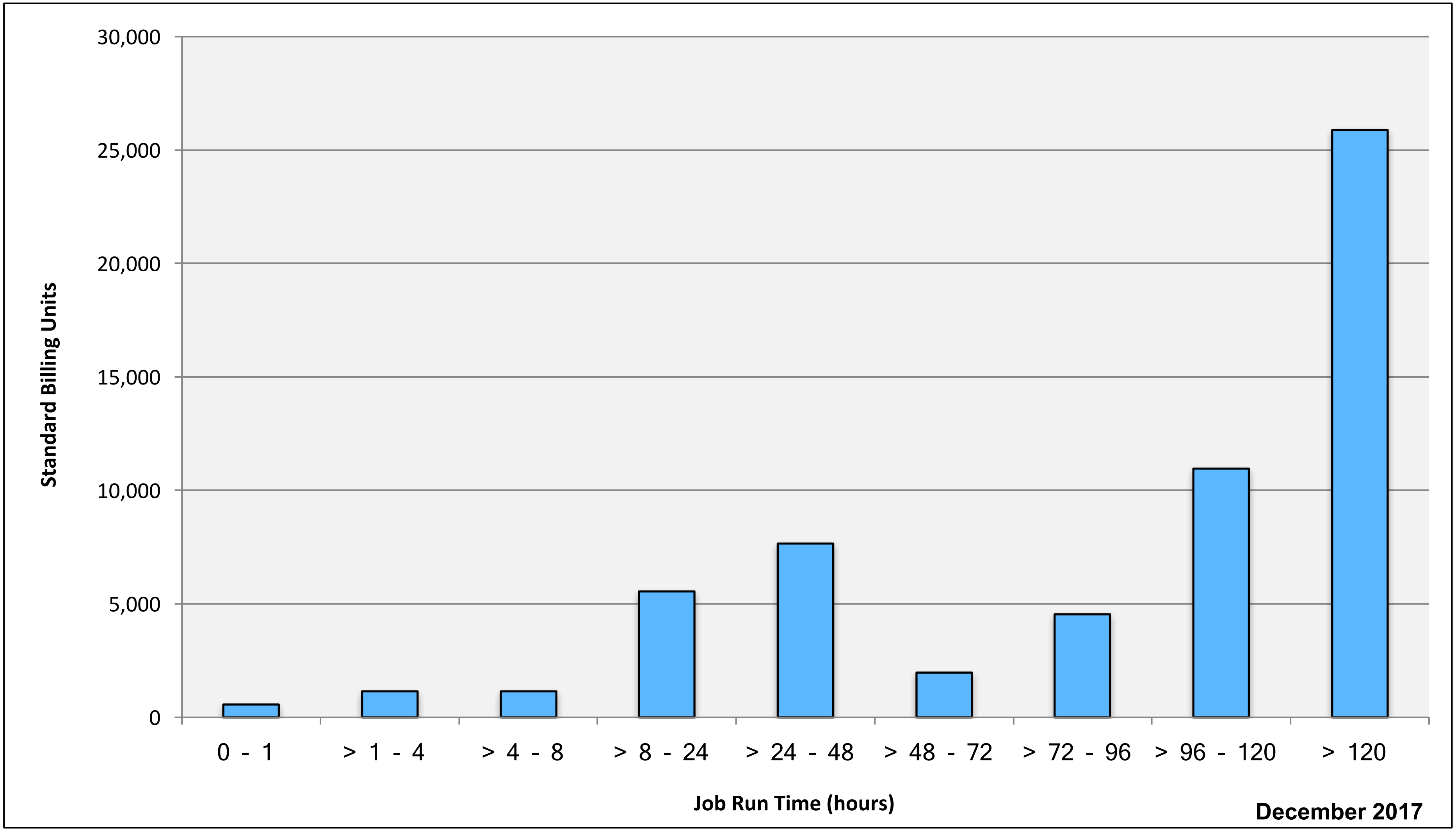
Merope: Average Expansion Factor



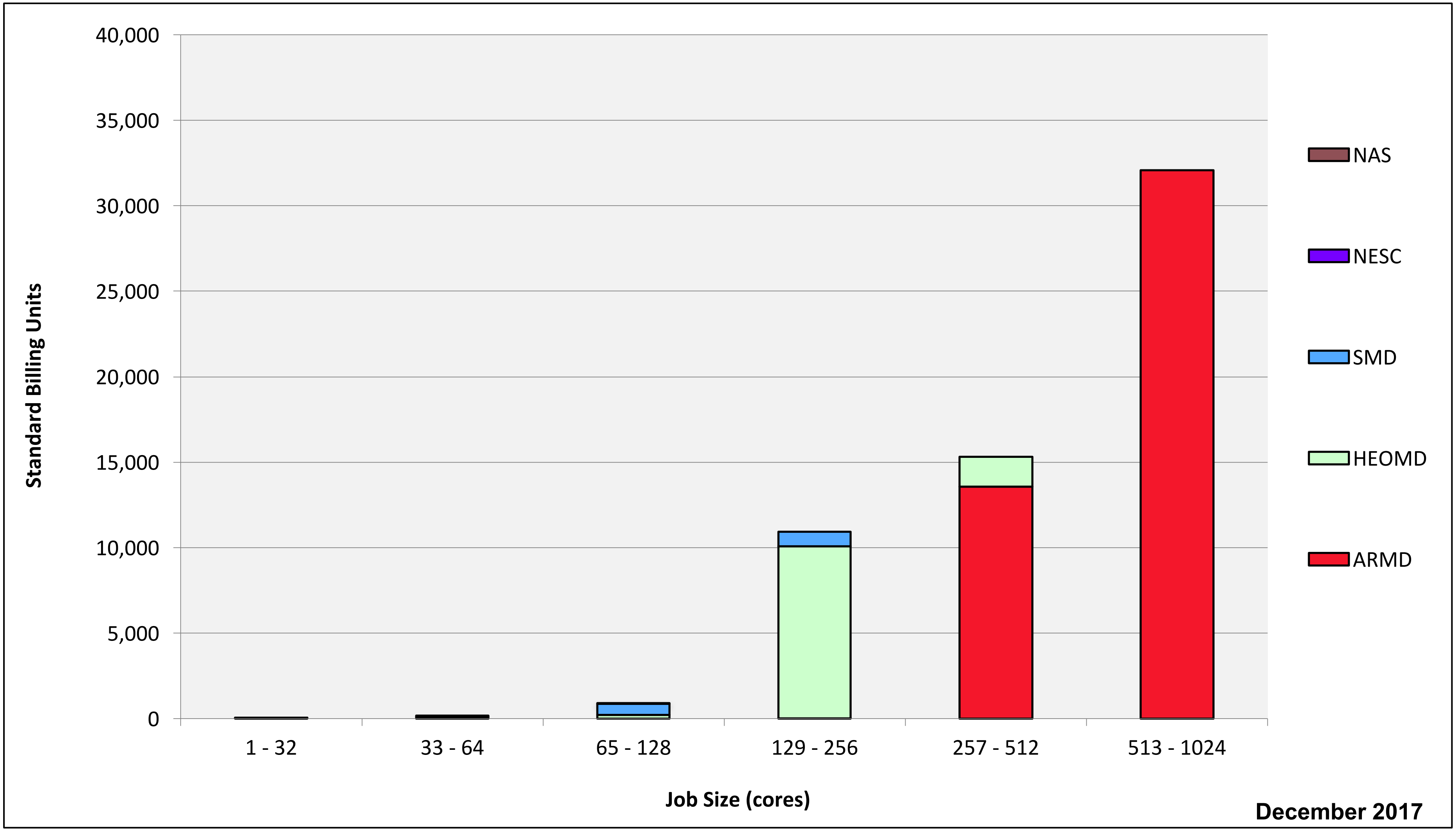
Endeavour: SBUs Reported, Normalized to 30-Day Month



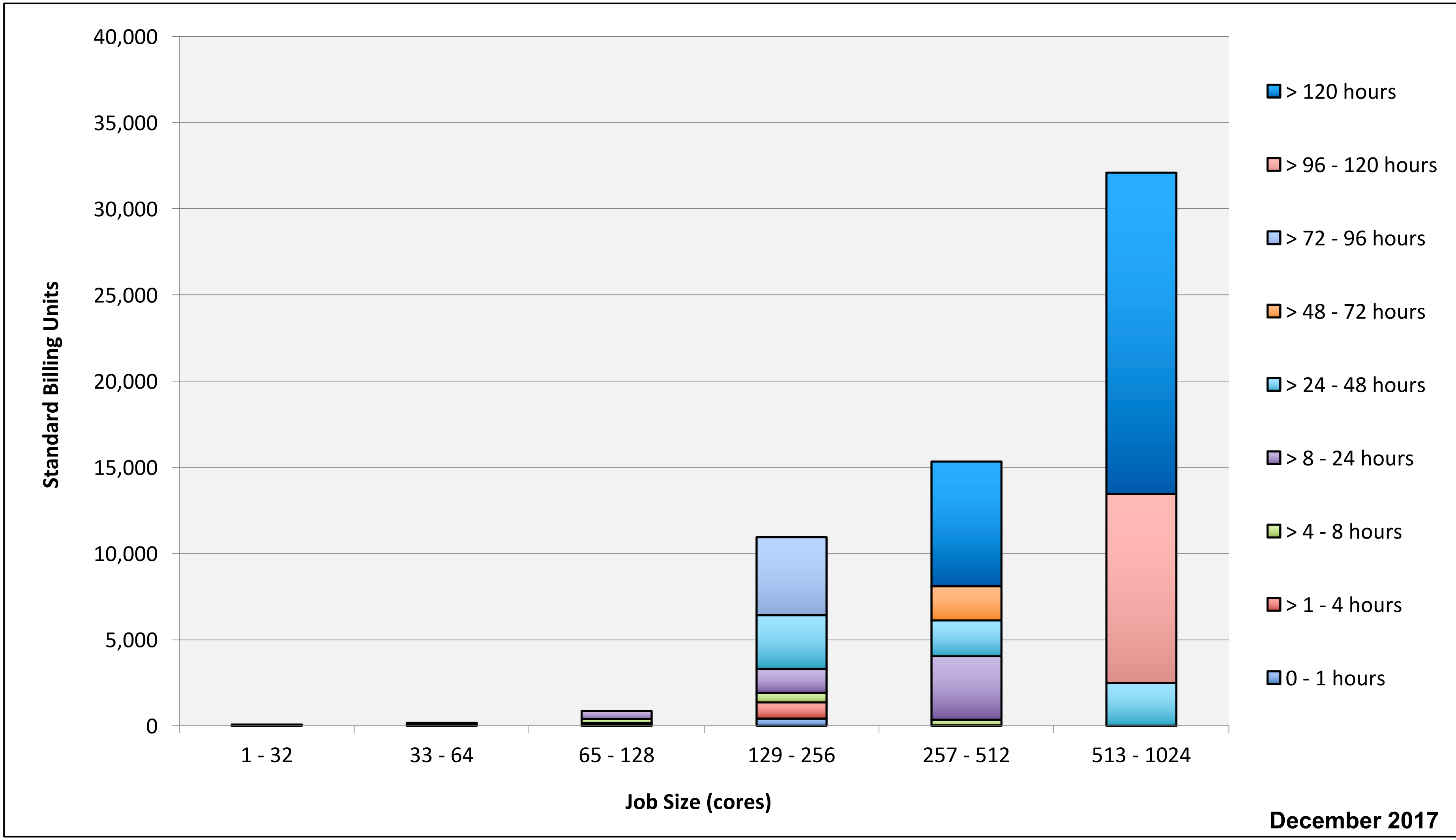
Endeavour: Monthly Utilization by Job Length



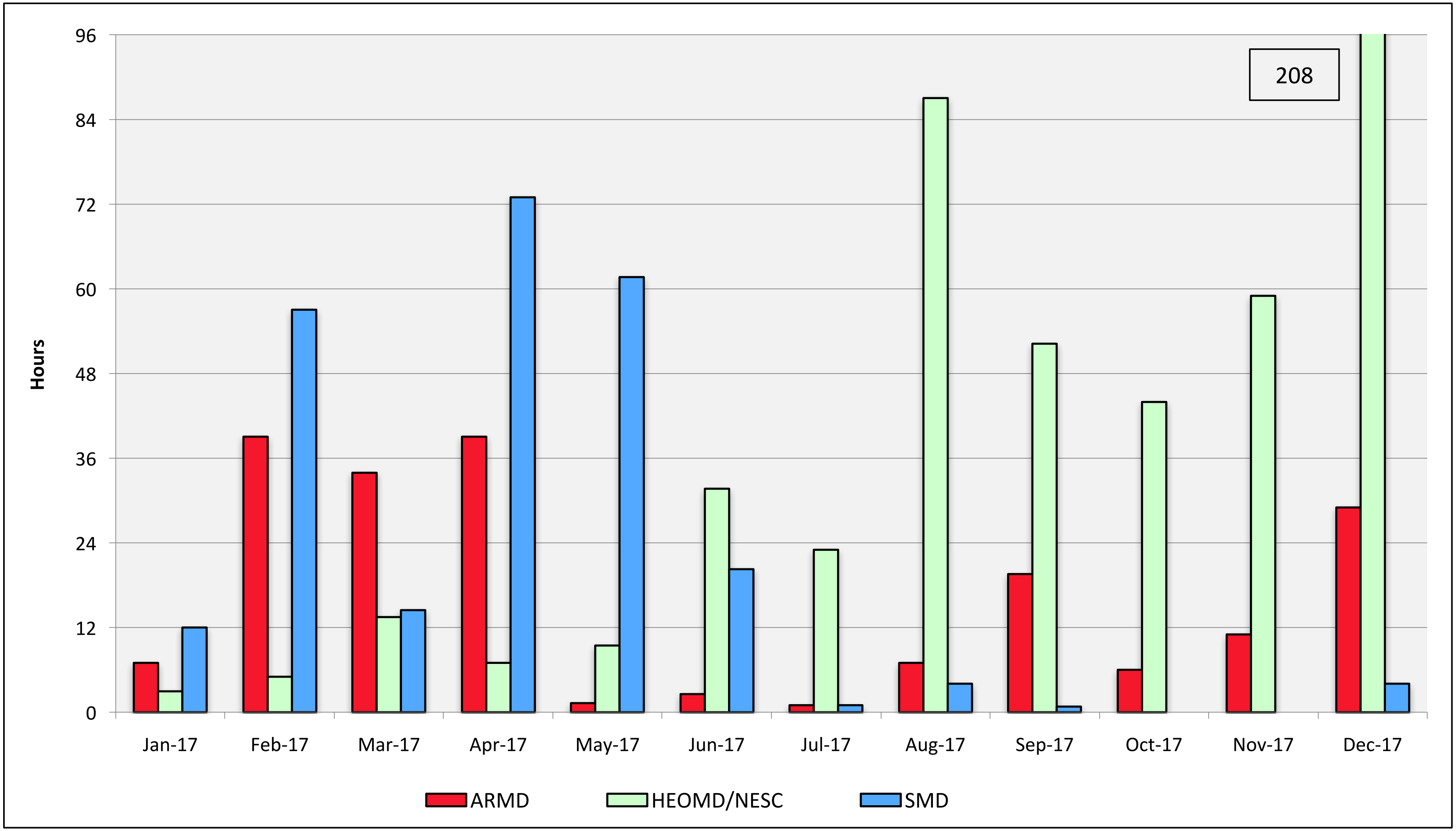
Endeavour: Monthly Utilization by Size and Mission



Endeavour:
Monthly Utilization by Size and Length



Endeavour:
Average Time to Clear All Jobs



Endeavour: Average Expansion Factor