# Project Status Report

## High End Computing Capability

## Strategic Capabilities Assets Program

April 10, 2018

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# HECC Tape Library Reaches Exabyte Capacity with Latest Generation Technology

- HECC recently deployed Linear Tape Open (LTO)-8 tape drives to double the tape library capacity to an exabyte and reduce archive storage costs.
- LTO-8 is the 8th generation of the format and can store 12 terabytes (TB) of uncompressed data per tape. This replaced the previous generation of 6-TB LTO-7 tape drives.
- One of the new features of LTO-8 is the LTO-7 Type M media (LTO-7M), specially formatted for LTO-8 tape drives, and which stores 9 TB of uncompressed data.
  - This provides the advantage of the scale of LTO-7 pricing with increased tape density for a lower cost per TB.
  - As more LTO-8 media comes to market, it will become even more cost effective than the LTO-7M media.
- HECC has a small number of pristine LTO-7 tapes that can be converted into LTO-7M media once new firmware is released by Spectra Logic. This provides an additional 1.8 petabytes of uncompressed data, for a cost savings of $15K.

**Mission Impact**: Doubling the tape library infrastructure allows HECC to keep pace with the' ever-increasing data storage demands of users supporting NASA science and engineering missions.




Currently, the six HECC tape libraries store just under 200 petabytes of dual-copy data, with a monthly growth rate of 3 petabytes.

***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

# Systems Team Upgrades Cluster Management Software on Electra

- During dedicated time for Electra from Feb 26 to March 2, HECC and HPE engineers upgraded the cluster management software on Electra, and spent time debugging and diagnosing cluster management issues.
- A dozen issues and enhancements were identified to improve the software's operations and functionality. HPE collected information and is working to address these issues and enhancement requests.
- In addition to the testing activities, system maintenance activities included:
  - Consolidating the cluster management systems by merging admin nodes.
  - Updating infrastructure systems.
  - Changes to the management network.
- Some of these changes were made in order to support and prepare for an HECC-wide dedicated time (see slide 4).

**Mission Impact**: Improvements to the cluster management software results in more time available for HECC engineers to focus on other aspects of the systems for users.



Before the recent dedicated time, the Electra supercomputer was using two independent management systems, one each for the Broadwell and Skylake halves. This configuration has now been consolidated into a single cluster management system.

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# Maintenance on HECC Systems Completed Successfully

- System engineers successfully completed maintenance activities on HECC resources during a scheduled downtime on March 12.
- The primary activities included: updating the firmware on the InfiniBand switches; upgrading the NFS servers operating system; and applying operating system patches and software updates.
- Additional activities included:
  - Performed NFS InfiniBand testing.
  - Performed archive performance testing.
  - Consolidated infrastructure system management.
  - Replaced faulty hardware components.
- The downtime activities were limited to tasks that could not be performed during normal operations without risk.

**Mission Impact**: Regular maintenance on the HECC systems provides a stable and well-performing environment for NASA users, and results in fewer unscheduled downtimes impacting HECC system availability.



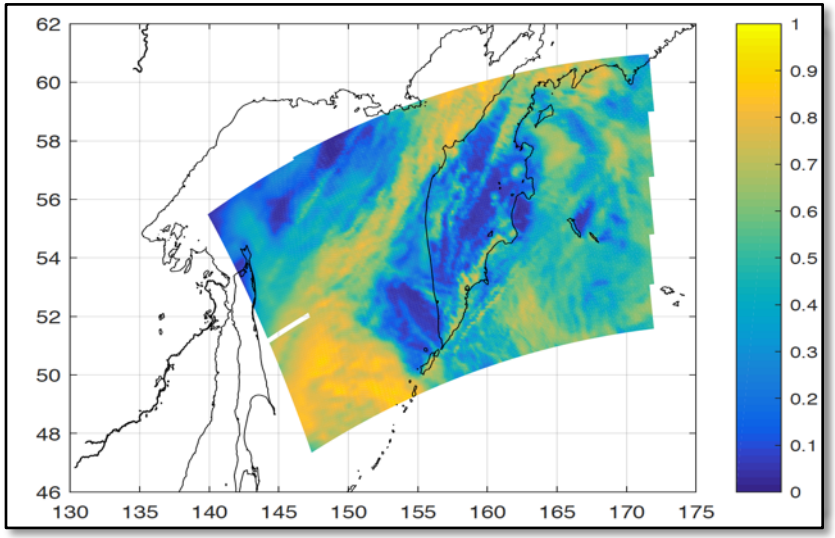

Quarterly maintenance on HECC systems allows for routine maintenance activities to be completed that cannot be done transparently during normal operations.

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

# Applications Experts Improve Efficiency of Radiative Transfer Model by a Factor of 12

- HECC Application Performance and Productivity (APP) experts achieved a performance breakthrough, working with user Wan Wu at NASA Langley on the Principal Component Radiative Transfer Model (PCRTM) for climate observing system simulations.
- The model uses nested scripts to run tens of thousands of simulations in parallel. Each independent parallel process was doing very inefficient I/O to a temporary file on the Lustre nobackupp8 filesystem, constantly checking on the presence of the file, reading or writing a few bytes, closing and deleting the file, and placing a heavy load on the metadata server for nobackupp8.
- By changing the scripts to put the file in /tmp rather than on nobackupp8, APP staff sped up each process by a factor of 12. The reason for this performance improvement: /tmp on each compute node is part of memory, so the key enhancement is replacing slow Lustre latencies with much faster memory latencies.
- The win is even more significant when several jobs are run concurrently, because the single point of contention—putting a heavy load on the metadata server—caused destructive interference that not only slowed down Wu's own jobs, but those of other users doing I/O to nobackupp8.

**Mission Impact:** A new methodology of replacing inefficient I/O with a four- to five-order of magnitude faster I/O provided significant application speedups and reduced HECC system instability, and is now being applied to other user applications.



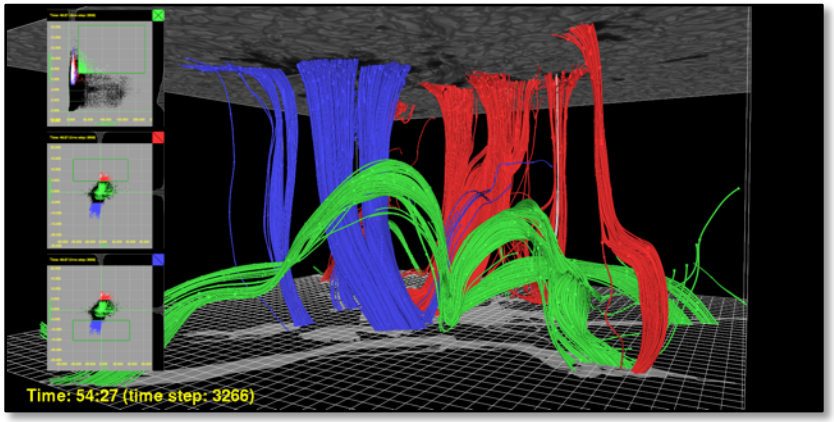

PCRTM Simulated Moderate-resolution Imaging Spectroradiometer (MODIS) Band 13 Reflectance. Compute-intensive simulations: one day MODIS includes more than 130 granules; each granule includes 203X135 pixels; forward simulation for each pixel takes approximately 10 seconds using the high-speed radiative transfer code.

***POC***: Johnny Chang, johnny.chang@nasa.gov, (650) 604-4356, NASA Advanced Supercomputing Division, CSRA LLC

# Choosing Field Lines Via Linked Scatterplots: A New Technique for Vector Field Exploration

- Working with solar researchers at Michigan State University and the University of Utah, HECC visualization experts developed a new technique for seeding magnetic field lines in large, time-varying magnetohydro-dynamic datasets, in order to identify scientifically interesting structures.
  - Seeding field lines in order to identify structures is a challenging problem, especially with time-varying data.
  - The Visualization team's approach combines a classic technique, linked scatterplots, with new field-line attribute measures to create a powerful, flexible environment for exploration.
- Using the new technique, the team identified structures of interest to the domain scientist that were much more difficult to locate by previous methods (see slide 10).
- The team submitted a description of the technique, "Choosing Field Lines Via Linked Scatterplots," to IEEE Vis 2018.

**Mission Impact**: This new visualization technique will lead to greater insight from magnetohydrodynamic simulations, and ultimately, to other types of vector field data, such as the typical flow field output of aeronautics computational studies.




Using scatterplots to select field lines in the solar convection zone. Each point in the scatterplots corresponds to a field line. Researchers used the top scatterplot (green selection and field lines) to choose lines that have an arching shape, and the second and third plots to choose field lines with a dominant direction towards the bottom of the domain (red) and towards the top of the domain (blue).

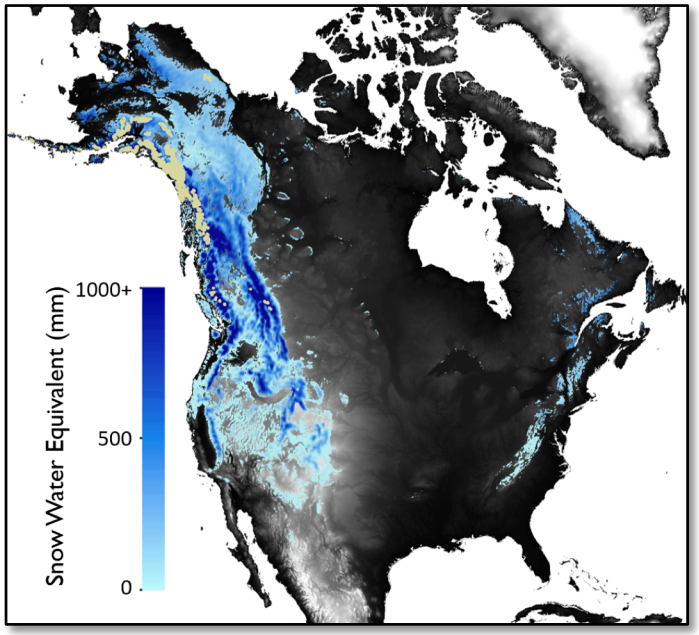
***POC***: Patrick Moran, patrick.moran@nasa.gov, (650) 604-1660, NASA Advanced Supercomputing Division.

# Simulations Suggest Mountains Hold a Disproportionate Amount of Continental Snow*

- Researchers at Ohio State University used Pleiades to run regional model simulations over 3.5 million km$^2$ of mountain area to produce a new estimate of mountain snow accumulation for North America.
- The simulation results suggest North American mountains hold nearly three times as much snow as previously estimated from global models, with mountain snow water storage of ~1000 km$^3$.
  - Mountains hold a disproportionate amount of snow. Though only 25% of the continental land area, mountains accumulate 60% of the snow.
  - This highlights the importance of mountains to the continental water budget, particularly in winter months.
- The new estimate can be used as a present-day benchmark value with which to compare future simulations (e.g., the Coupled Model Intercomparison Project and the Intergovern-mental Panel on Climate Change).

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

**Mission Impact**: Supported by HECC resources, regional climate model simulations of mountains not only improve our knowledge of the water budget but also highlight the need for a satellite capable of measuring snow depth in complex terrain.




Peak snow water equivalent, in millimeters, for mountain areas of North America. Tan areas indicate glaciers/permanent snow, which were excluded from the Ohio State University analysis.

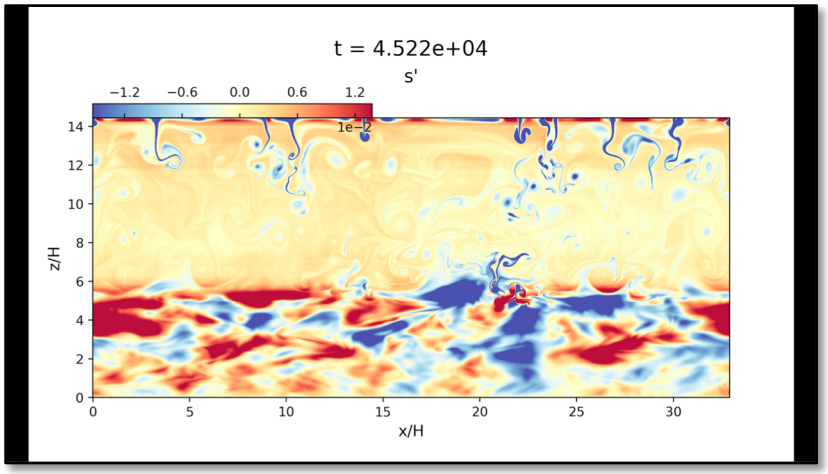
***POCs***: Melissa Wrzesien, wrzesien.1@osu.edu; Michael Durand, durand.8@osu.edu, (614) 247-4835, Ohio State University and Byrd Polar and Climate Research Center

# Pleiades Simulations Help Reveal Magnetic Convection in Stars like Our Sun*

- Astrophysicists at the University of Colorado are running simulations on Pleiades to help them better understand the interior physics of stars like our Sun.
  - The researchers are studying the transition boundary between the convective and wave regions, called the tachocline, which is thought to be an important part of the solar magnetic dynamo.
  - In many solar dynamo theories, this region is where magnetic fields are stored and organized over an 11-year solar cycle.
- Results have shown that the boundary region may be very different than previously thought:
  - Internal gravity waves act to efficiently stop the turbulent convection, likely limiting the connections between the dynamo-generated magnetic fields in the convection zone and the stable interior.
  - This boundary region may play a surprisingly small role in the operation of the solar dynamo. If true, this suggests that solar and stellar dynamos operate very differently than our current conceptual models.
- Simulations are conducted in 2D and 3D, typically running on between 512 and 16,380 cores and requiring 24 to 120 hours of evolution.

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

**Mission Impact**: Simulations run on HECC resources help astrophysicists understand the rotating, stratified, magnetized dynamo systems of stars, supporting one of NASA's fundamental goals in Astrophysics—to "explore the origin and evolution of the galaxies, stars and planets that make up our universe."



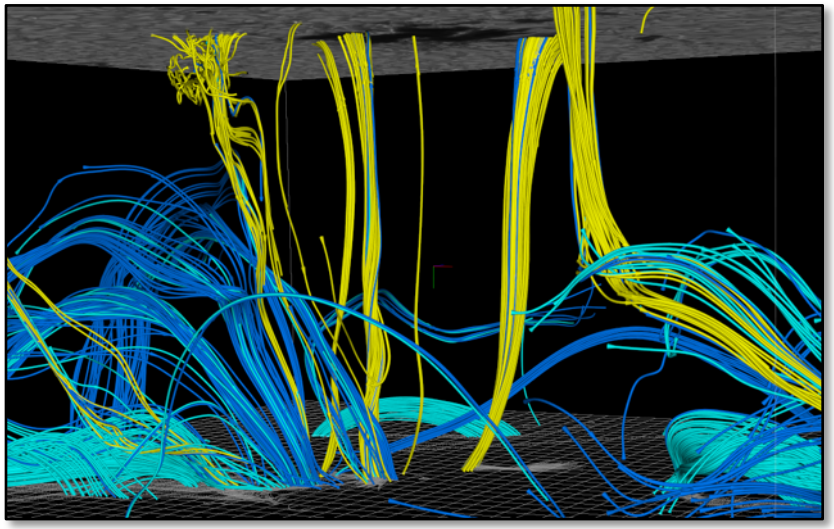

Movie from a simulation of stratified stellar convection showing entropy fluctuations, with the convection zone above and a wave region below. Hot, high entropy (red) fluid rises in the convection zone, while cold, low entropy (blue) fluid falls. Watch as the waves amplify and break into the convection zone above. The simulation was produced using the open-source Dedalus pseudospectral framework.

***POC***: Benjamin Brown, bpbrown@colorado.edu, (303) 492-8647, Astrophysical & Planetary Sciences, University of Colorado

# Interactive Exploration of Magnetic Field Lines Reveals New Solar Phenomena*

- Earth's space weather is driven by magnetic activity in the Sun. Space weather events can harm astronauts, disable satellites, disrupt radio communication and global positioning systems, and interfere with electricity distribution.
- Researchers in the Physics and Astronomy Department at Michigan State University ran magnetohydrodynamics (MHD) simulations on Pleiades to understand the role of solar magneto-convection space weather events.
  - Simulation results, coupled with HECC's advanced visualization techniques (see slide 7) supporting interactive exploration of magnetic field data, help to clarify the evolution of solar magnetic fields and detect emerging magnetic features that drive the production of sunspots and solar eruptions.
  - Researchers identified key processes involved in the production of sunspots, flares, and coronal mass ejections.

**Mission Impact**: HECC supercomputers and visualization experts helped identify key processes in the space weather events—furthering NASA's scientific goals to understand the Sun, its variations, and its interactions with Earth and the solar system.



Snapshot of magnetic field lines in the solar convection zone. Convective upflows and downflows advect the magnetic field into coherent loop-like structures that can emerge through the solar surface, producing sunspots as well as occasional flares and coronal mass ejections of energetic particles and radiation. *Nina McCurdy, University of Utah; Patrick Moran, NASA/Ames*

***POCs***: Nina McCurdy, University of Utah, nina@cs.utah.edu;
Patrick Moran, patrick.moran@nasa.gov, (650) 604-1660,
NASA Advanced Supercomputing Division

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

# HECC Facility Hosts Several Visitors and Tours in March 2018

- HECC hosted 16 tour groups in March; guests learned about the agency-wide missions being supported by HECC assets, and some groups also viewed the D-Wave 2000Q quantum computer system. Visitors this month included:
  - Patrick Koller, CEO of Faurecia SA, Nanterre, France.
  - Masha Kuznetsova, Director, Community Coordinated Modeling Center (CCMC), NASA Goddard Space Flight Center; and members from the CCMC software development team.
  - Lakshmi Karan, Executive Director, Genentech Foundation.
  - NASA's Aerospace Safety Advisory Panel.
  - Professor Kozo Fujii, with three additional professors and ten students from the Tokyo University of Science.
  - University of Arizona chapter of Students for the Exploration and Development of Space.
  - Students from Fordham University Bronx, NY.



Cetin Kiris, Chief, NAS Applied Modeling and Simulation Branch, led a tour of the NAS facility for students from the Tokyo University of Science.

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

# Papers

- "**Kepler Data Visualization I – Architecture, Diagnostic Tests, and Data Products for Vetting Transiting Planets Candidates**," J. Twicken, J. Catanzarite, B. Clark, et al., arXiv:1803.04526 [astro-ph.EP], March 12, 2018. *
  *https://arxiv.org/abs/1803.04526*
- "**Formation of Dawn-Dusk Asymmetry in Earth's Magnetotail Thin Current Sheet: A Three-Dimensional Particle-in-Cell Simulation**," S. Lu, P. Pritchett, V. Angelopoulos, A. Atremyev, Journal of Geophysical Research: Space Physics (accepted for publication), March 12, 2018. *
  *https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1002/2017JA025095*
- "**Computational Investigation of a Boundary-Layer-Ingestion Propulsion System**," B. Blumenthal, et al., Journal of Aircraft (accepted article), March 13, 2018. *
  *https://arc.aiaa.org/doi/abs/10.2514/1.C034454*
- "**Mesoscopic Modeling of the Uniaxial Compression and Recovery of Vertically Aligned Carbon Nanotube Forests**," B. Wittmaack, A. Vilkov, L. Zhigilei, Composites Science and Technology, March 14, 2018. *
  *https://www.sciencedirect.com/science/article/pii/S0266353817330683*
- "**As a Matter of Force–Systematic Biases in Idealized Turbulence Simulations**," P. Grete, B. O'Shea, K. Beckwith, arXiv:1803.05481 [physics.flu-dyn], March 14, 2018. *
  *https://arxiv.org/abs/1803.05481*
- "**Modelling the Bow Shock Pulsar Wind Nebulae Propagating Through a Non-Uniform ISM**," O. Toropina, M. Ramanova, R. Lovelace, arXiv:1803.06240 [astro-ph.SR], March 15, 2018. *
  *https://arxiv.org/abs/1803.06240*

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

# Papers (cont.)

- "**Electron and Proton Acceleration in Trans-Relativistic Magnetic Reconnection: Dependence on Plasma Beta and Magnetization**," D. Ball, L. Sironi, F. Ozel, arXiv:1803.05556 [astro-ph.HE], March 15, 2018. *
  *https://arxiv.org/abs/1803.05556*
- "**Prandtl-Number Effects in High-Rayleigh Number Spherical Convection**," R. Orvedahl, et al., The Astrophysical Journal, vol. 856, no. 1, March 20, 2018. *
  *http://iopscience.iop.org/article/10.3847/1538-4357/aaaeb5/meta*
- "**The Sensitivity of Solsticial Pauses to Atmospheric Ice and Dust in the MarsWRF General Circulation Model**," C. Lee, et al., Icarus (Elsevier), March 20, 2018. *
  *https://www.sciencedirect.com/science/article/pii/S0019103517306802*
- "**K2-231 b: A Sub-Neptune Exoplanet Transiting a Solar Twin in Ruprecht 147**," J. Curtis, et al., arXiv:1803.07430 [astro-ph.EP], March 20, 2018. *
  *https://arxiv.org/abs/1803.07430*

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

# Presentations

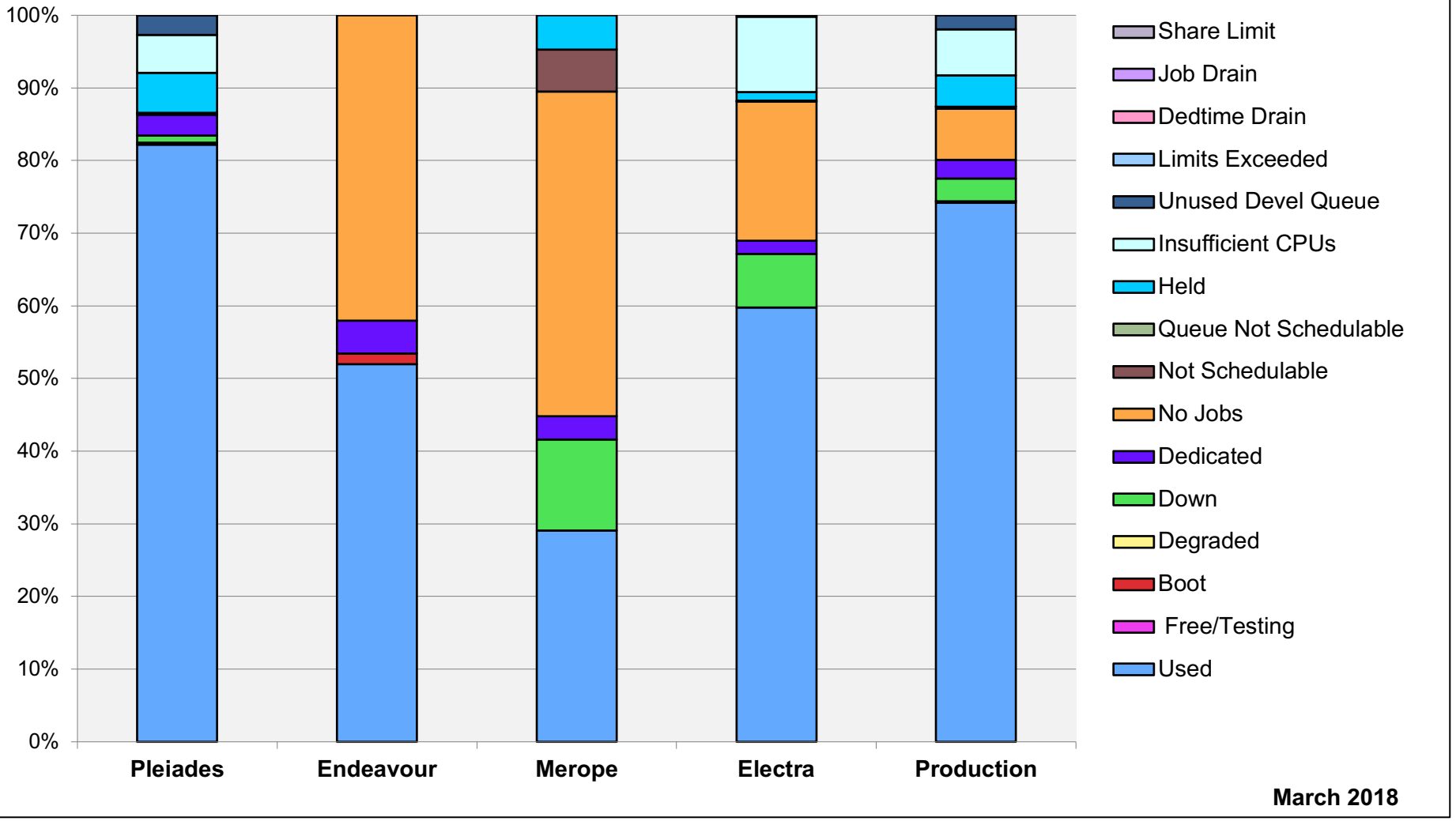



- "**NASA Blazes a Different Path to Energy Efficient Computing**," W. Thigpen, a Conferencias Magistrales at the 9th International Supercomputing Conference in Mexico (ISUM18), Mérida, Yucatán, Mexico, Presented March 7, 2018. *https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20180001924.pdf* (PDF - 33 MB)
- "**Quantum (Enhanced) Machine Learning**," R. Biswas, SIAM Conference on Parallel Processing for Scientific Computing, Tokyo, Japan, Presented March 9, 2018.

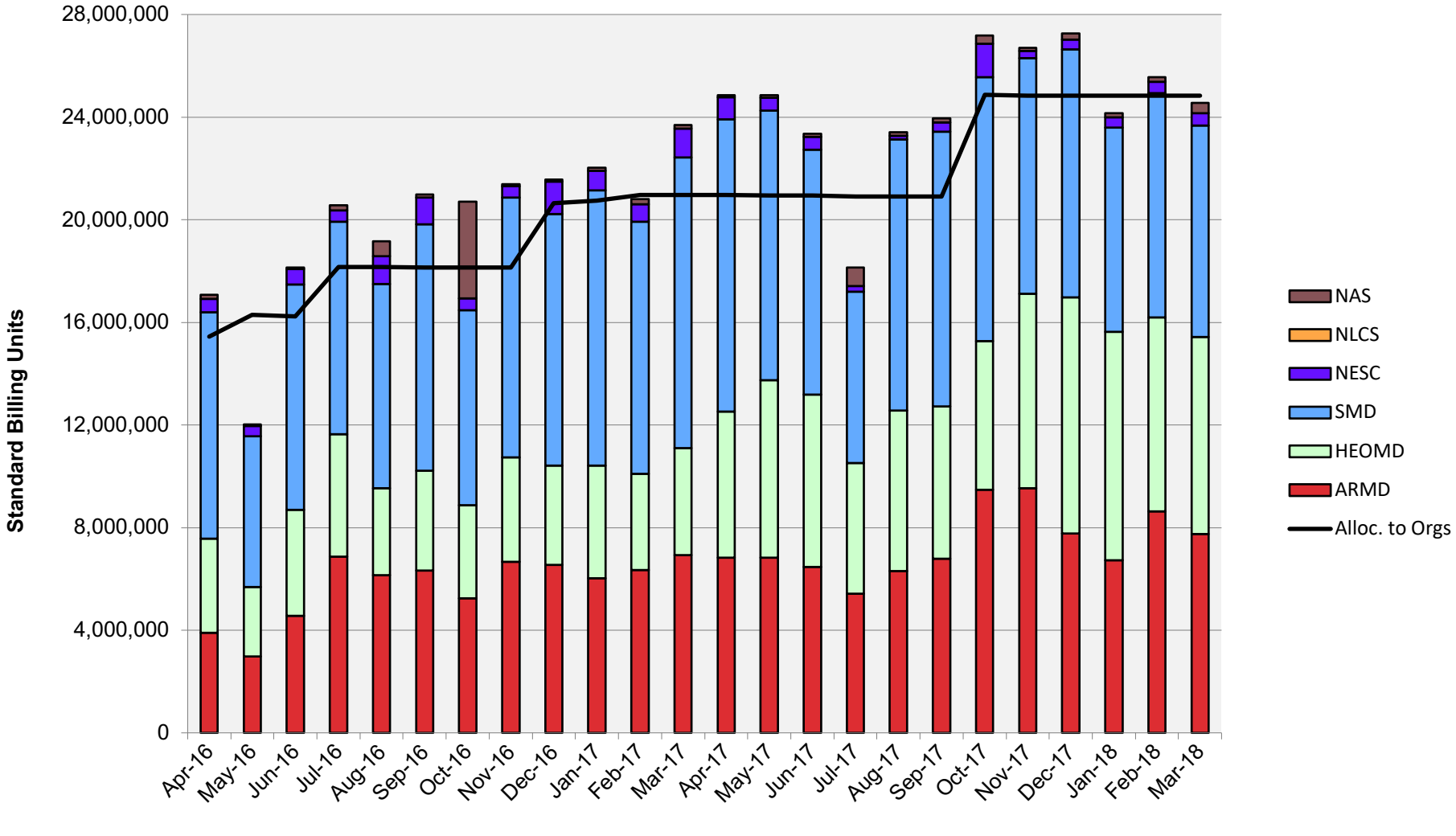
# News and Events

- **Helping Keep Astronauts Safe with Advanced Simulations, Visualizations**, *NAS Feature Story*, March 5, 2018-–Cutting-edge simulations run on the Pleiades supercomputer are helping engineers shape the final configuration of the Orion launch abort vehicle, designed to keep astronauts safe during launch. *https://www.nas.nasa.gov/publications/articles/feature_Orion_acoustics_Cadieux.html*
- **How Much Snow Accumulates in North America Each Year? More Than Scientists Thought**, *Ohio State News*, March 13, 2018—Scientists at The Ohio State University have revised an estimate of snow volume for the entire continent, and discovered that snow accumulation in a typical year is 50% higher than previously thought. So far, they have used 1.8 million core-hours on the Pleiades supercomputer and produced about 16 terabytes of data to run their regional climate computer models. *https://news.osu.edu/news/2018/03/13/moresnow/*
- **NASA Achieves Optimal Energy Efficiency with Its First Modular Supercomputer**, *HPCwire*, March 28, 2018—As the needs and densities of servers and data centers increase, organizations are turning to advanced methods for cooling to bolster their HPC environments. Today, NASA is achieving new levels of water and power efficiency and performance of the Modular Supercomputing Facility (MSF) at NASA's Ames Research Center in Silicon Valley. *https://www.hpcwire.com/solution_content/hpe/government-academia/nasa-achieves-optimal-energy-efficiency-with-its-first-modular-supercomputer/*

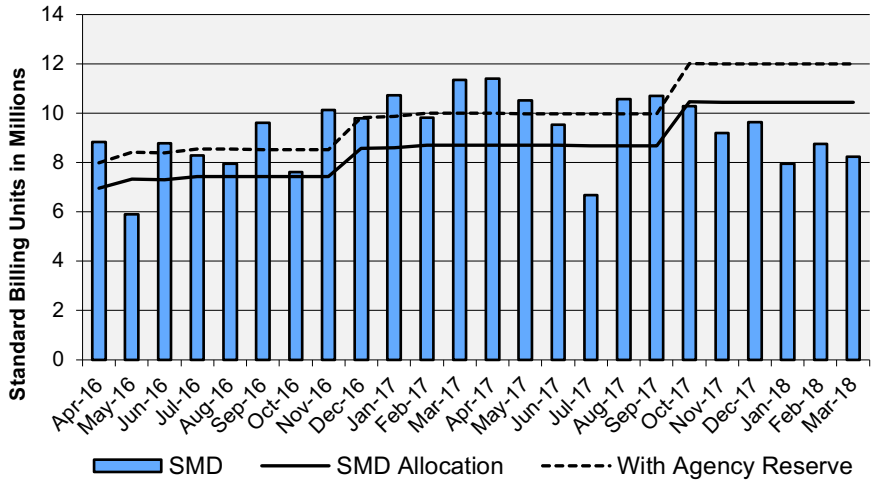
# HECC Utilization

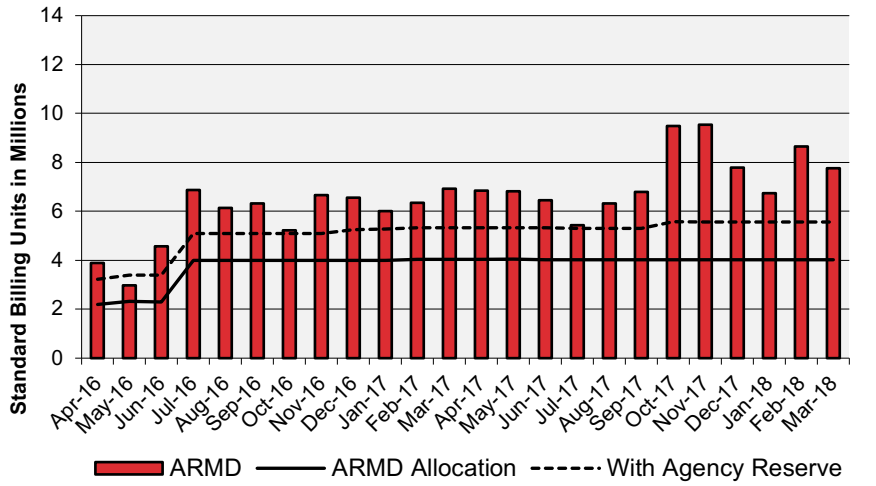


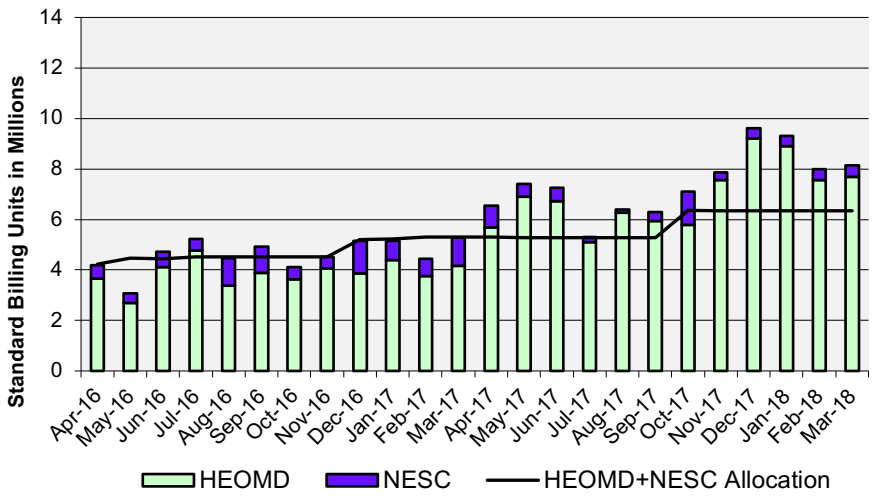
# HECC Utilization Normalized to 30-Day Month



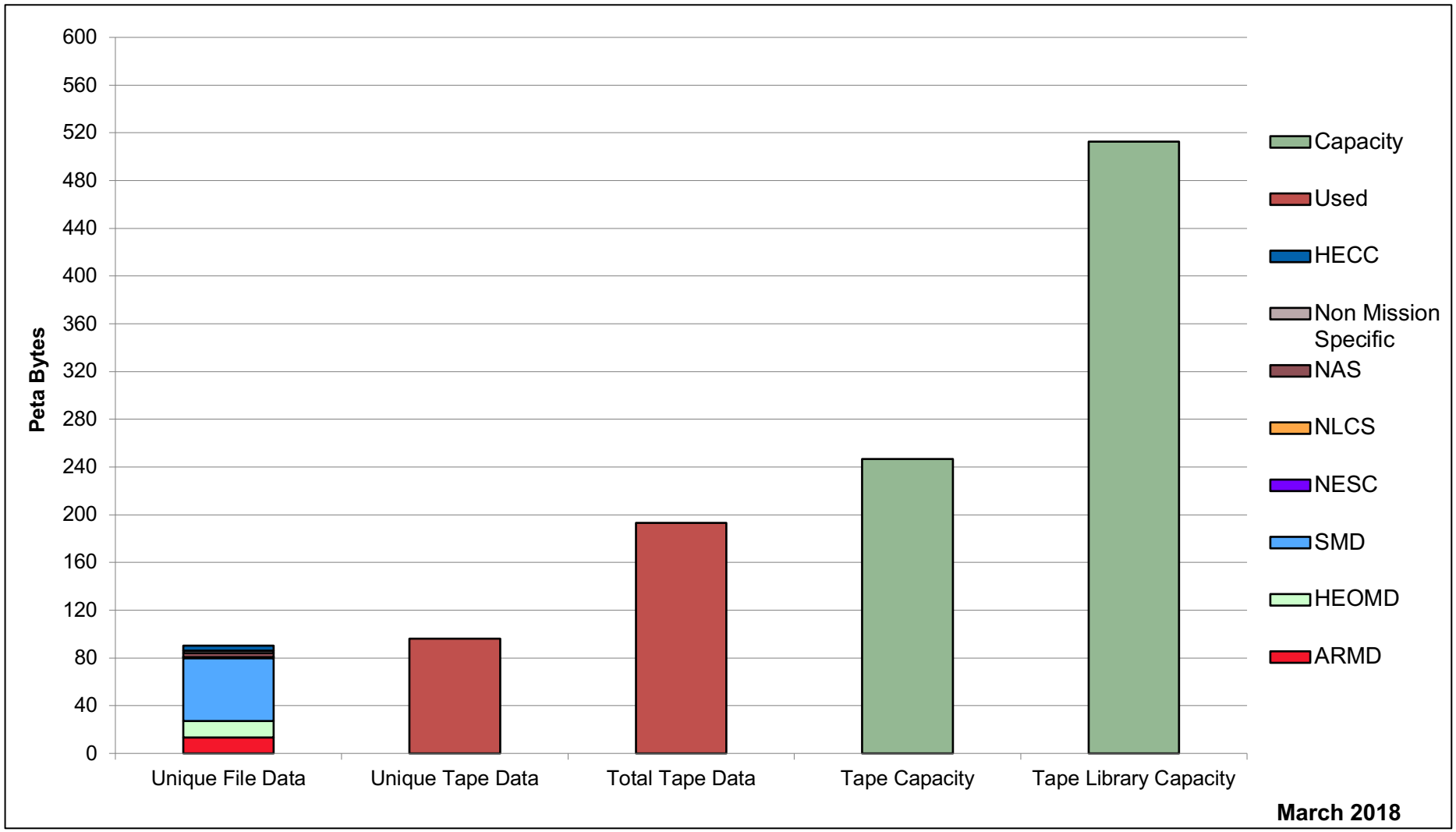
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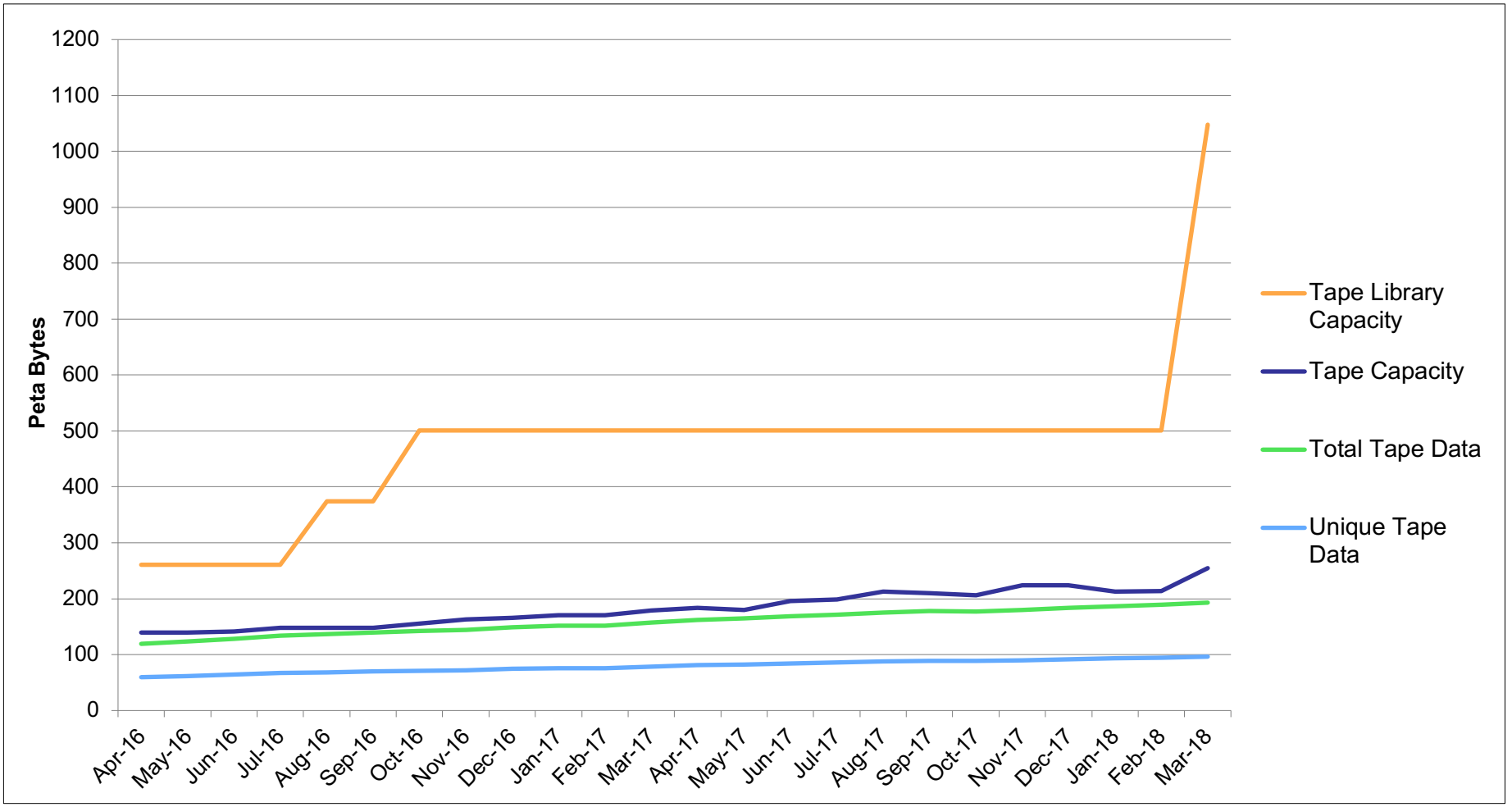



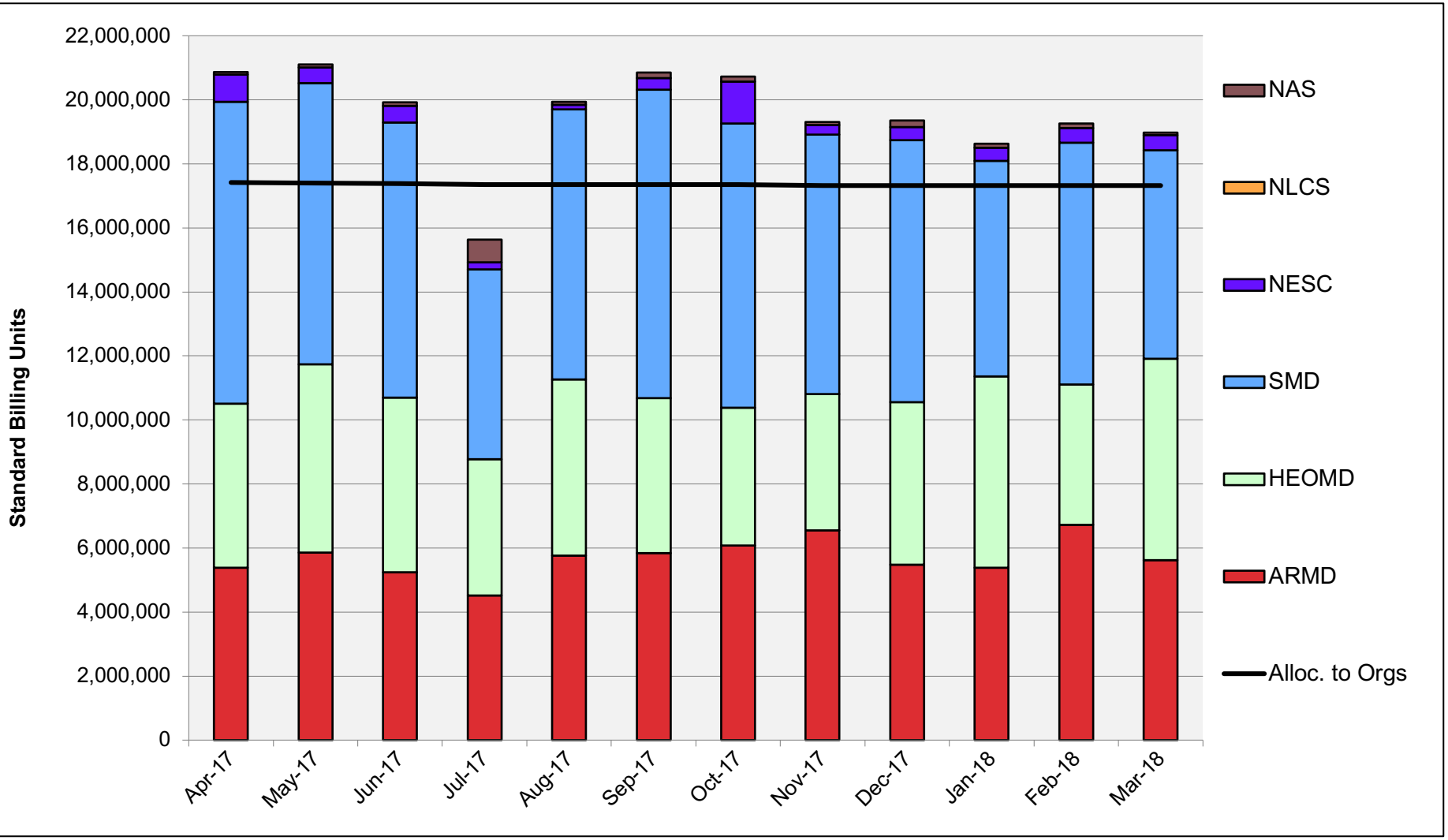
# Tape Archive Status



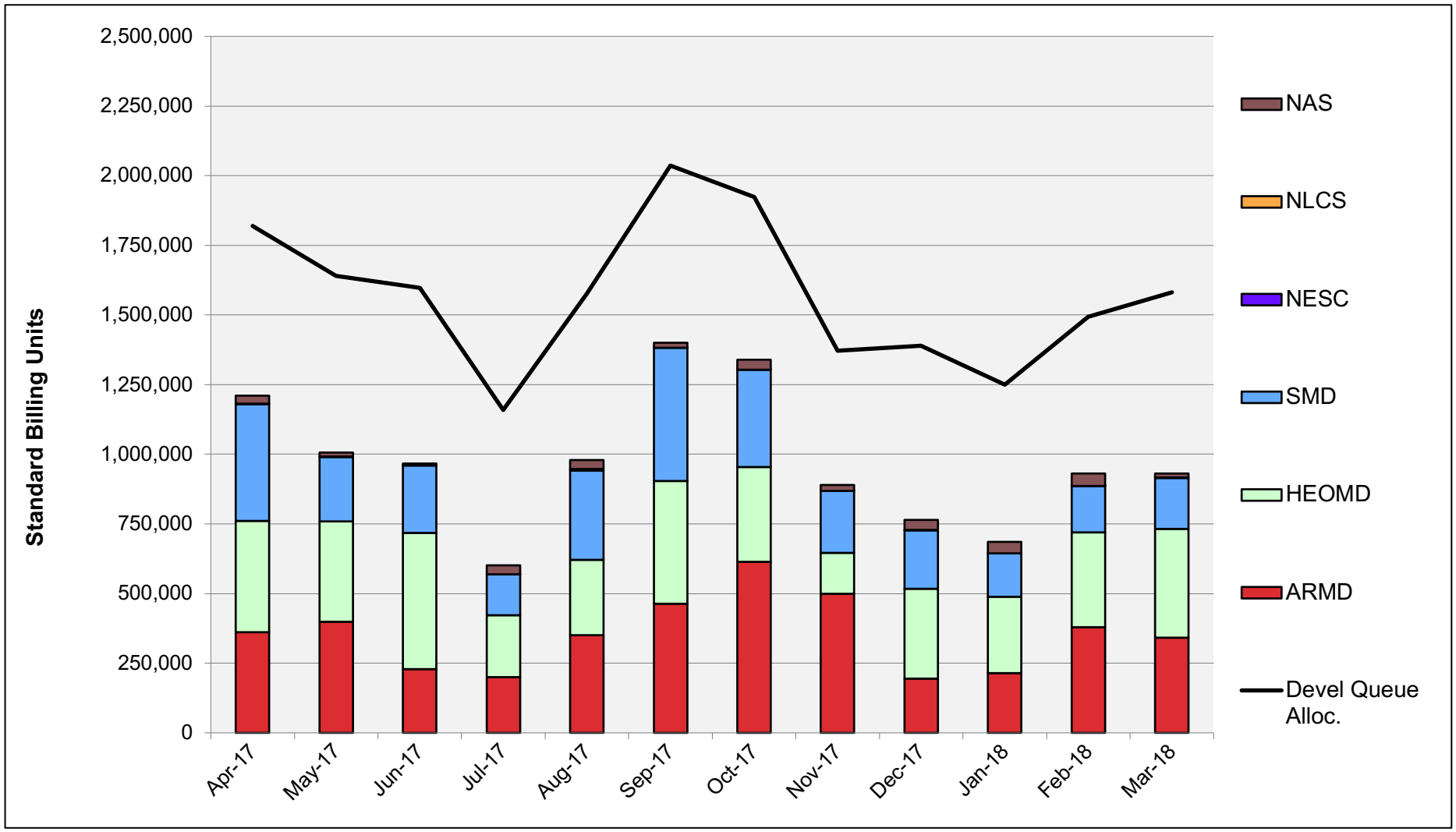
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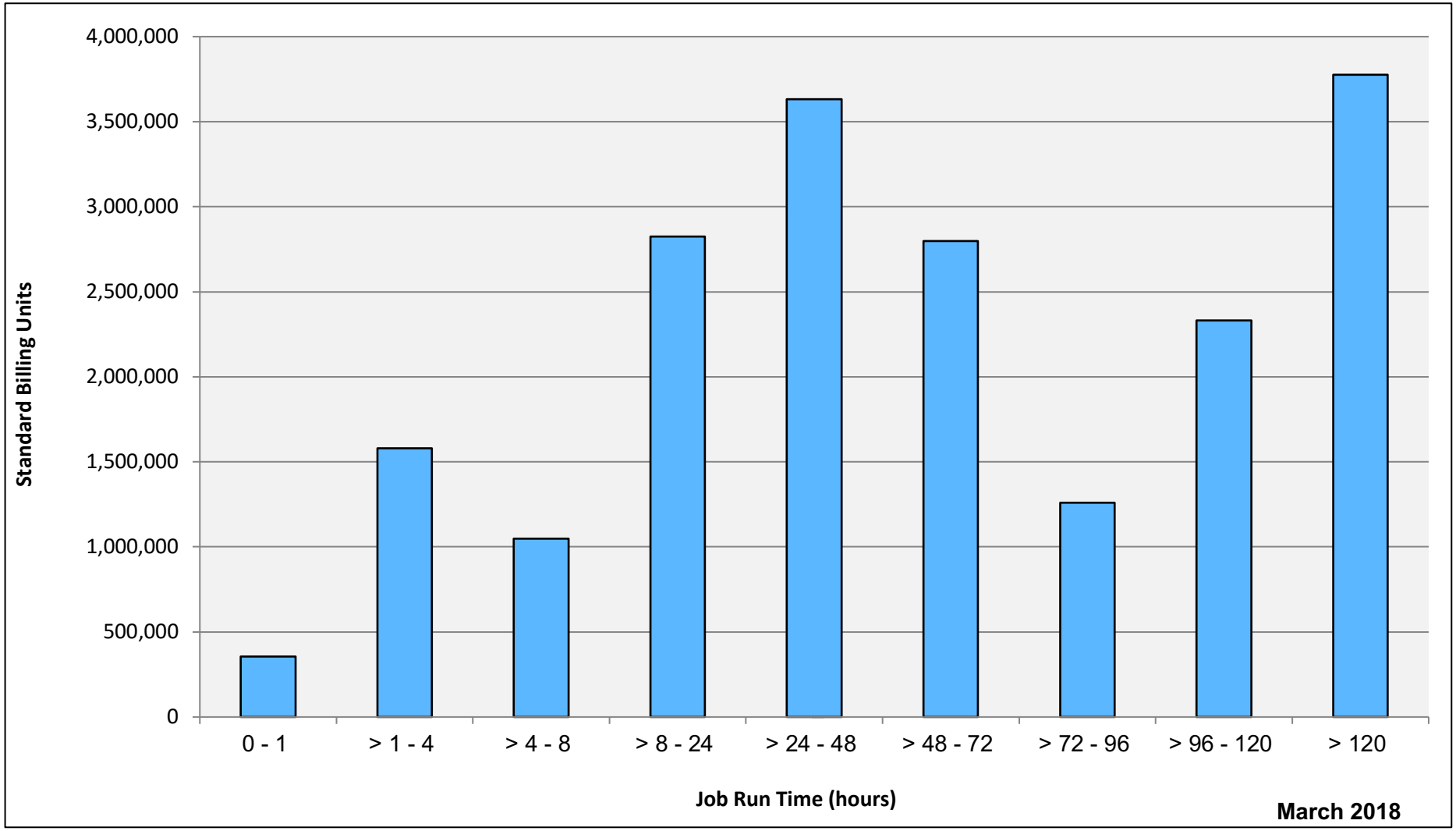
# Pleiades:
# SBUs Reported, Normalized to 30-Day Month



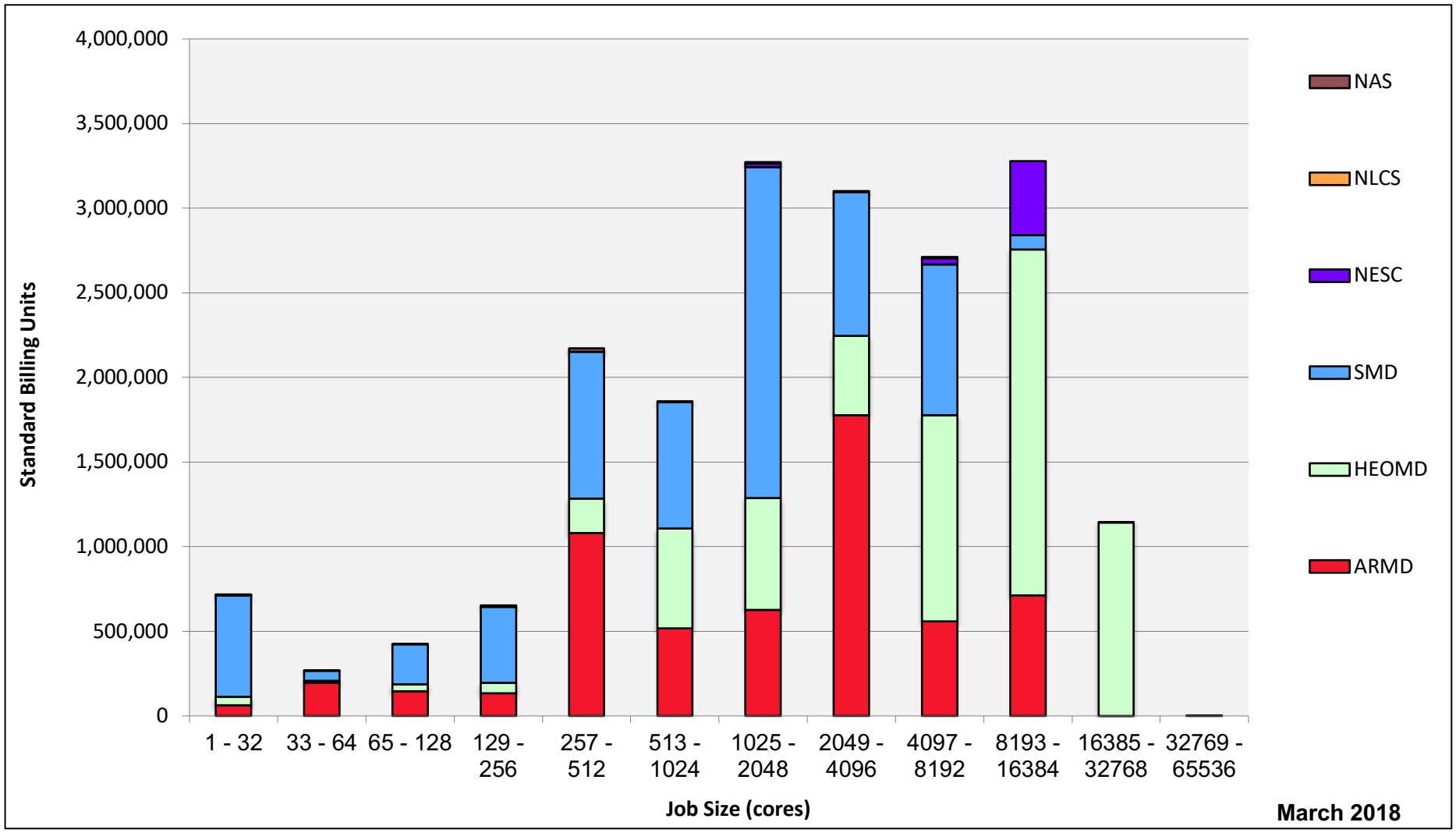
# Pleiades:
# Devel Queue Utilization



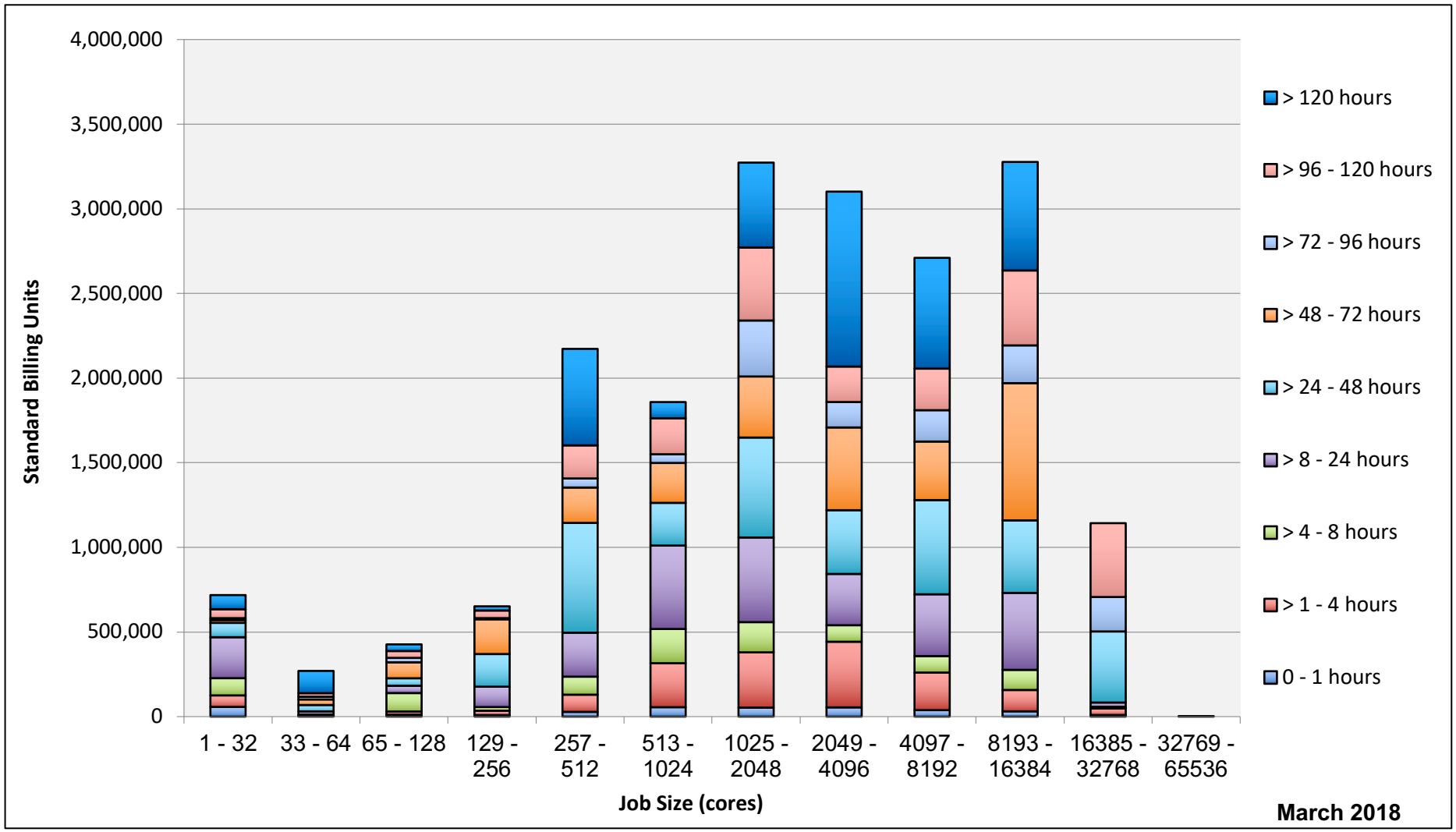
# Pleiades:
# Monthly Utilization by Job Length



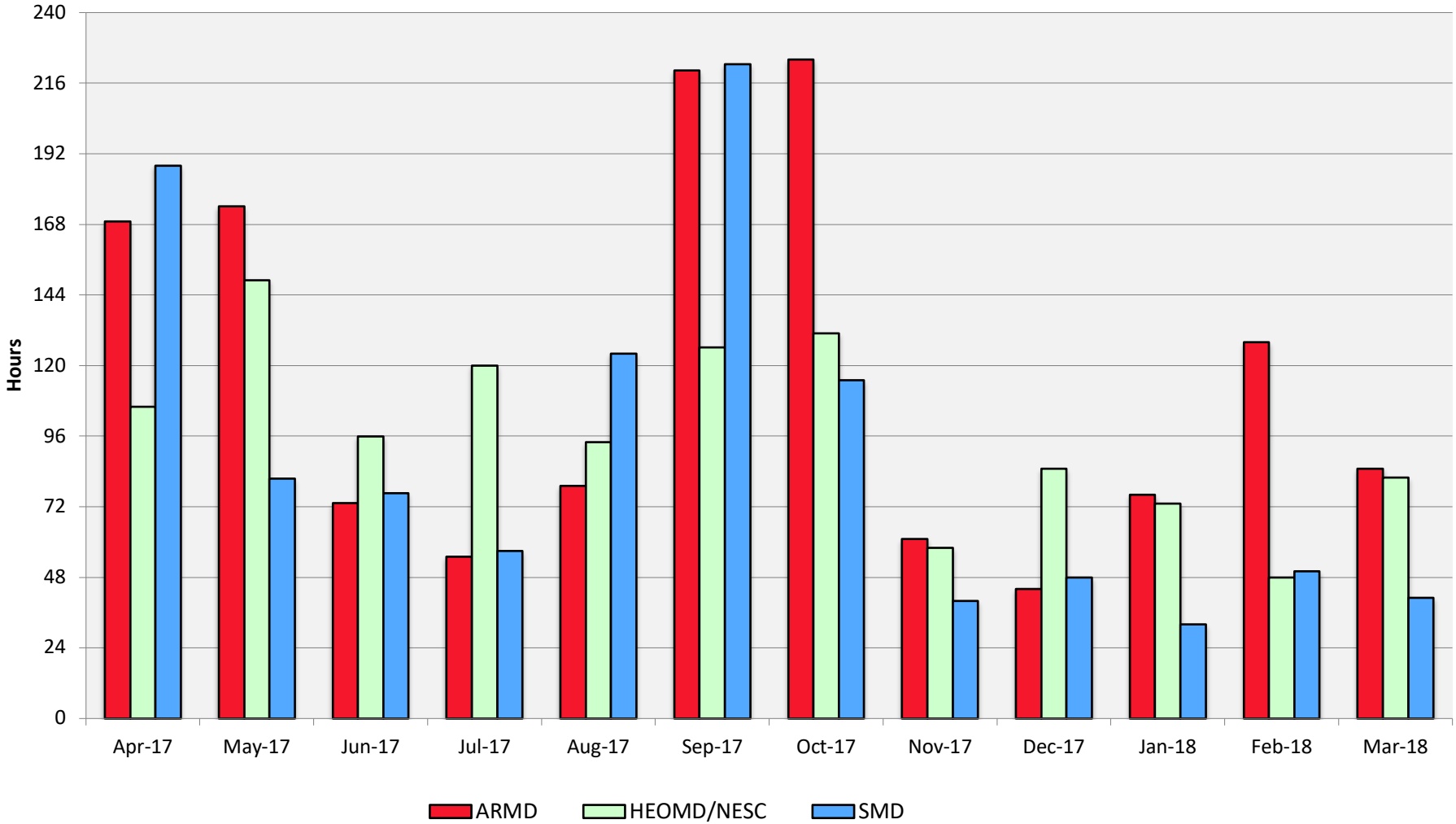
# Pleiades:
# Monthly Utilization by Size and Mission



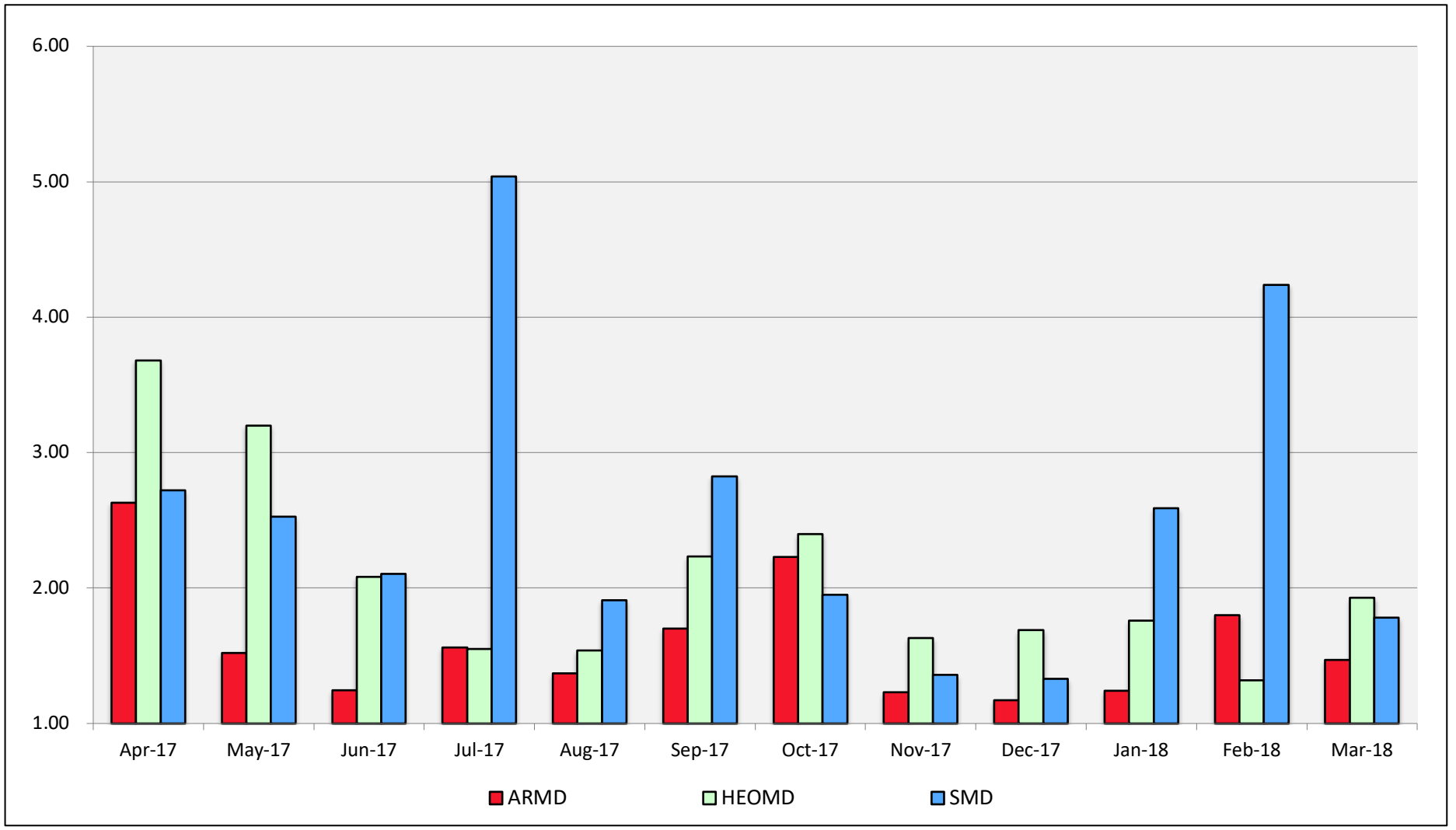
# Pleiades:
# Monthly Utilization by Size and Length



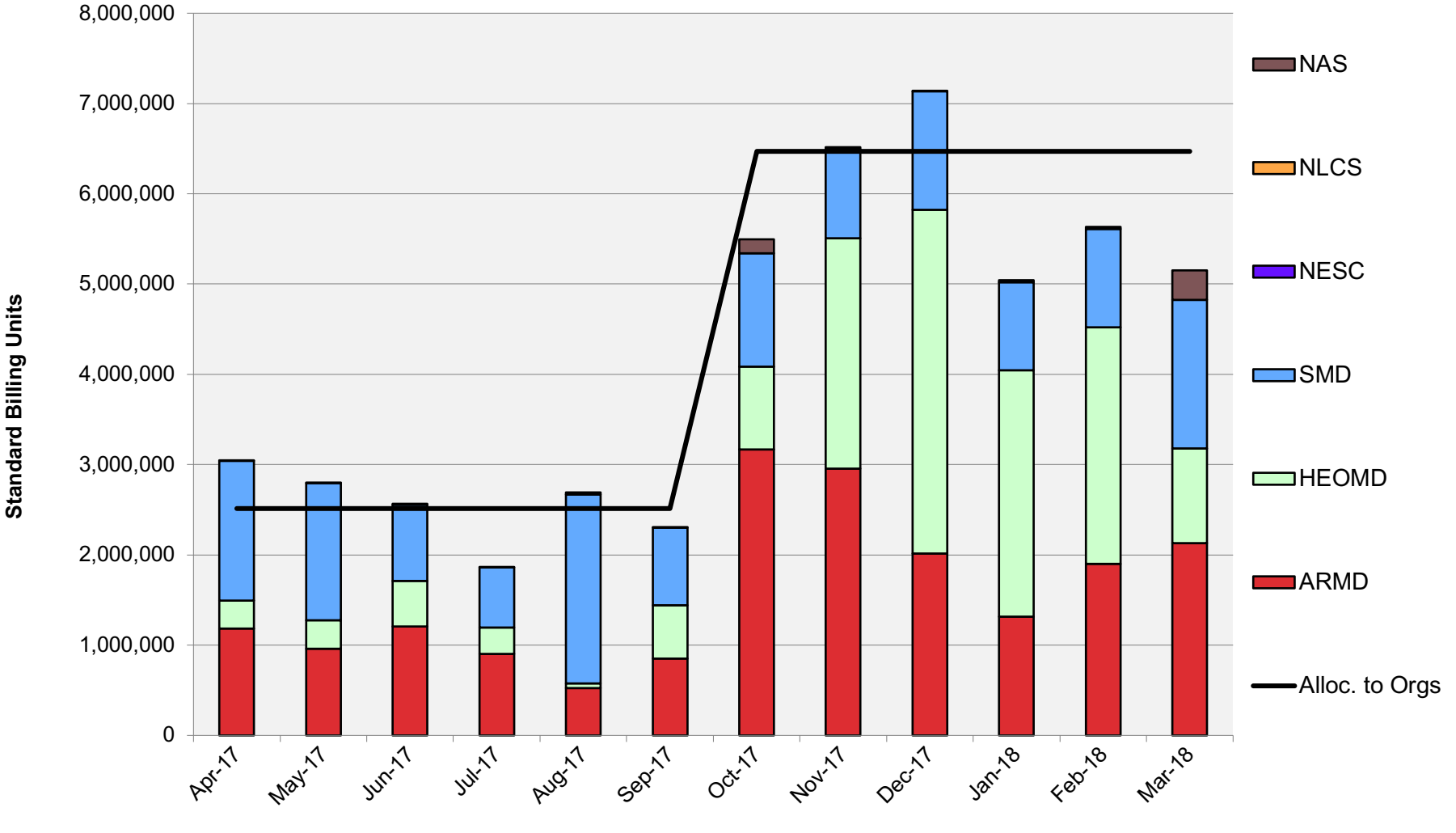
# Pleiades:
# Average Time to Clear All Jobs



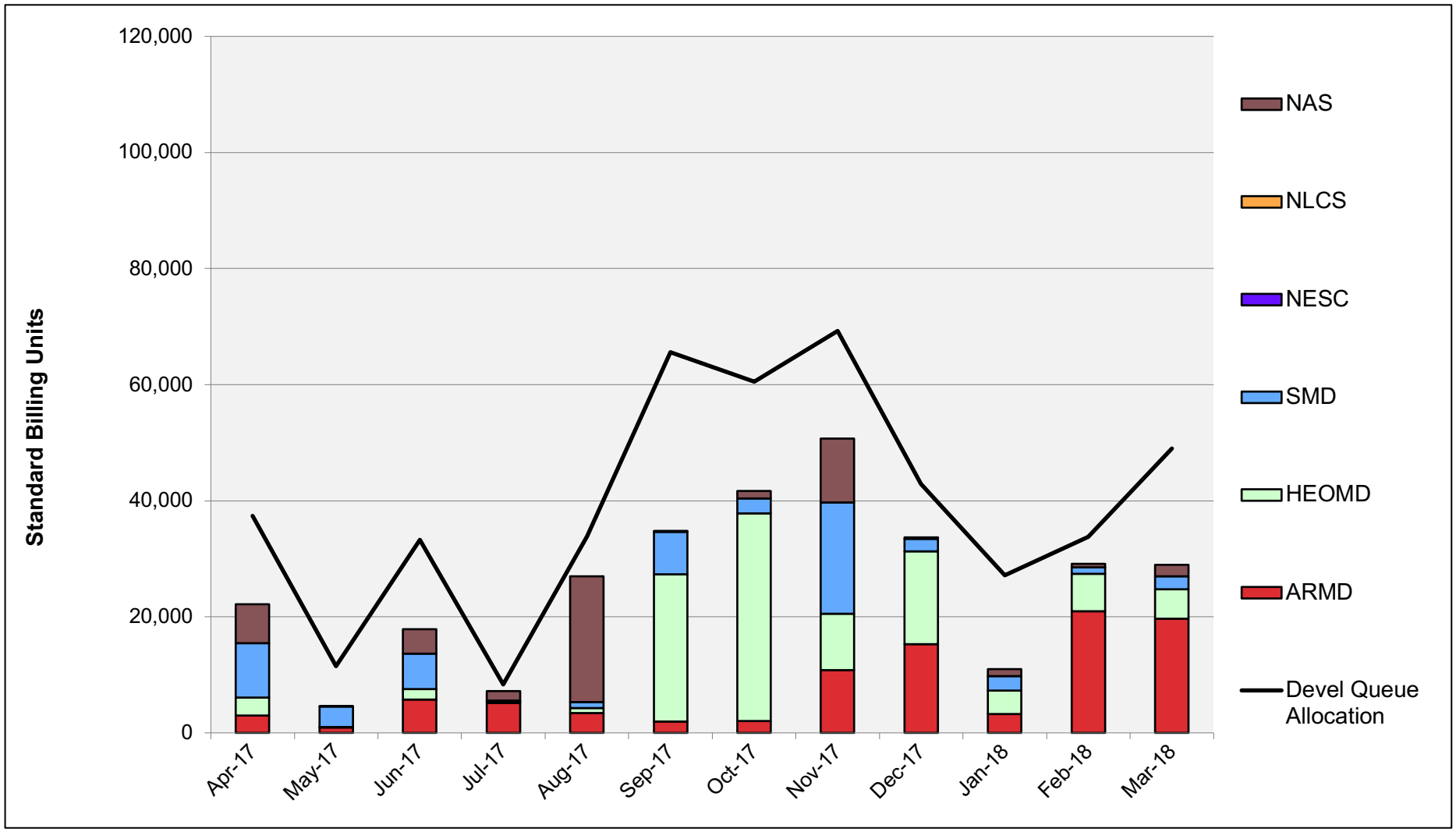
# Pleiades:
# Average Expansion Factor



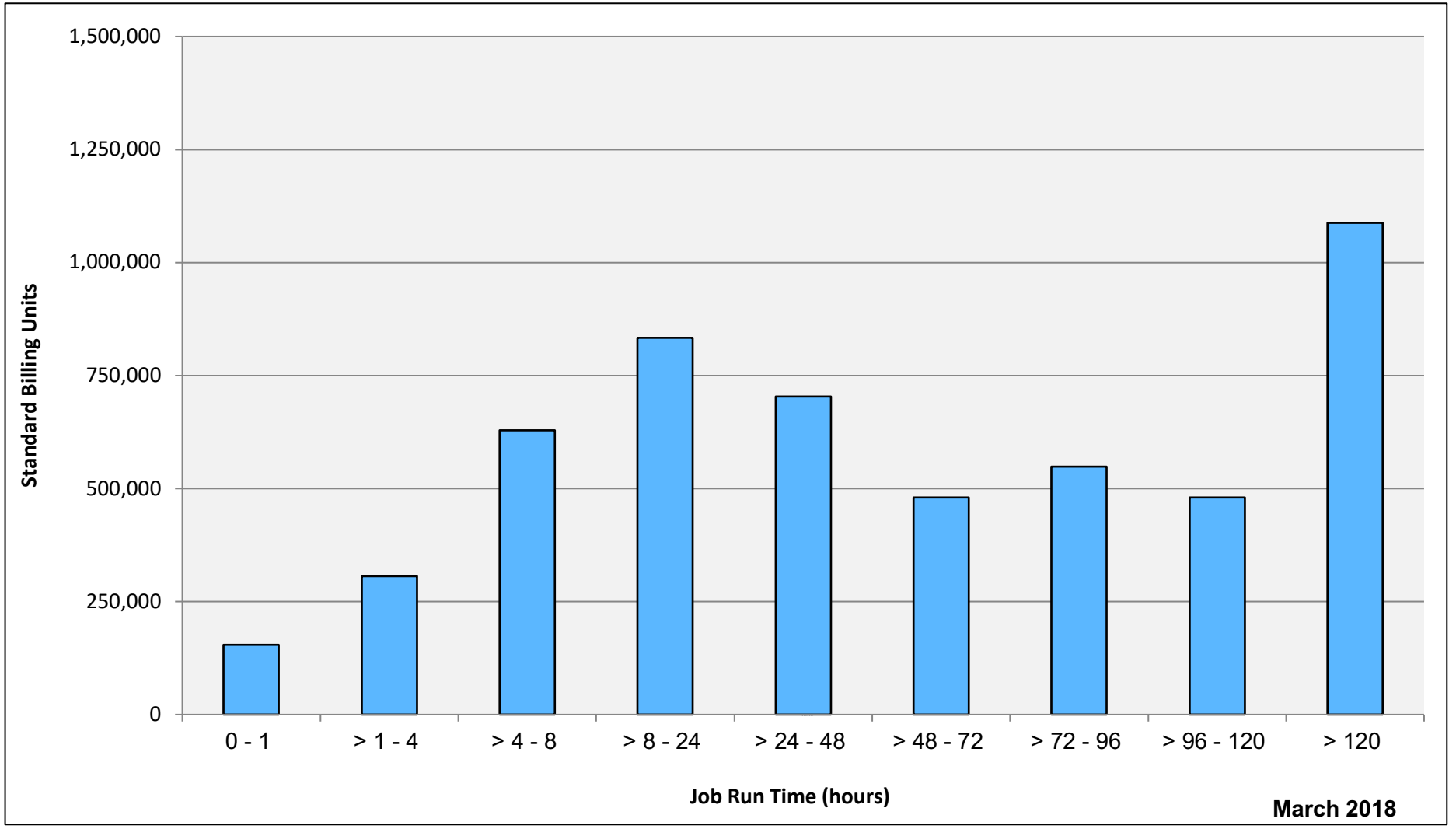
# Electra:
# SBUs Reported, Normalized to 30-Day Month



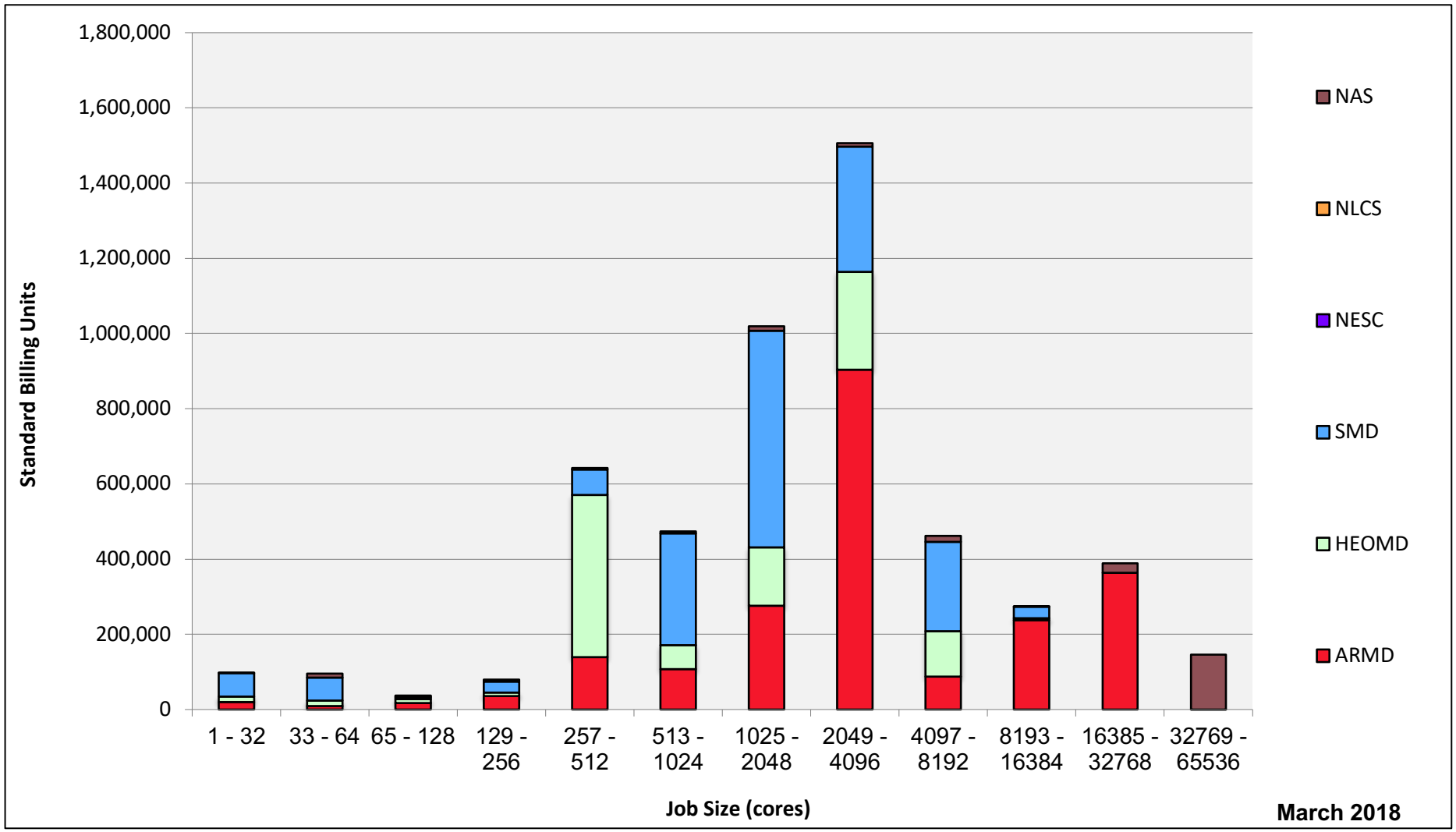
# Electra:
# Devel Queue Utilization



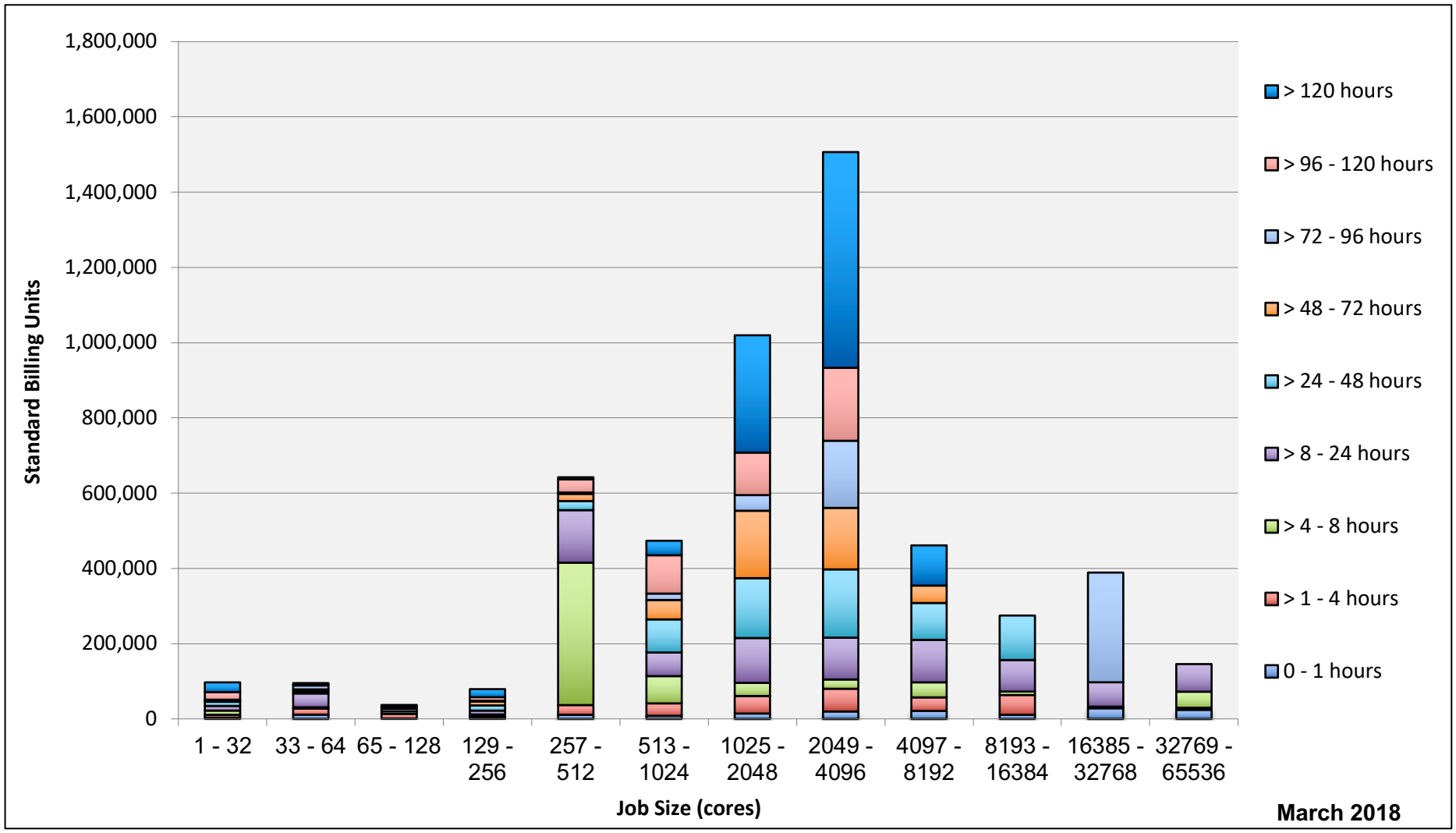
# Electra:
# Monthly Utilization by Job Length



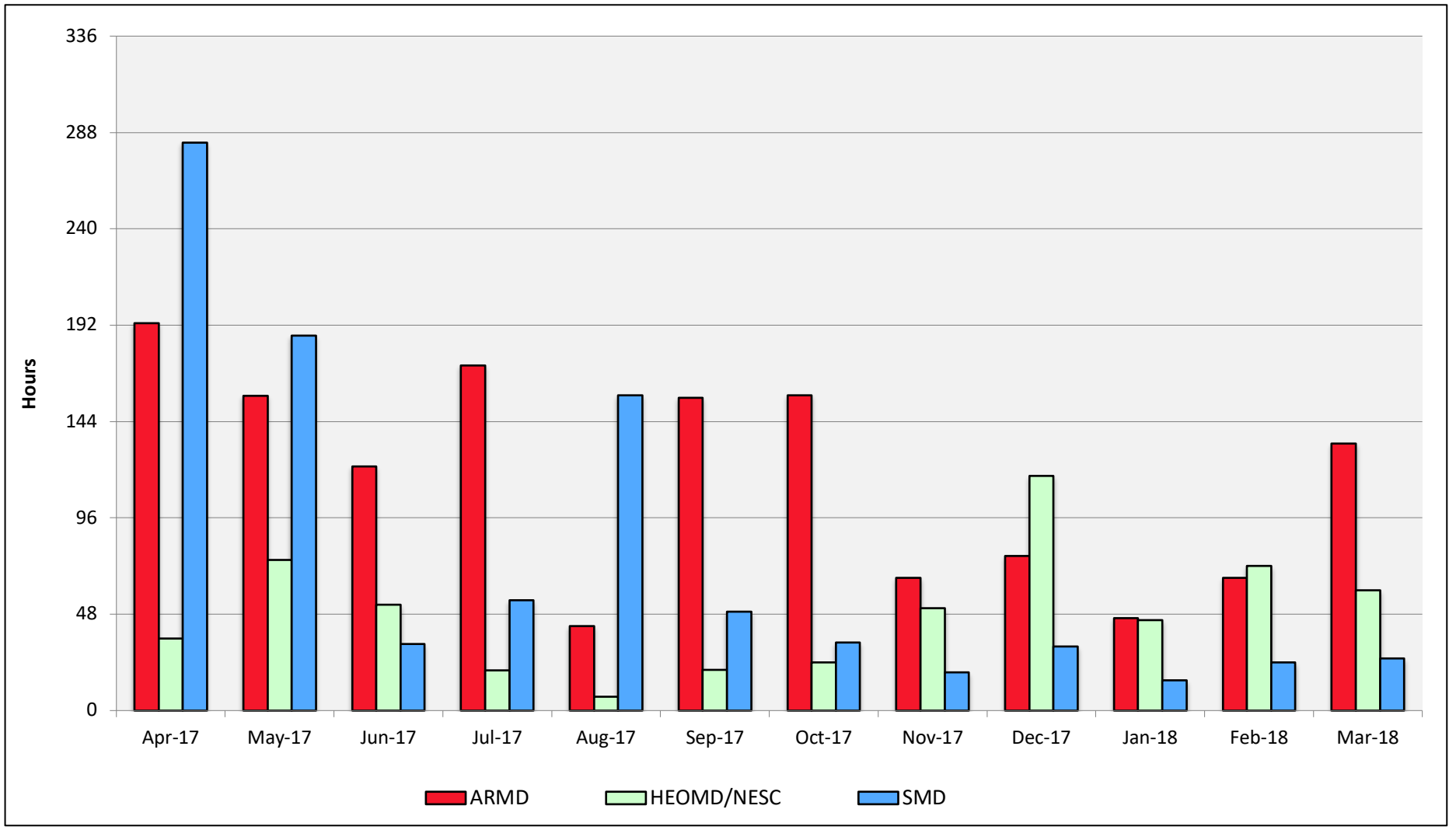
# Electra:
# Monthly Utilization by Size and Mission



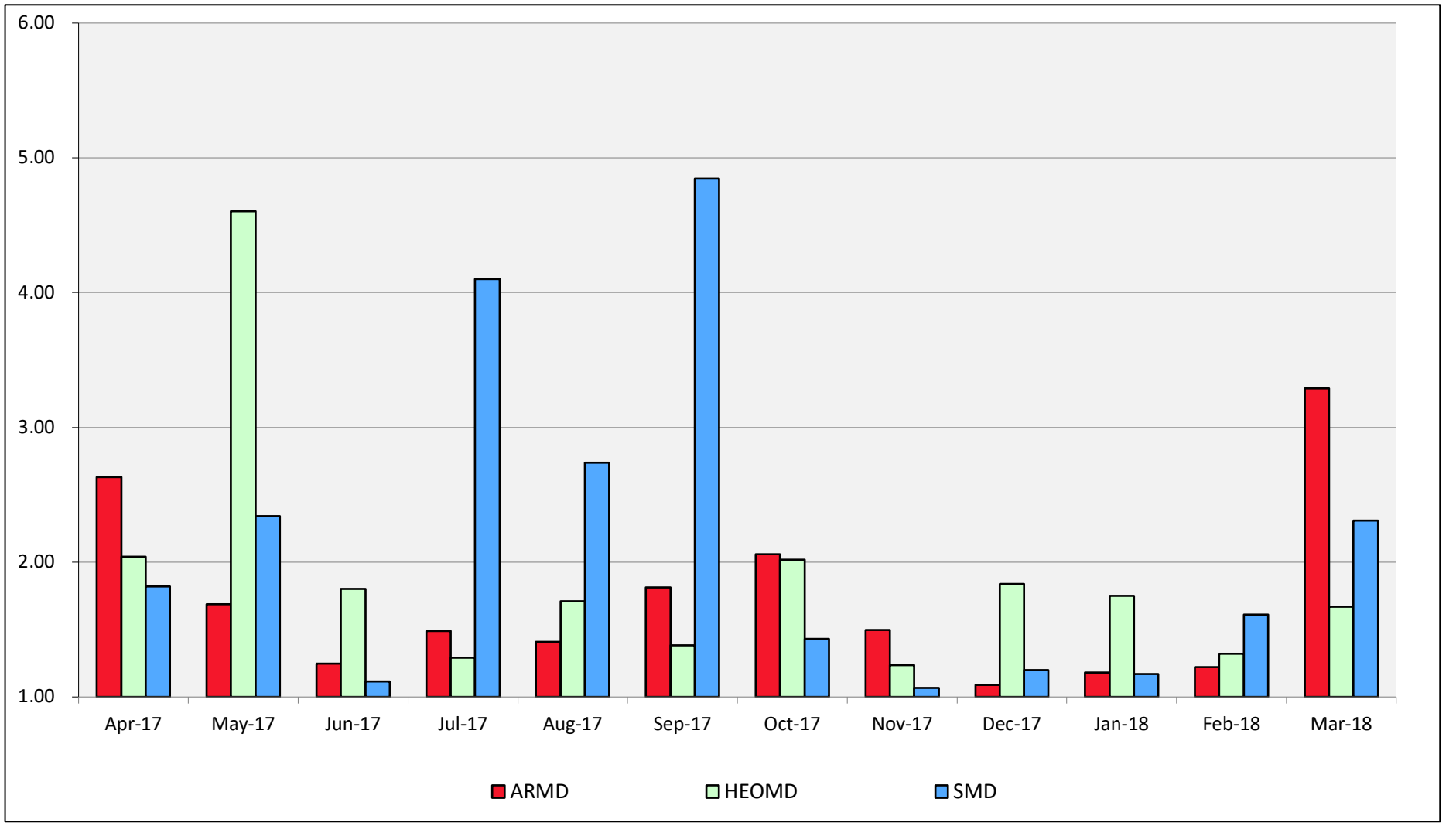
# Electra:
# Monthly Utilization by Size and Length



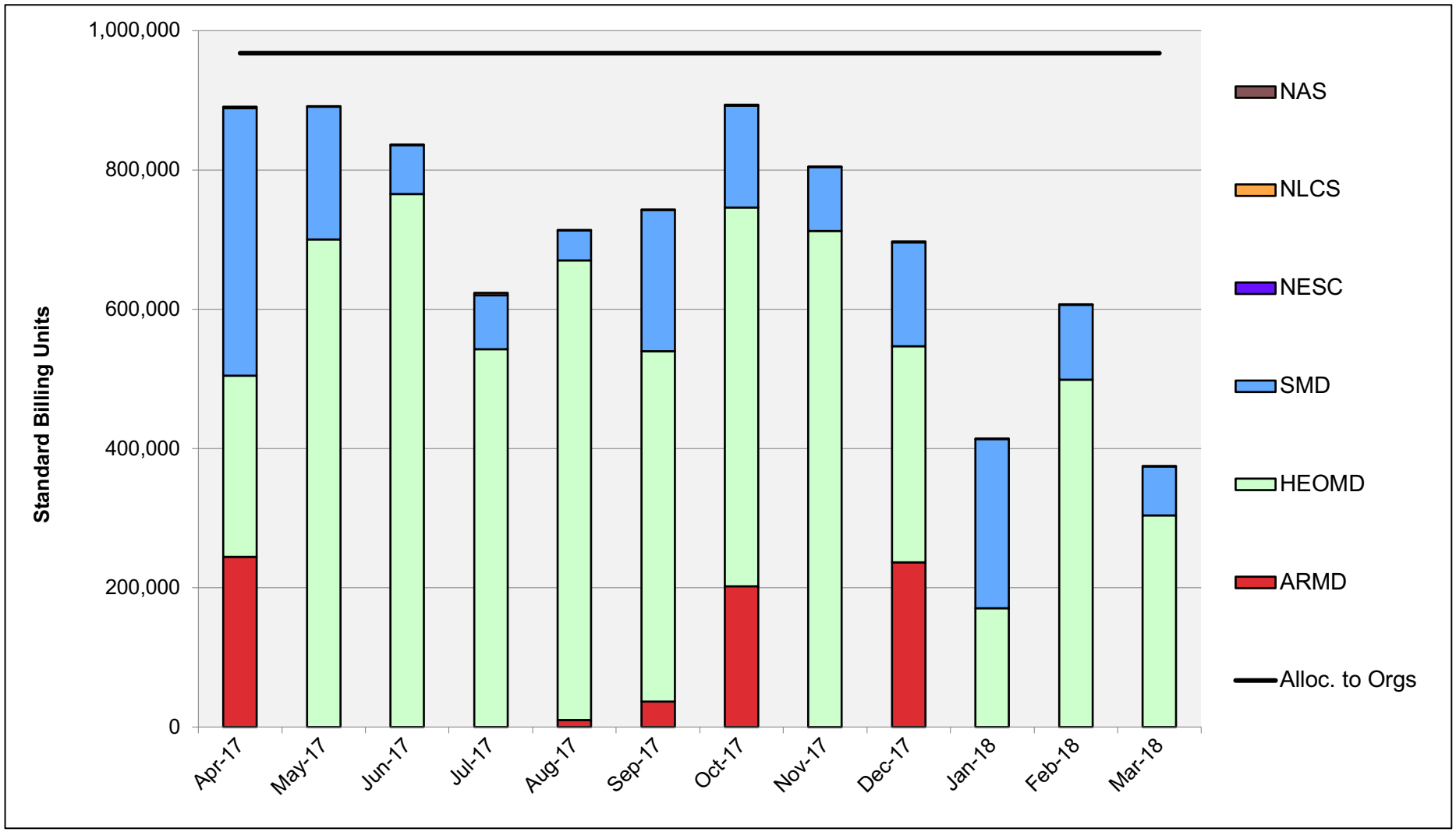
# Electra:
# Average Time to Clear All Jobs



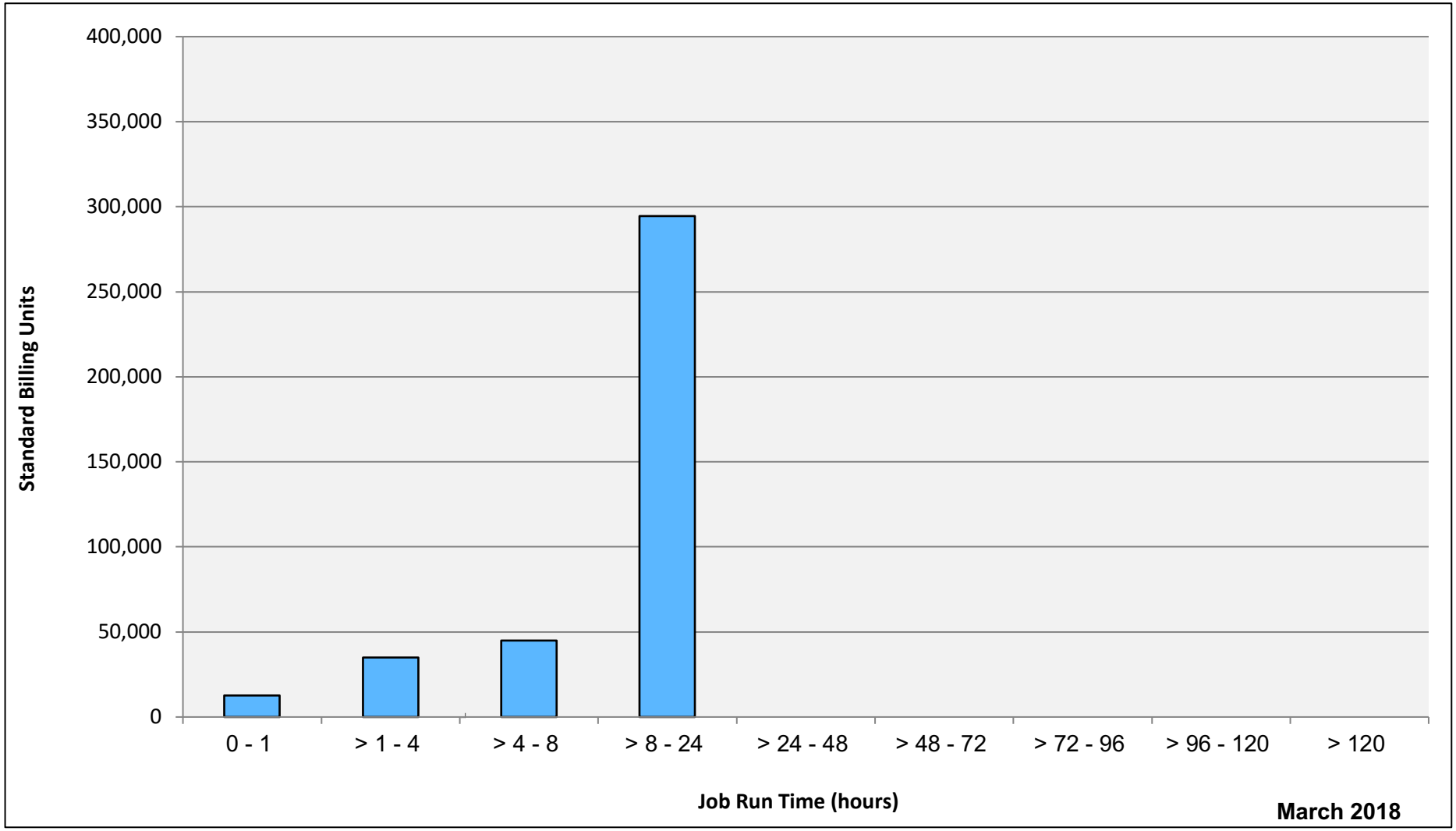
# Electra:
# Average Expansion Factor



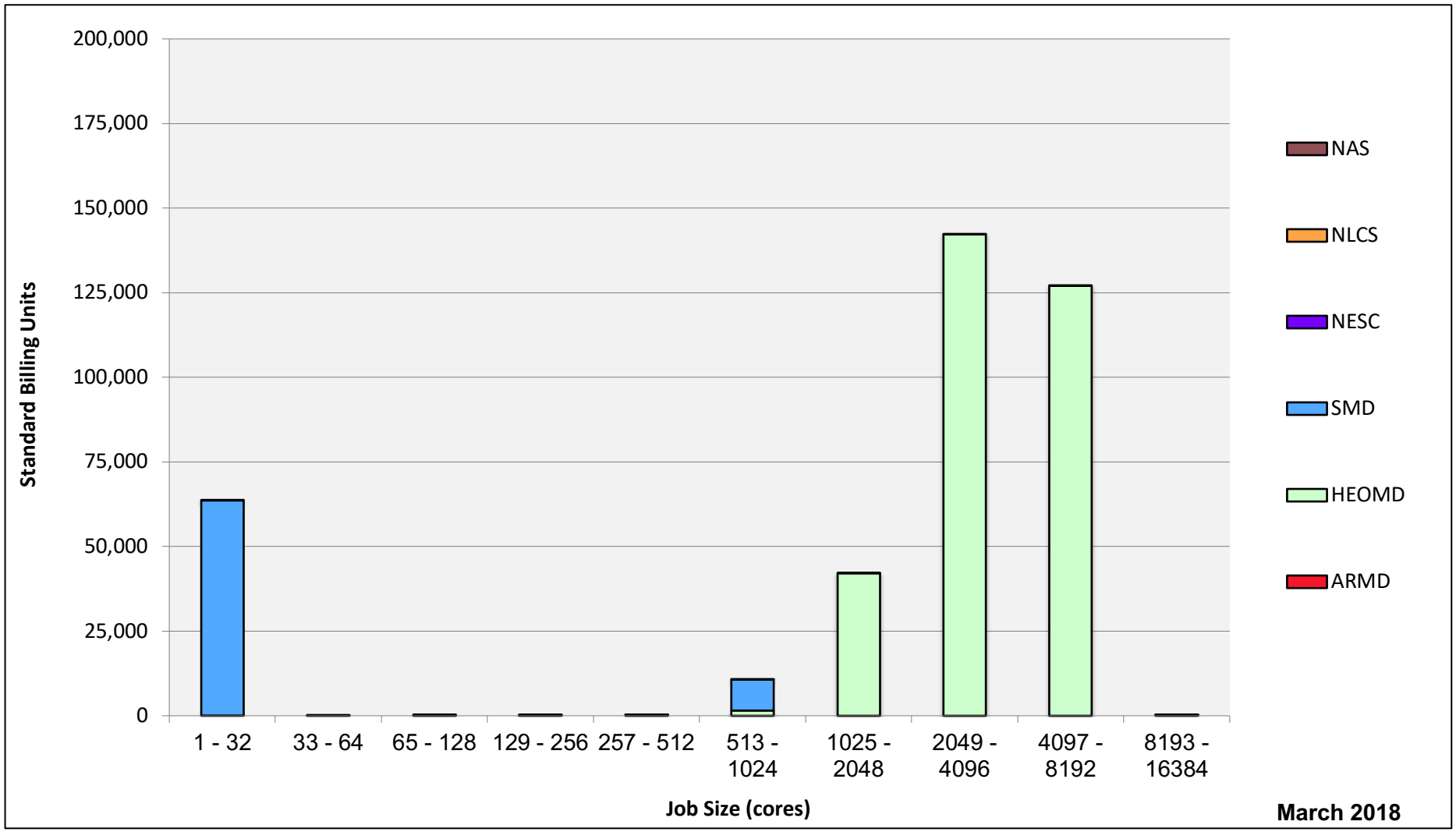
# Merope:
# SBUs Reported, Normalized to 30-Day Month



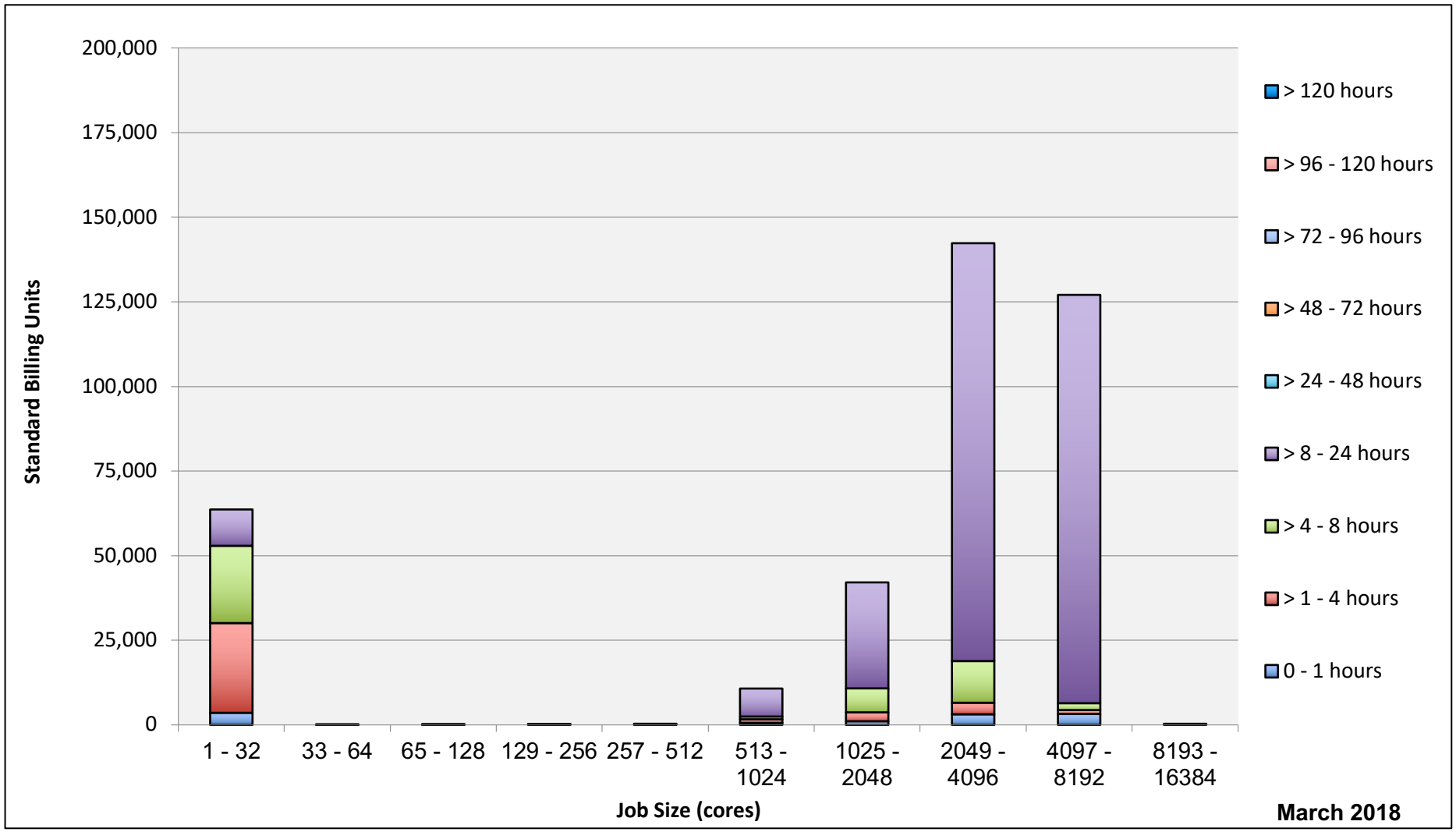
# Merope:
# Monthly Utilization by Job Length



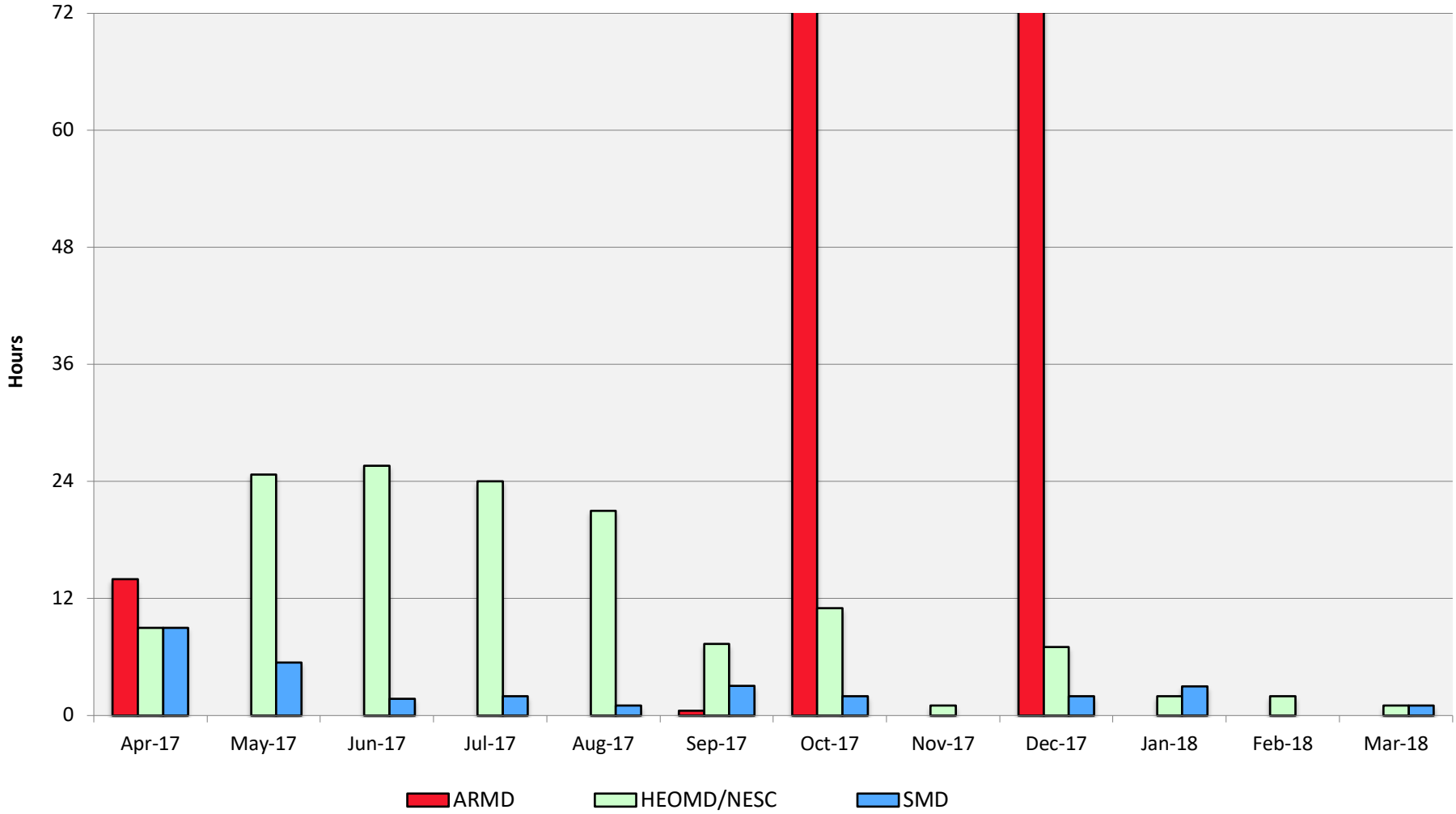
# Merope:
# Monthly Utilization by Size and Mission



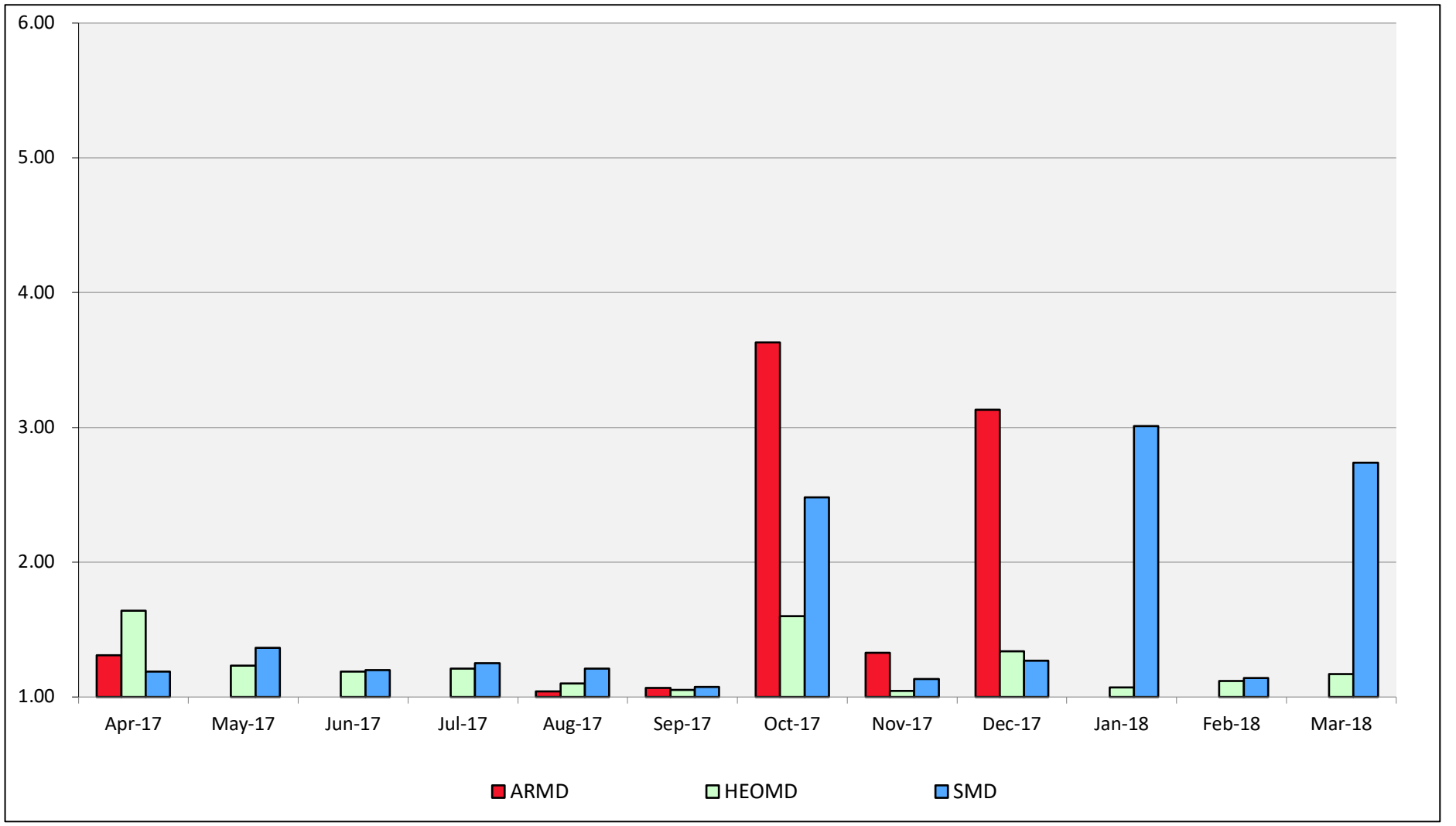
# Merope:
# Monthly Utilization by Size and Length



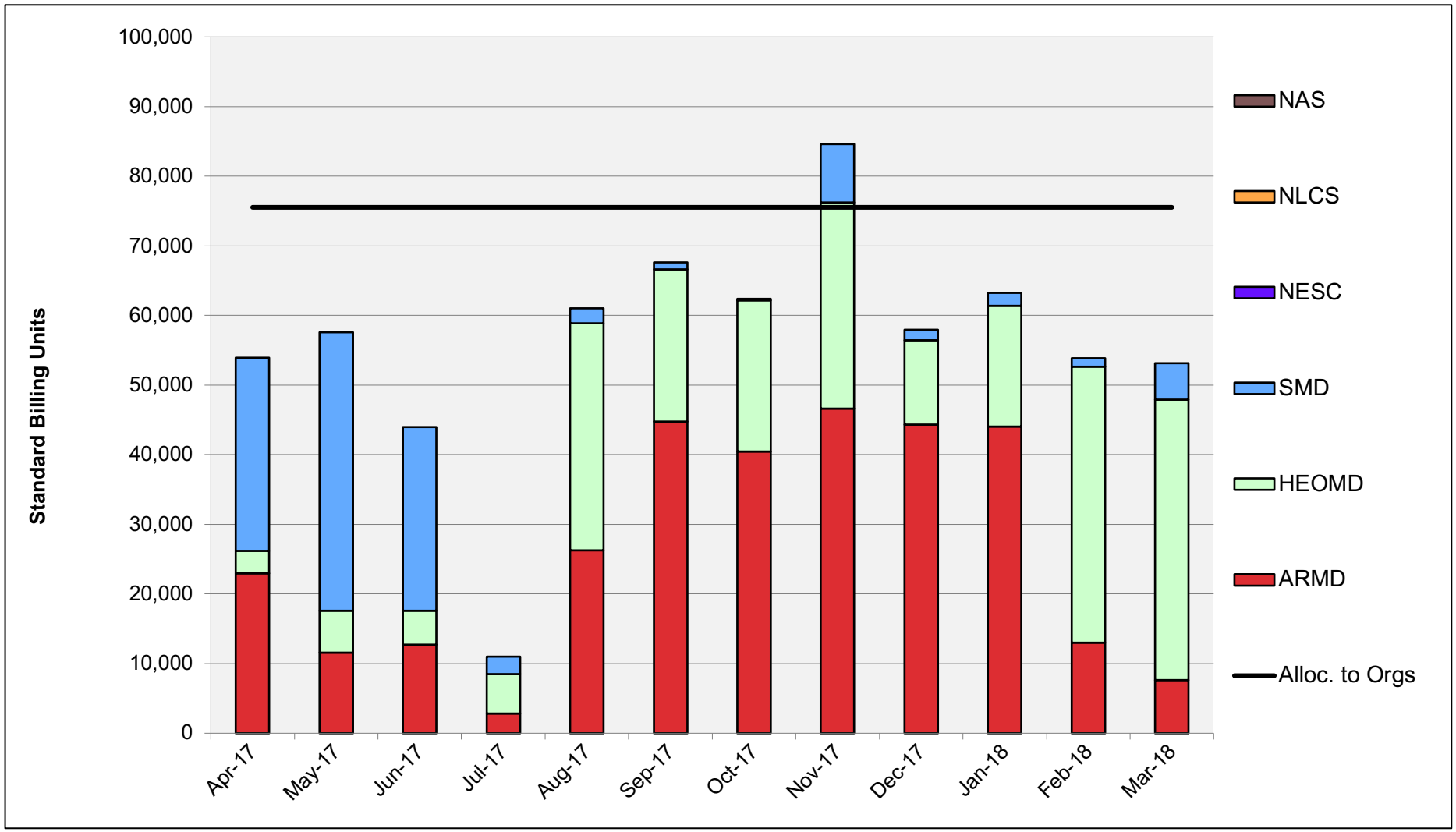
# Merope:
# Average Time to Clear All Jobs



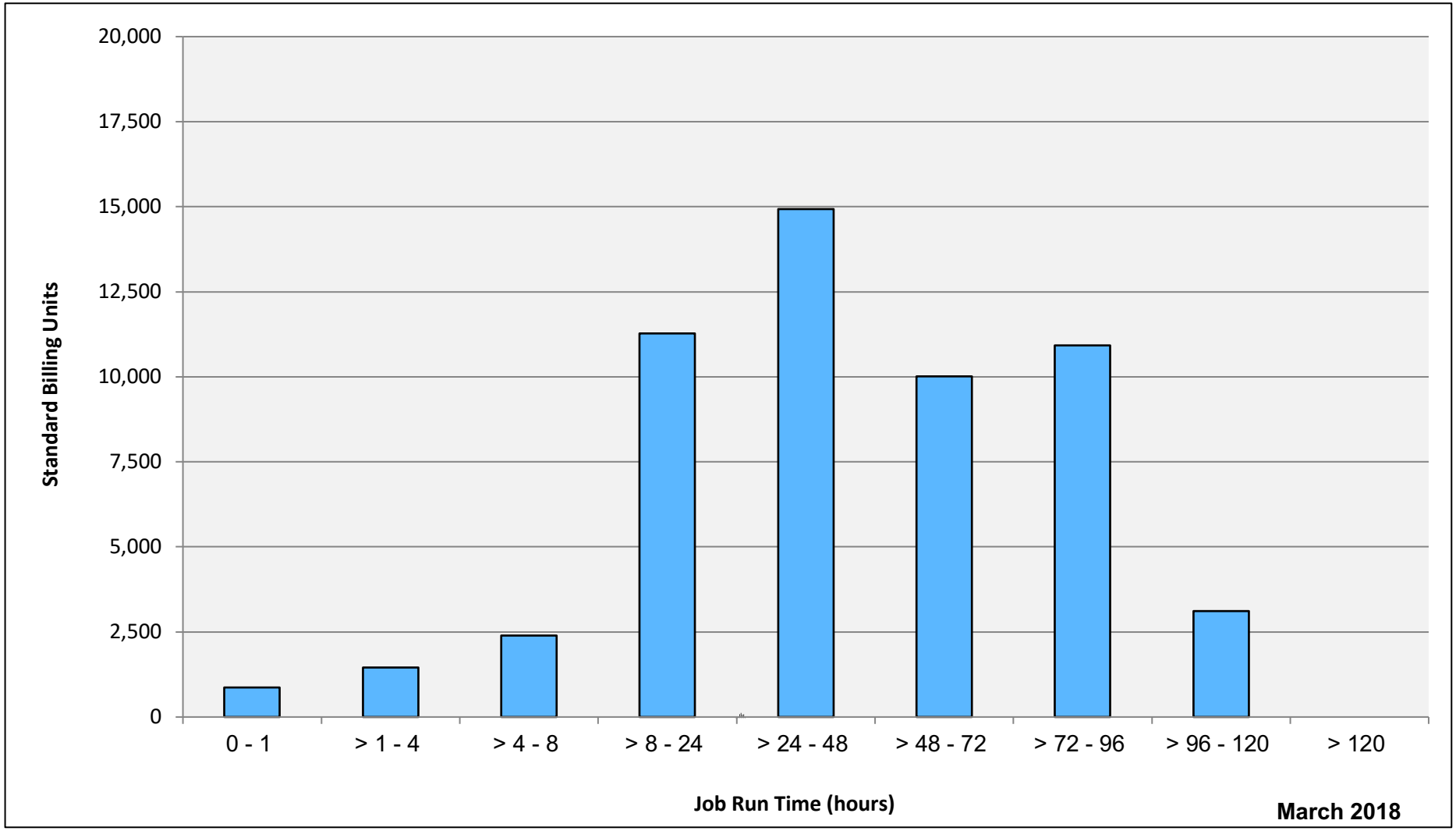
# Merope:
# Average Expansion Factor



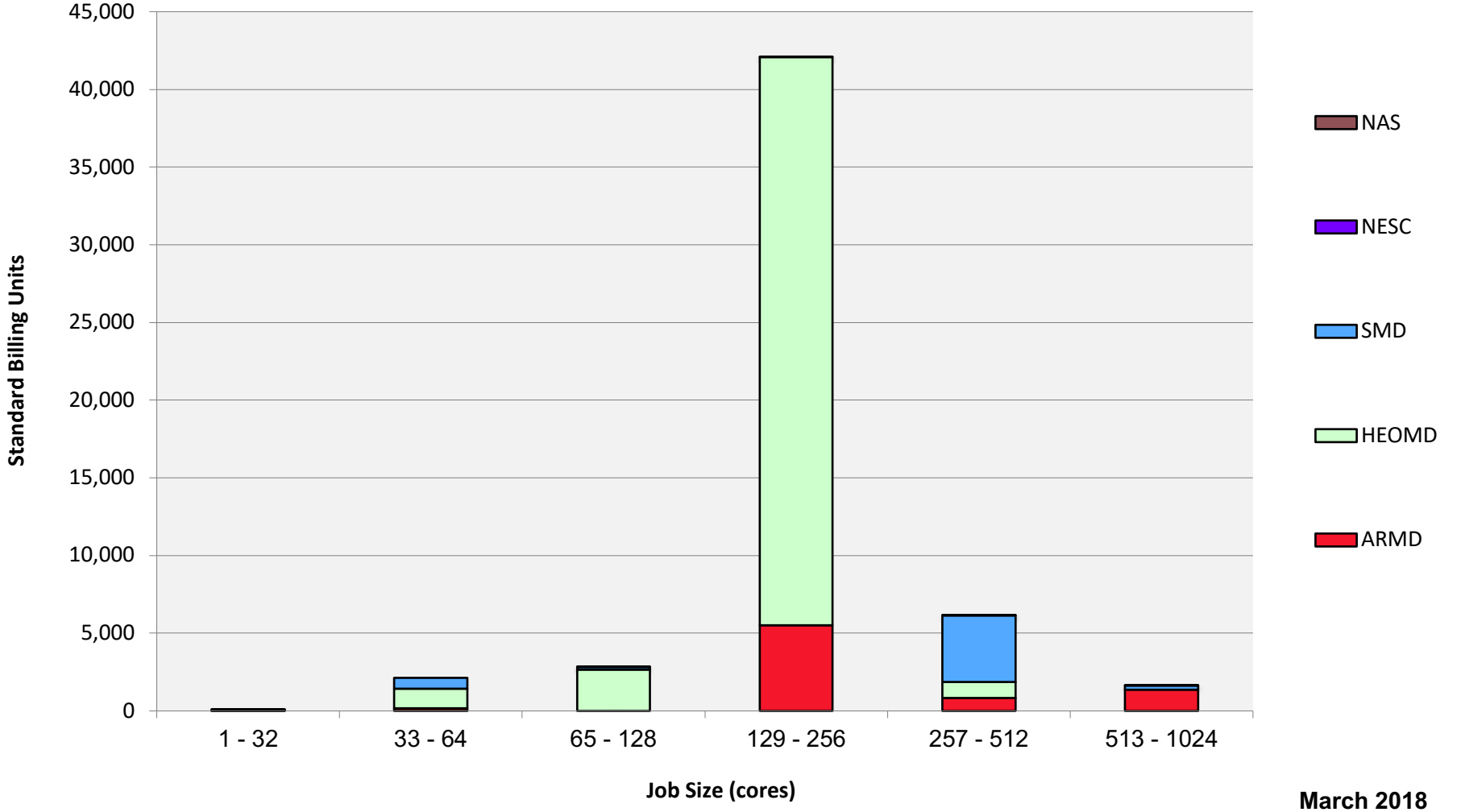
# Endeavour:
# SBUs Reported, Normalized to 30-Day Month



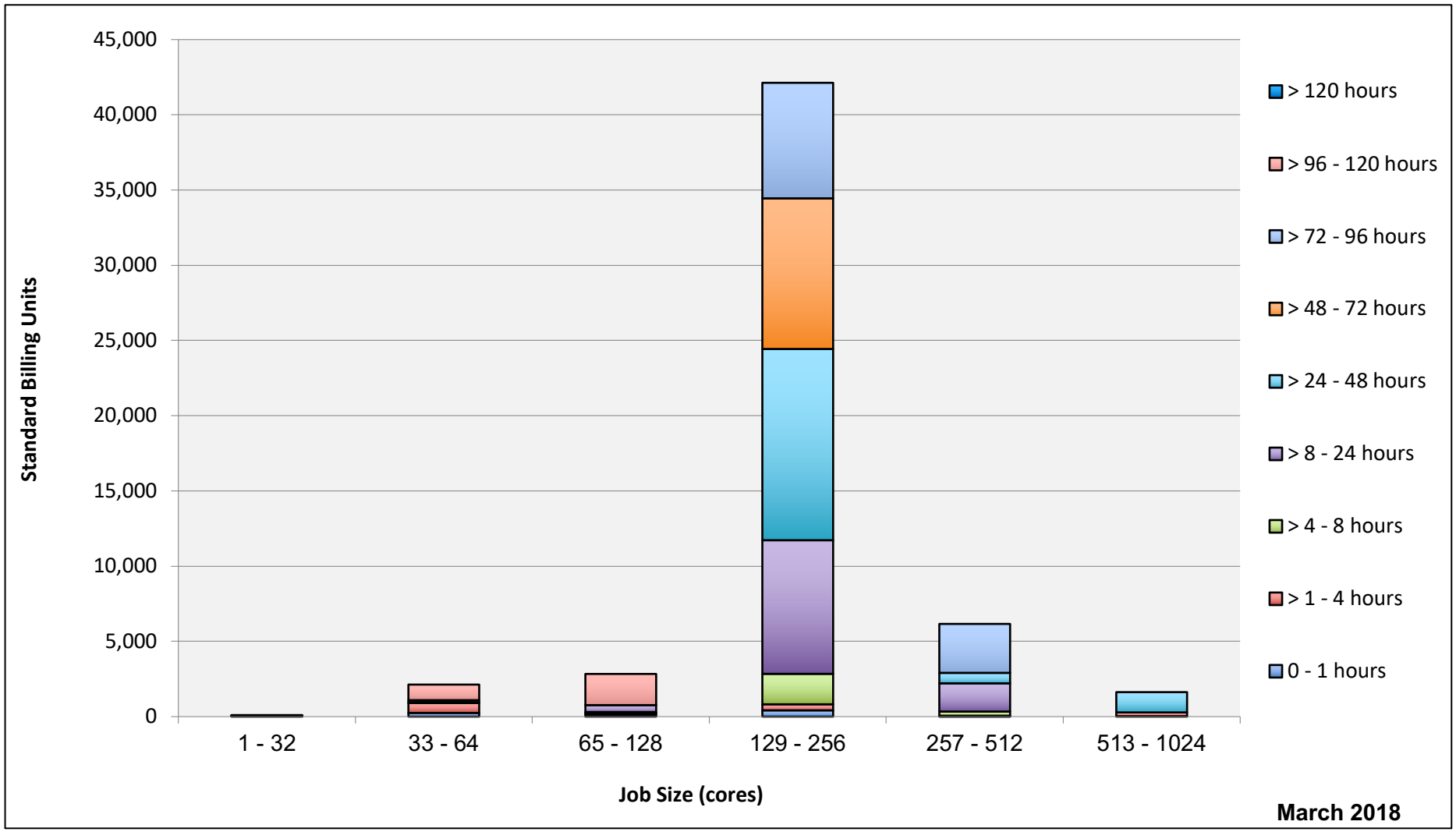
# Endeavour:
# Monthly Utilization by Job Length



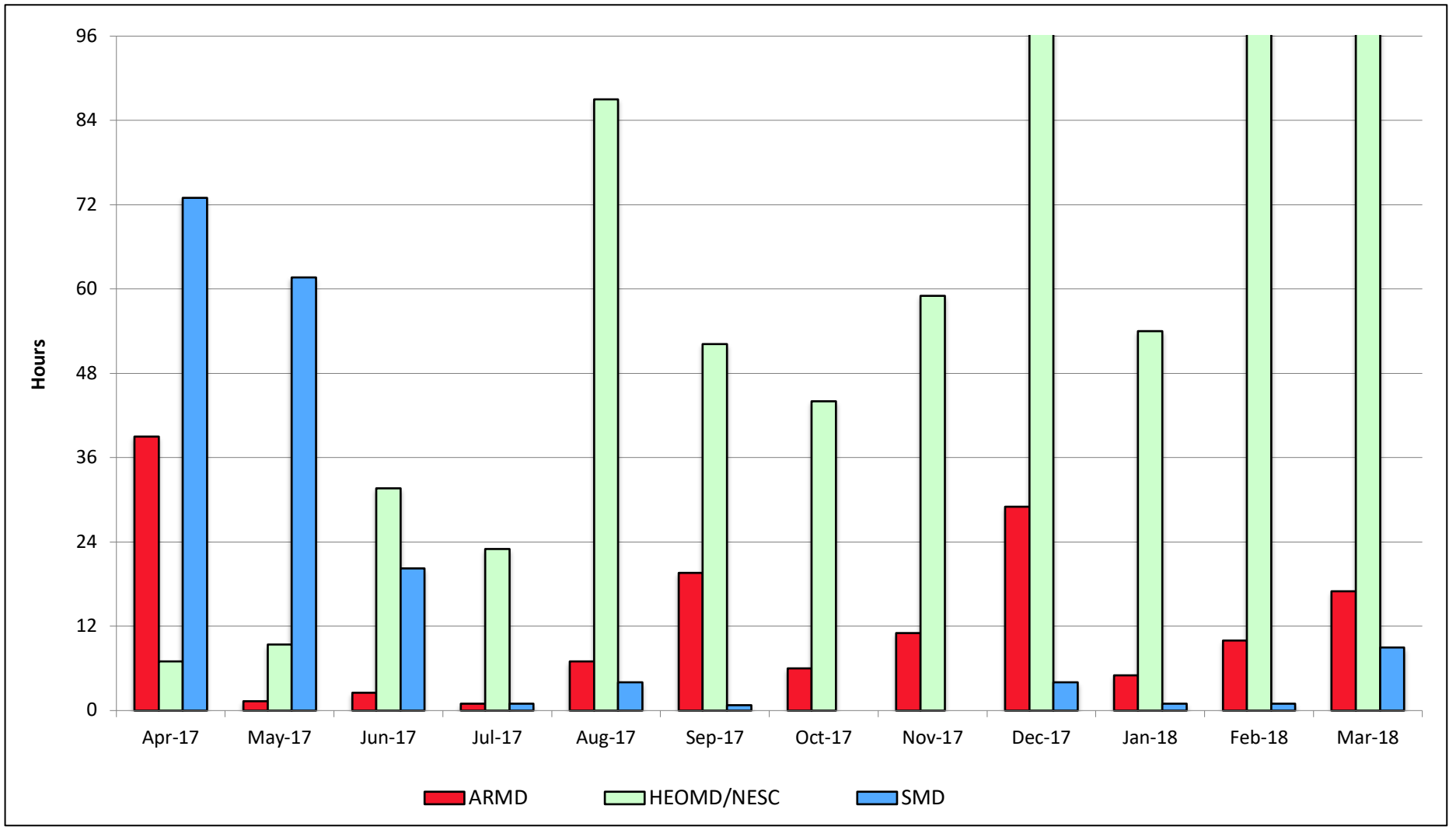
# Endeavour:
# Monthly Utilization by Size and Mission



# Endeavour:
# Monthly Utilization by Size and Length



# Endeavour:
# Average Time to Clear All Jobs



# Endeavour:
# Average Expansion Factor

