Project Status Report

High End Computing Capability

Strategic Capabilities Assets Program

March 10, 2019

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Secondary Infrastructure for NAS Facility Expansion Begins

- The secondary infrastructure construction to support the NAS Facility Expansion (NFE) modules began in February.
- HECC and Ames Facilities staff are teaming with Hewlett Packard Enterprise, Schneider Electric, and Tri-Technic to install the NFE site foundation and distribute power, communications, water, and sewer to the first module.
  - Excavating and trenching for conduits and sewer and storm drain pipes is underway on the aggregate pad installed during the primary infrastructure project phase.
- Schneider Electric will complete assembly of the modular data center in March, and will ship to the NFE site during the concrete pad curing period in mid-April.
- The first module, 2.5-megawatt transformer, and 600-ton cooling system are scheduled to be commissioned in June 2019.

Mission Impact: The NAS Facility Expansion will provide the infrastructure to support four times the capacity of existing HECC resources to serve NASA's science and engineering projects.

Excavation of trenches for power and communication conduits is underway for the NAS Facility Expansion. The 25-kilovolt power is distributed underground from switchgear (shown in the background) to a 2.5-megawatt transformer to be installed next to the first module.

POCs: Bill Thigpen, william.w.thigpen@nasa.gov, (650) 604-1061, NASA Advanced Supercomputing (NAS) Division;
Chris Tanner, christopher.tanner@nasa.gov, (650) 604-6754, NAS Division, ASRC

Critical HECC Assets Protected by Rotary Uninterruptable Power Supply

- The HECC Facilities team, in collaboration with NASA Ames Facilities Engineering and vendors Jacobs, and Hitec, returned two of three Rotary Uninterruptible Power Supplies (RUPS) to service in February.
  - The RUPS had been out of service since November 2018 after a load-shedding operation malfunction caused an unplanned outage of the Pleiades supercomputer.
- Hitec installed a system software upgrade to correct the malfunctions associated with load shedding.
- RUPS units #1 and #3 induction coupling bearings were re-greased and the quarterly preventative maintenance was completed.
- With the upgrades and maintenance, the HECC critical security and communication components and half the main computer floor including all of the data storage is again protected by RUPS power.

Mission Impact: Protecting HECC resources at NASA's largest supercomputing facility provides reduced risk of failure due to power outage events, and increases resource availability for users.

The Rotary Uninterruptible Power Supply (RUPS) control panel received a software upgrade to improve the load-shedding operation. The RUPS protects critical building electricity loads, such as data storage and data center cooling, from unplanned power outages.

POCs: Bill Thigpen, william.w.thigpen@nasa.gov, (650) 604-1061, NASA Advanced Supercomputing (NAS) Division;
Chris Tanner, christopher.tanner@nasa.gov, (650) 604-6754, NAS Division, ASRC

Chiller Repair Returns Merope System to Full Capacity

- HECC Facilities engineers collaborated with Ames Facilities Maintenance and Jacobs staff to repair Chiller #6 outside Building N233A, returning the Merope supercomputer's 1,792 nodes to full availability.
  - The Merope nodes had been offline since November 2018, as a result of multiple chiller malfunctions.
- Chiller #6 is one of four 90-ton chillers in N233A that provide cooling water to the Merope system.
  - Chiller #4, 5, and 6 now provide the cooling for Merope to operate at full capacity.
  - Chiller #4, 5, and 6 were all refurbished/repaired within the last six months.
  - The 4th 90-ton chiller, Chiller #3 (currently down), is being replaced with a new 112-ton chiller. When operational, it will provide redundancy and increase N233A's total cooling capacity by 75 kilowatts.
- Merope's availability will remain solid for users, as a result of the cooling system maintenance.

Mission Impact: Maintaining a robust cooling system is crucial to the continuous operation of supercomputing capabilities for HECC users.

The chillers supporting Building N233A at NASA Ames provide critical cooling to the Merope supercomputer. Each existing chiller's cooling capacity is 90 tons (316kW). The three operational chillers can cool 948 KW.

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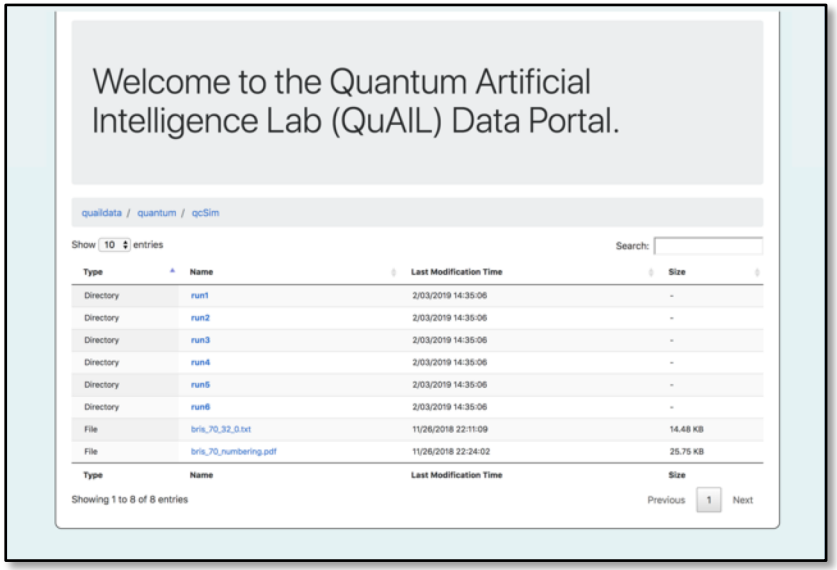
Chris Tanner, christopher.tanner@nasa.gov, (650) 604-6754, NAS Division, ASRC

Big Data Team Launches QuAIL Data Portal

- HECC's Big Data Team developed and is hosting a web-based data portal to share 43 gigabytes of datasets from the NASA Ames Quantum Artificial Intelligence Laboratory (QuAIL) project.
  - QuAIL is NASA's hub for assessing the potential of quantum computers to impact computational challenges faced by the space agency in the decades to come.
  - Data is available for download, organized by region and in compressed format.
- The web portal leveraged hardware and software infrastructure from a previous portal and will be integrated by the Team for a general NAS Data Portal with broad applicability.
  - A re-exporter is used to make internal Lustre filesystem data available outside the NAS enclave.
- Portal construction and security approvals were expedited to enable quick data availability to meet tight January publication deadlines.

Mission Impact: Developing the Quantum Artificial Intelligence Laboratory (QuAIL) Data Portal for public sharing of quantum computing datasets provides opportunities for science communities and citizen scientists to collaborate and leverage NASA data.



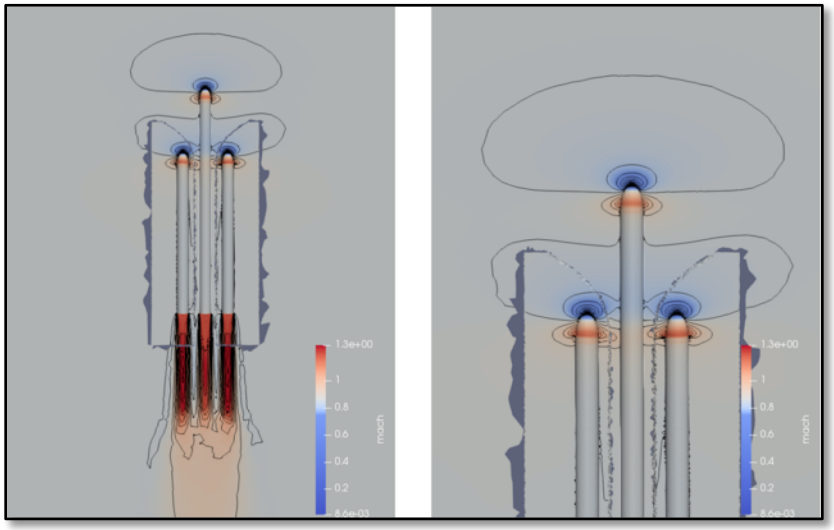
Screenshot from the new NAS Data Portal, featuring downloads of large datasets from NASA's Quantum Artificial Intelligence Laboratory (QuAIL) project. Other computational datasets will also soon be available.

POCs: Shubha Ranjan, shubha.ranjan@nasa.gov, (650) 604-1918, NASA Advanced Supercomputing (NAS) Division;
Ryan Spaulding, ryan.c.Spaulding@nasa.gov, (408) 772-6567, NAS Division, ASRC

Application Experts Teach Users Performance Analysis & Optimization Techniques

- Following training from the HECC Applications (APP) team, users at NASA Langley were able to improve their HyperSolve CFD code by 5–15%, depending on the dataset used.
  - The training was part of a joint effort between HECC and various projects at Langley to improve application performance.
  - The APP team explained how they analyzed and then modified the computational kernel of the HyperSolve code to achieve a 2X improvement in the kernel through the following: compiler keywords inserted in the code to force inlineing, memory layout changes, and code simplification.
- The users were then able to apply the HECC-recommended code improvements to their full application.
- The training effort with Langley is continuing with a code from a different project. APP staff will also be starting up a similar effort with Glenn users in the near future.

Mission Impact: Teaching users the skills needed to do performance analysis and optimization results in more efficient codes and an awareness of issues to consider during future code development, which in turn lead to faster times-to-solution.



HyperSolve steady overset simulation of notional heavy-lift vehicle. Left: The Mach contours on three domains. Right: Close up Mach contours. *Matthew O'Connell, Cameron Druyor, and Kyle Thompson, NASA/Langley.*

POCs: Gabriele Jost, gabriele.jost@nasa.gov , NASA Advanced Supercomputing (NAS) Division, Supersmith;
Daniel Kokron, daniel.s.kokron@nasa.gov, NAS Division, Redline Performance Solutions

Tools Team Implements Tracking of Cloud Computing Resource Usage

- The HECC Tools Team modified accounting source modules to track, summarize, and query the resource usage information for Cloud computing.
- Accounting updates included:
  - Modification to the PBS data loading client program to track cloud resource usage.
  - Modification of the acct_query and acct_ytd programs to include the option to display usage for cloud clients.
  - Creation of "cloud" cluster and client "awspubwest" information in the accounting database to summarize and query usage data.
  - Creation of the cloud cluster allocation host and awspubwest client name in API server to allow scripts to manage allocations and current files.
  - Modification of the acct_sum program to summarize the daily usage for cloud clients.
  - Creation of an allocation host, "cloud," in the account management database to assign the allocations.

Mission Impact: The HECC resource accounting system will now track and report cloud computing resource usage in addition to supercomputing usage. This provides a comprehensive summary of HECC resource usage.

```
ACCT_QUERY: Generating data ...

GRAND TOTAL FOR 02/01/19 TO 02/22/19
CLIENT    USER              PROJECT           QUEUE           SBU Hrs
--------- ----------------- ----------------- --------------- -----------
awspubwest [redacted]          cstaff            drc                 0.000
awspubwest [redacted]          cstaff            drc                 0.000
awspubwest [redacted]          cstaff            cloud_exec      10961.028
awspubwest [redacted]          cstaff            drc               958.855
awspubwest [redacted]          cstaff            frontend       105588.819
TOTAL FOR            awspubwest.cstaff                          117508.702

TOTAL FOR ALL PROJECTS FOR CLIENT: awspubwest                   117508.702

% acct_ytd -cawspubwest all

                                                                    Linear
                          Fiscal                                     YTD   Project
Project  Host/Group       Year     Used     % Used    Limit     Remain     Usage  Exp Date
-------- ---------------- ------ ---------- ------- --------- ---------- ------- ----------
g1119    cloud            2019       0.000    0.00  10000.000  10000.000    0.00  09/30/19
css      cloud            2019       0.000    0.00      3.000      3.000    0.00  09/30/19
cstaff   cloud            2019  130663.138  261.33  50000.000 -80663.138  660.57  09/30/19
scicon   cloud            2019     175.974    1.76  10000.000   9824.026    4.45  09/30/19
a1703    cloud            2019       0.000    0.00    100.000    100.000    0.00  09/30/19
a1727    cloud            2019    1884.813  157.07   1200.000   -684.813  397.03  09/30/19
e1305    cloud            2019     161.273  161.27    100.000    -61.273  407.66  09/30/19
```

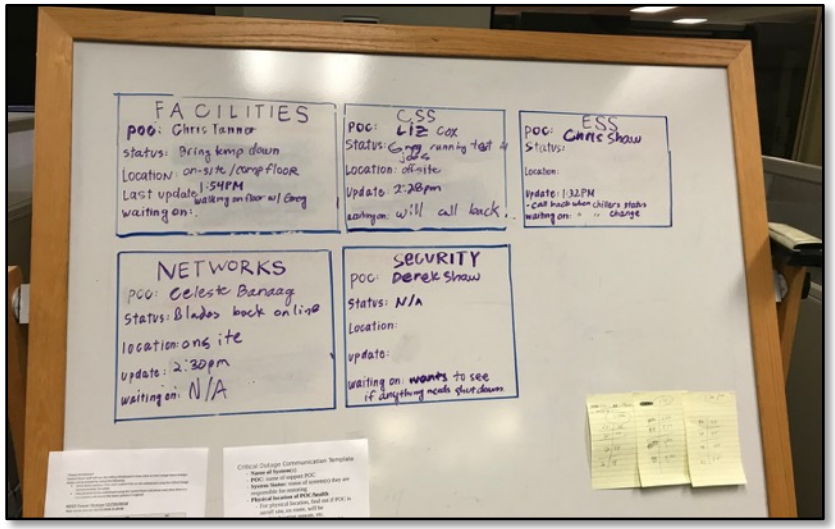
The new acct_query command has options to summarize information on Cloud usage.

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

HECC Team Implements Improved Communication Process for Critical Outages

- A team of HECC engineers implemented a more effective process to communicate information between NAS groups during critical outages.
- Documentation and communication templates were created to assist in handling outages, including:
  - Critical Outage List – Defines which types of outages are considered critical.
  - Communication Procedure – Outlines steps to take when coordinating information exchange between support POCs, users, and management.
  - Communication Template – Defines the exact information to request from each support POC during every status update.
  - Outage Notification List – Establishes which support POCs to call for each type of outage.
- The process and supporting documentation will be evaluated after each critical outage to analyze for further process improvement.
- Quarterly tabletop exercises will be conducted to ensure proper training of Control Room staff, as well as to identify new areas for process improvement.

Mission Impact: This new HECC process improves communication and coordination between HECC support teams during critical unplanned outages, reducing return-to-service time from an outage.



Whiteboard used during a tabletop exercise for testing a new High-End Computing Capability procedure, showing a fictitious outage scenario. The whiteboard will be used during each critical outage to display the current status of each support point of contact. It provides an at-a-glance summary of the latest outage status.

POC: Celeste Banaag, celeste.banaag@nasa.gov, (650) 604-2039, NASA Advanced Supercomputing Division, ASRC

ESS Replaces Centrify with Apple Native PIV for Mac Two-Factor Authentication

- The HECC Engineering Servers and Services (ESS) team completed development of Apple Native PIV (personal identity verification) as the agency's two-factor authentication solution for HECC staff Macs, replacing Centrify.
- Key benefits of Native PIV include:
  - Fully Apple supported.
  - No licensing cost.
  - Domain modifications are no longer needed to manage NAS users.
  - Direct control of PIV through Jamf Pro servers; for example, switching from PIV-M to passwords, as needed.
- The transition to Native PIV is a mostly automated process through a series of scripts and configuration profiles pushed via Jamf Pro.
- The ESS team is in the process of migrating all systems to Native PIV with High Sierra.

Mission Impact: Migrating to Native PIV eliminates the difficult Centrify process and additional licensing cost, and maintains agency two-factor compliance by leveraging Apple's built-in smartcard support for HECC Mac systems.

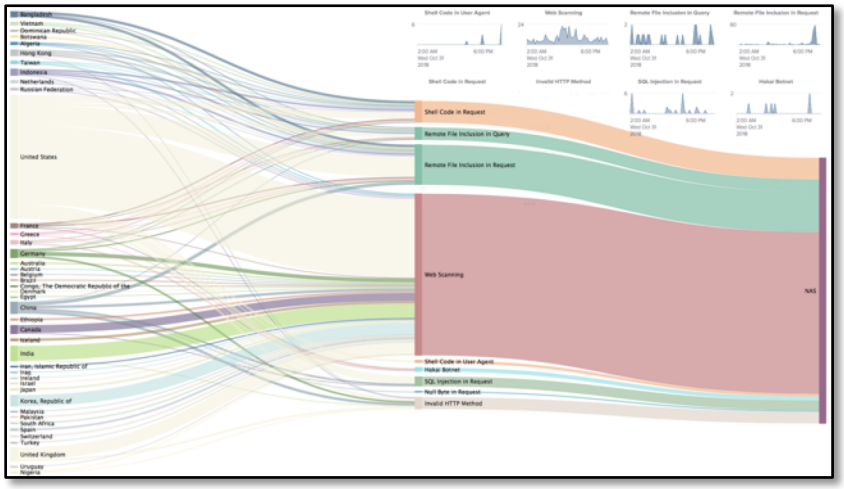
The Apple Native PIV login solution is implemented via Jamf Pro for simplified two-factor authentication management on High-End Computing Capability Mac systems.

POCs: Ted Bohrer, ted.bohrer@nasa.gov, NASA Advanced Supercomputing (NAS) Division, nLogic;
Ed Garcia, edmund.a.garcia@nasa.gov, NAS Division, ASRC

HECC Security Team Provides Critical Operations for HECC Systems

- Throughout the year, the HECC Security team fulfills numerous operational duties to ensure HECC computing resources operate within compliance of government laws, regulations, and polices and with minimal cybersecurity risk, including:
  - Review projects and software for compliance and cybersecurity risks.
  - Conduct security scans of HECC systems to identify missing patches and vulnerabilities.
  - Review and approve requests for elevated privileges on HECC systems.
  - Disseminate IT security information to HECC support groups and users.
  - Monitor HECC IT assets for cybersecurity risks, malicious activity, and compliance.
  - Assist HECC users and system administrators with cybersecurity issues.
  - Coordinate with other IT security groups within the agency and federal government for incident response.

Mission Impact: The HECC Security Team provides a critical service for the successful operations of high-end computing within the NASA Advanced Supercomputing Facility at Ames Research Center.



Composite image of two visualizations showing suspected malicious activity on HECC systems within a sample 24-hour period.
(View in Slide Show mode and click image for full scale.)

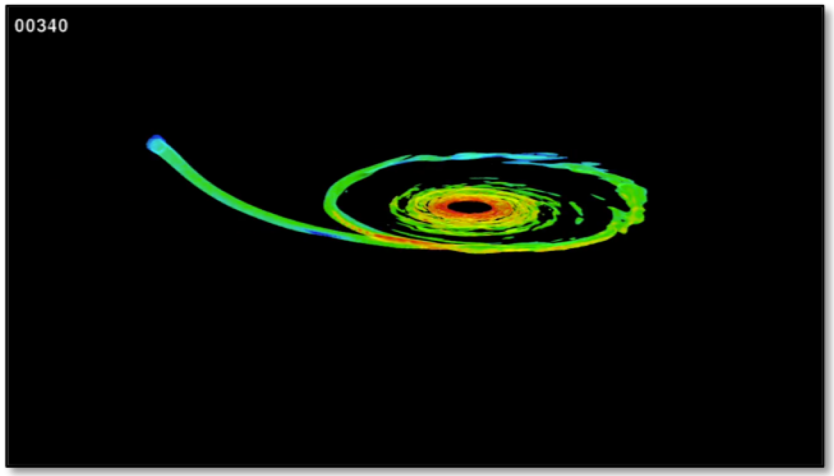
POC: Derek G. Shaw, derek.g.shaw@nasa.gov, (650) 604-4229, NASA Advanced Supercomputing Division

White Dwarf Simulations Run on Pleiades to Help Understand Binary Star Systems*

- Researchers at the University of California Santa Barbara (UCSB) are running unique simulations on Pleiades to help understand the physical origin of light and gas variations around binary star systems observed by space telescopes.
- Their initial direct simulation focused on calculating the behavior of disks around white dwarf stars, specifically KIC 004547333, observed by the Kepler spacecraft.
  - Results showed interesting dynamics: orbits in the disk interior.
  - They suspected the tilt in the outer ring was due to a numerical artifact associated with insufficient resolution at the stream impact point with the disk.
  - Additional higher-resolution simulations run on Pleiades appear to have fixed the problem.
- The UCSB group is running a new simulation and awaits a tilt to develop for physical reasons to explain observations. Once the basic dynamics are understood, they will post-process the data to generate light curves and spectra on Pleiades, and compare them directly to NASA ground- and space-based observations.

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

Mission Impact: Simulations such as these, made possible by HECC supercomputing resources and visualization services, represent the first step in fully understanding the origin the light variability in binary star systems.



Visualization of the build-up of a rotating disk around a white dwarf star (black center) as it is fed by a stream from an orbiting companion star. Both stars (not shown) orbit around their common center of mass, close to the white dwarf star. Colors indicate brightness of the light emitted by the disk; red and pink are brightest and green is faintest. As the disk builds and spreads out, the outermost parts start to tilt and wobble. *Patrick Moran, NASA/Ames; Yan-Fei Jiang, University of California at Santa Barbara*

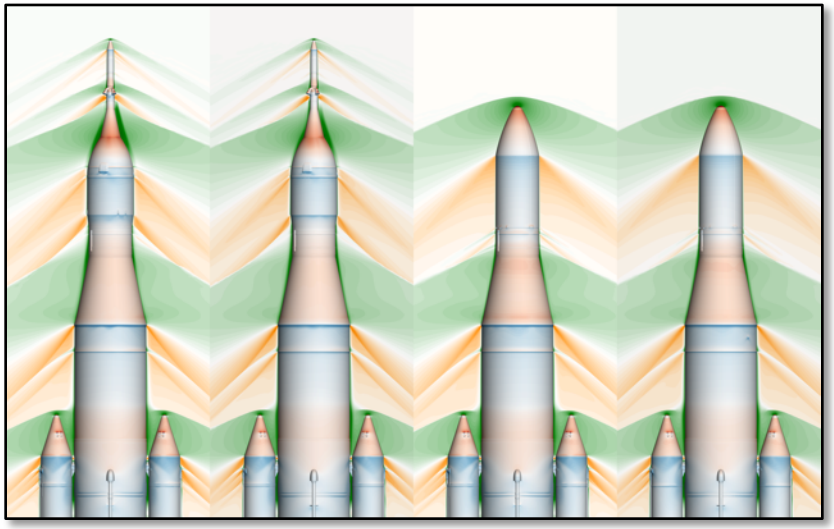
POC: Omer Blaes, blaes@physics.ucsb.edu, (805) 893-7239, University of California at Santa Barbara

Building Aerodynamic Databases for Space Launch System Design and Analysis*

- Aerospace engineers ran CFD simulations on Pleiades and Electra to quantify the aerodynamic forces on the SLS from ascent through booster separation. They delivered multiple aerodynamic databases used to help design and analyze the SLS systems, including:
  - Distributed line-loads used in structural analysis, and surface pressures used in venting and other flow dynamics analysis.
  - Protuberance aerodynamic loads used in the vehicle design, and forces and moments on the vehicle during ascent and booster separation.
- Several versions of SLS vehicle designs were modeled, including:
  - Multiple design iterations of the SLS Block 1 vehicle, to launch in the unpiloted Exploration Mission-1 (EM-1).
  - Designs for the crewed Exploration Mission-2 (EM-2), and the first cargo mission, the Europa Clipper.
  - Multiple designs of the SLS Block 1B configuration.
- The team will continue to provide aerodynamic analyses as the SLS vehicle design evolves.

** 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 to supplement wind tunnel test data, in order to create composite aerodynamic databases that are critical in ensuring a successful SLS launch.

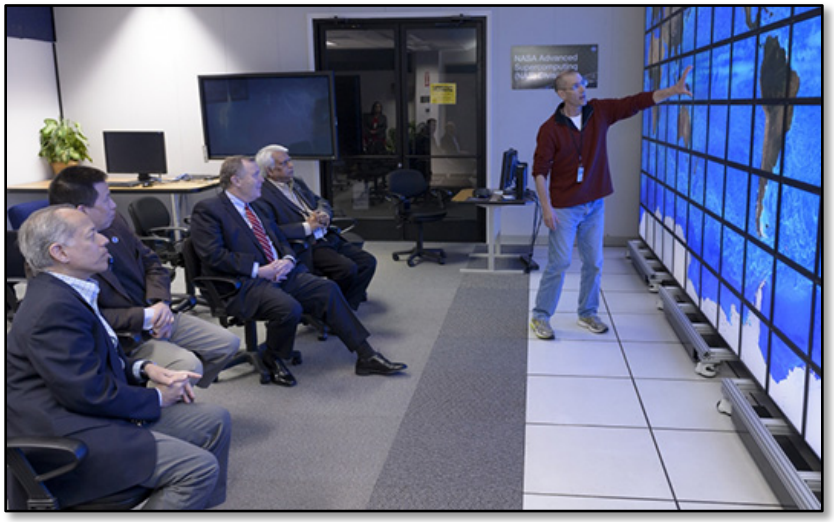


SLS Block 1 cargo vehicle ascent and wind tunnel geometries showing flow fields. Left to right: EM-1 ascent; EM-1 wind tunnel; cargo ascent; cargo wind tunnel. Surfaces are colored by pressure contours, where blue is low and red is high. The green-white-orange colors represent low to high velocities. *Henry Lee, Stuart Rogers, 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 February 2018

- HECC hosted 5 tour groups in February; 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:
  - NASA Deputy Administrator James Morhard, who was briefed about the HECC Project and NAS Division and toured the facility.
  - A group from Great Britain's Olympic High Performance System team.
  - Sheryl Ehrman, Dean of the College of Engineering at San Jose State University.
  - A large group of high school students and their teachers from Oundle School in the United Kingdom; with a focus on computer science the students visited Silicon Valley technology companies and NASA Ames.
  - Students from Red Bluff High School engaged in a year-long research project that contributes to the National Park Service program at Lassen Volcanic National Park. They are also providing data for a new NASA Astrobiology database program.



NASA Deputy Administrator Jim Morhard (third from left) was briefed on HECC resources and services during his visit to the NASA Advanced Supercomputing (NAS) facility. NASA Ames managers accompanied the tour. From left: Rupak Biswas, Director of Exploration Technology; Eugene Tu, Center Director; Piyush Mehrotra, NAS Division Chief. NAS Visualization lead Chris Henze demonstrated scientific visualizations of global ocean data displayed on the hyperwall. Bill Thigpen, HECC Deputy Project Manager (not shown) gave Morhard a tour of the main NAS supercomputer room.

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

Papers

- *"**Constraints to Vegetation Growth Reduced by Region-Specific Changes in Seasonal Climate**," H. Hashimoto, R. Nemani, et al., Climate, vol. 7, issue 2, February 1, 2019. * *https://www.mdpi.com/2225-1154/7/2/27*
- "**On the Numerical Behavior of Diffuse-Interface Methods for Transcritical Real-Fluids Simulations**," P. Ma, H. Wu, D. Bunuti, M. Ihme, International Journal of Multiphase Flow, vol. 113, published online February 2, 2019. * *https://www.sciencedirect.com/science/article/pii/S0301932218300673*
- "**Star Formation Thresholds: Real and Illusory**," S. Khullar, M. Krumholz, C. Federrath, A. Cunningham, arXiv:1902.00934 [astro-ph.SR], February 3, 2019. * *https://arxiv.org/abs/1902.00934*
- "**The Evolution of Galaxy Shakes in CANDELS: From Prolate to Discy**," H. Zhang, et al., Monthly Notices of the Royal Astronomical Society, vol. 484, issue 4, February 5, 2019. * *https://academic.oup.com/mnras/article-abstract/484/4/5170/5307087*
- "**Link Between Trees Fragmenting Granules and Deep Downflows in MHD Simulation**," T. Roudier, et al., Astronomy & Astrophysics, vol. 622, February 6, 2019. * *https://www.aanda.org/articles/aa/abs/2019/02/aa34283-18/aa34283-18.html*
- "**On the Kinetic Nature of Solar Wind Discontinuities**," A. Artemyev, et al., Geophysical Research Letters, vol. 46, issue 3, February 6, 2019. * *https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/2018GL079906*

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

Papers (cont.)

- "**Flows Around Averaged Solar Active Regions**," D. Braun, arXiv:1902.02298 [astro-ph.SR], February 6, 2019. *
  https://arxiv.org/abs/1902.02298
- "**Stellar Energetic Particles in the Magnetically Turbulent Habitable Zones of TRAPPIST-1-like Planetary Systems**," F. Fraschetti, et al., arXiv:1902.03732 [astro-ph.HE], February 11, 2019. *
  https://arxiv.org/abs/1902.03732
- "**Correlations and Cascades in Magnetized Turbulence**," K. Beckwith, et al., IEEE Transactions on Plasma Science, published online February 13, 2019. *
  https://ieeexplore.ieee.org/abstract/document/8641441
- "**Distinguishing Mergers and Disks in High Redshift Observations of Galaxy Kinematics**," R. Simons, et al., arXiv:1902.06762 [astro-ph.GA], February 18, 2019. *
  https://arxiv.org/abs/1902.06762
- "**A Six-Moment Multi-Fluid Plasma Model**," Z. Huang, et al., arXiv:1902.06816 [physics.comp-ph], February 18, 2019. *
  https://arxiv.org/abs/1902.06816
- "**Characterizing the Transition from Balanced to Unbalanced Motions in the Southern California Current**," T. Chereskin, et al., Journal of Geophysical Research Oceans, published online February 21, 2019. *
  https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/2018JC014583

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

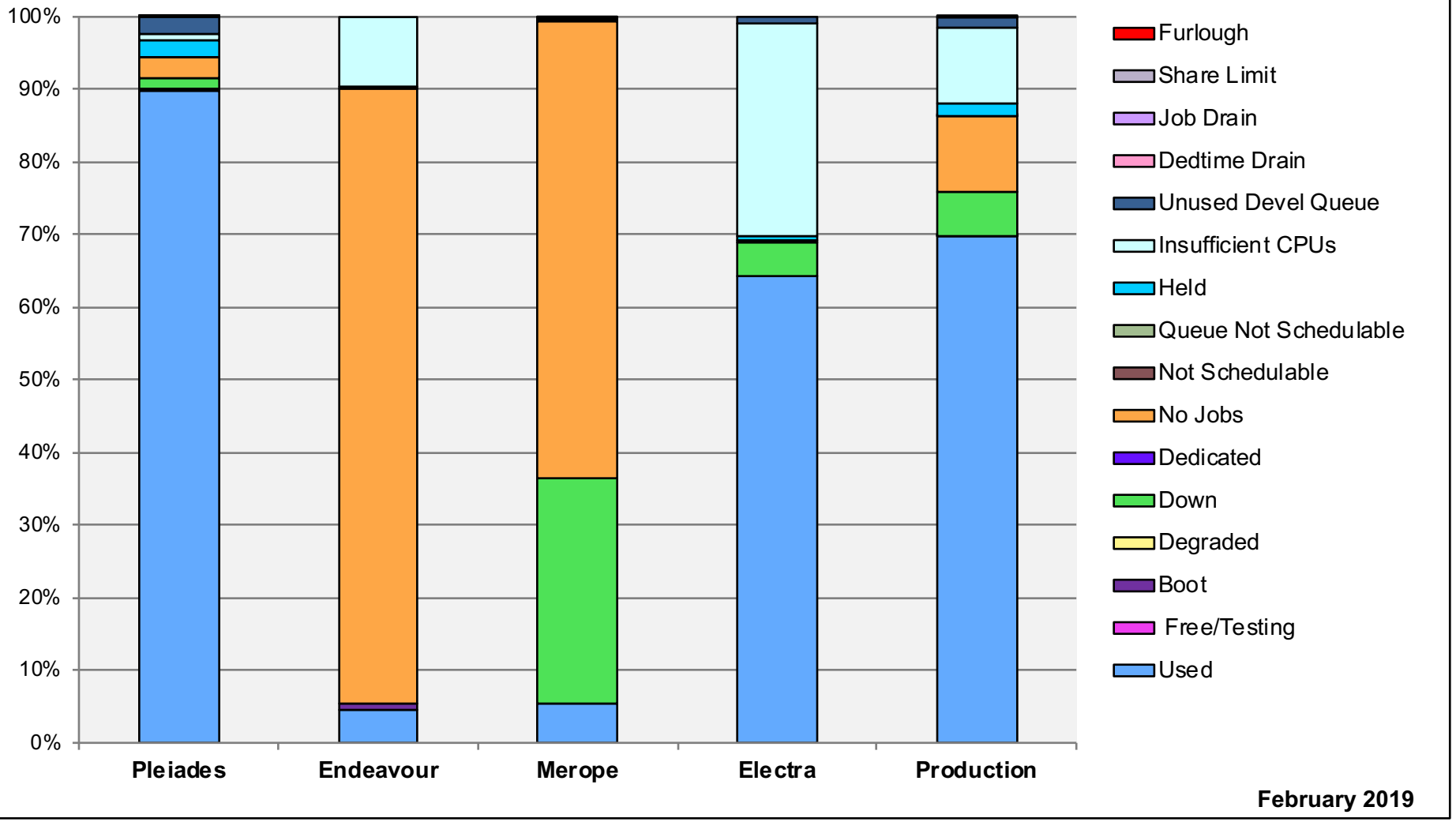
News and Events

- **NCCS and NAS Enable "Pulsar in a Box" Simulations**, *NASA Center for Climate Simulation highlights*, February 5, 2019—Researchers use supercomputers at the NASA Center for Climate Simulation (NASA Goddard) and the NASA Advanced Supercomputing Division (NASA Ames) to enable groundbreaking "pulsar in a box" simulations that track charged particles through surrounding magnetic and electric fields. *https://www.nccs.nasa.gov/news-events/nccs-highlights/pulsar-simulations*
- **What Machine Learning Can Tells Us About Climate Change**, *Science Node*, February 18, 2019—A NASA study shines new light on how climate change may affect the Amazon rainforest. Machine learning expert Kamalika Das, at NASA's Ames Research Center, ran her simulations on the Pleiades supercomputer to develop her optimization-based models. *https://sciencenode.org/feature/What%20machine%20learning%20can%20tell%20us%20about%20climate%20change.php*
- **HPC Goes Modular: NASA's approach to supercomputing saves energy,** *Scientific Computing World,* February/March 2019, Issue #164 — Robert Roe speaks to Bill Thigpen, Advanced Computing Branch Chief for the NASA Advanced Supercomputing Division.

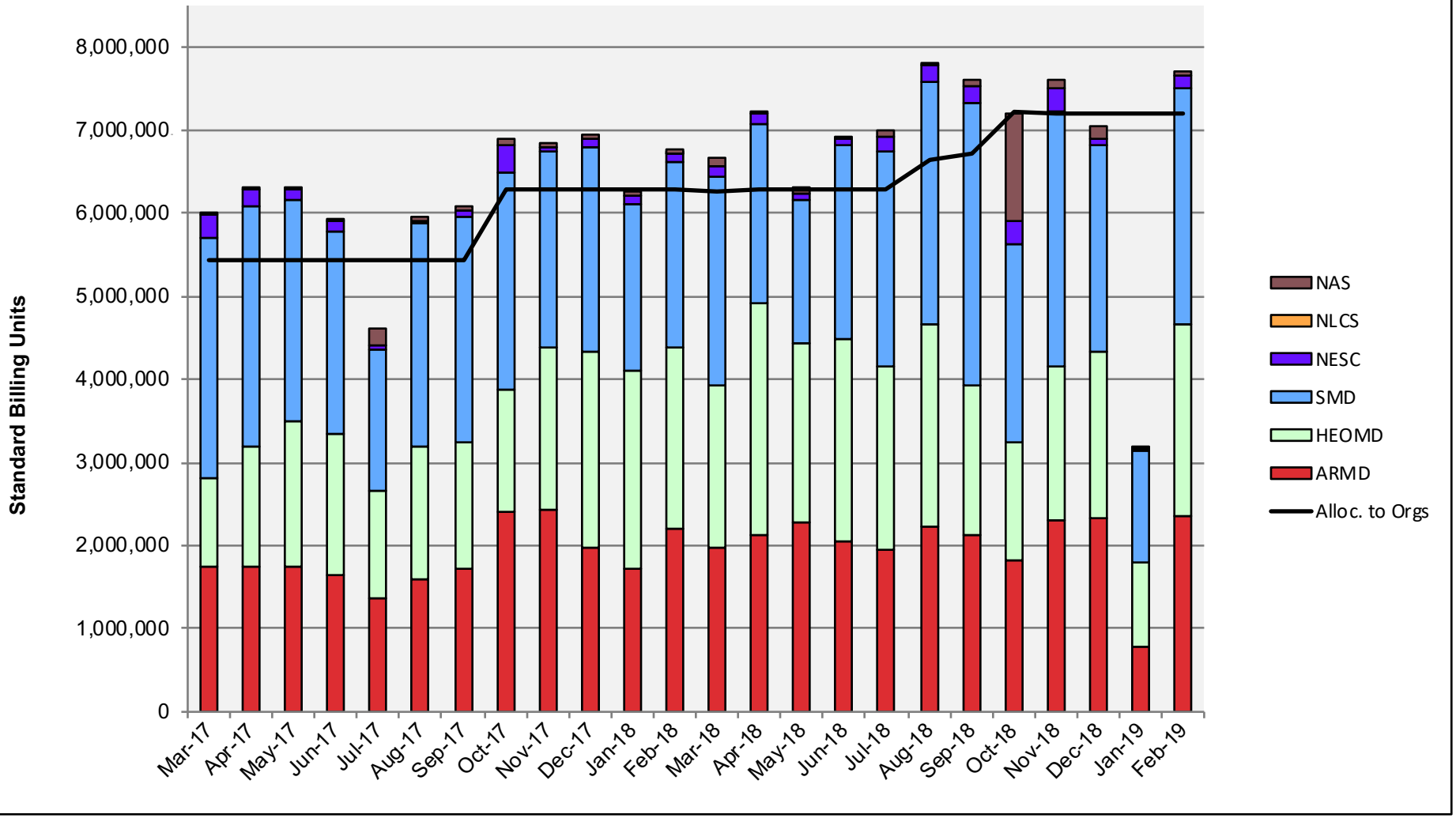
News and Events: Social Media

- **Agency Coverage of NAS Computing**
  - NCCS Coverage of “Pulsar in a Box” story with work done on both NCCS and NAS resources.
    - Twitter: 2 retweets, 12 likes
    - Facebook: 497 users reached, 44 engagements
- **Top Posts from NAS**
  - Honoring legacy of Kalpana Chawla for NASA Remembers campaign.
    - Twitter: 147 retweets, 698 likes
    - Facebook: 1,292 users reached, 216 engagements
  - Black holes and plasma jets simulations (news tie-in) run on HECC machines.
    - Twitter: 5 retweets, 7 likes
    - Facebook: 218 users reached, 15 engagements
  - Climate and machine learning (Science Node news tie-in) run on HECC machines.
    - Twitter: 4 retweets, 9 likes
    - Facebook: 535 users reached, 21 engagements
  - Pegasus 5 NASA Spin-off/Tech Briefs.
    - Facebook: 256 users reached, 17 engagements

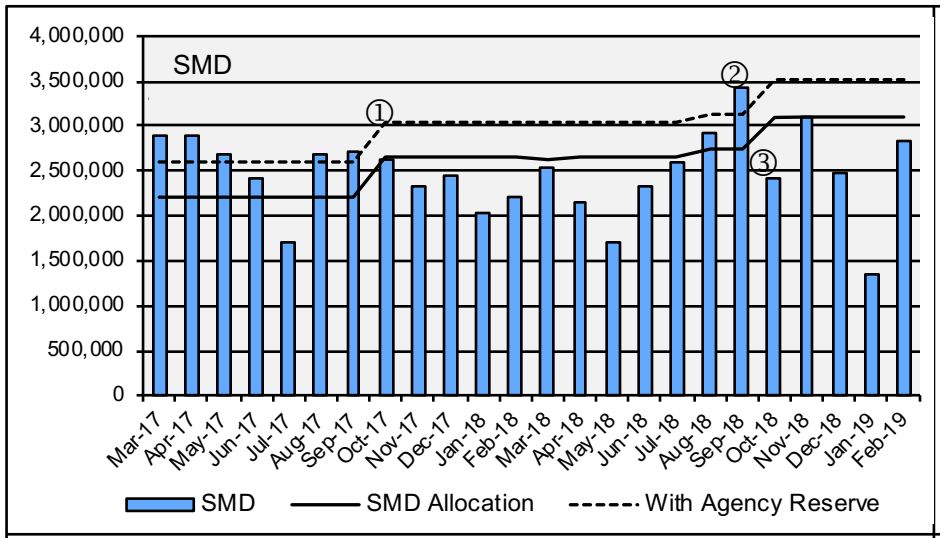
HECC Utilization

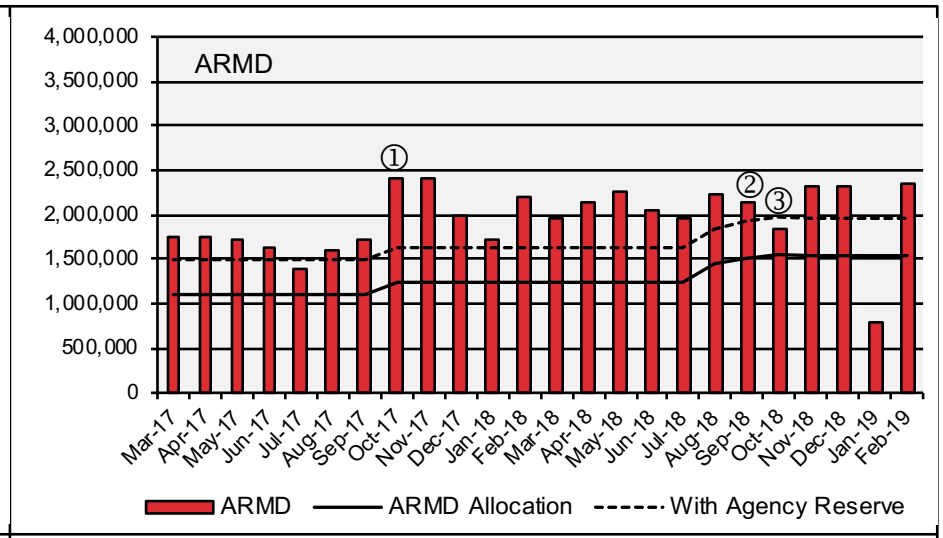


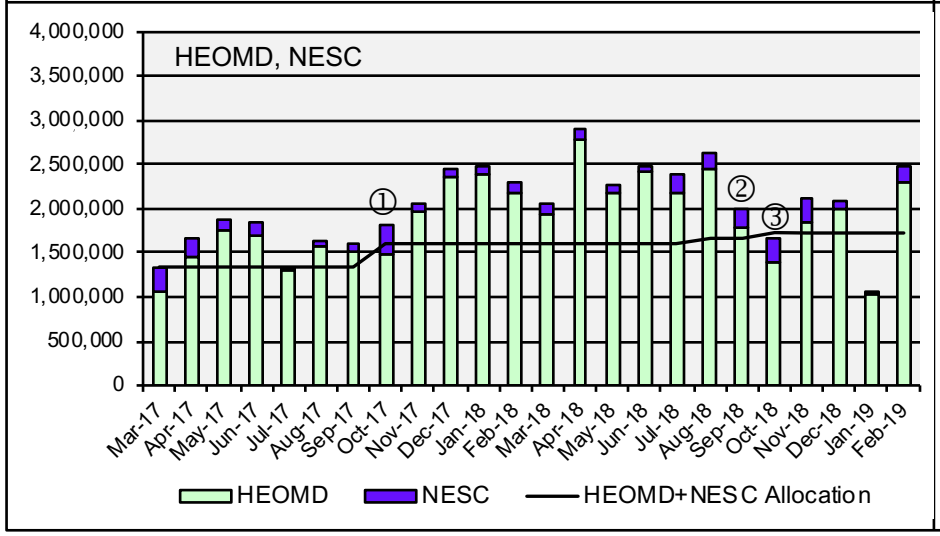
HECC Utilization Normalized to 30-Day Month



HECC Utilization Normalized to 30-Day Month





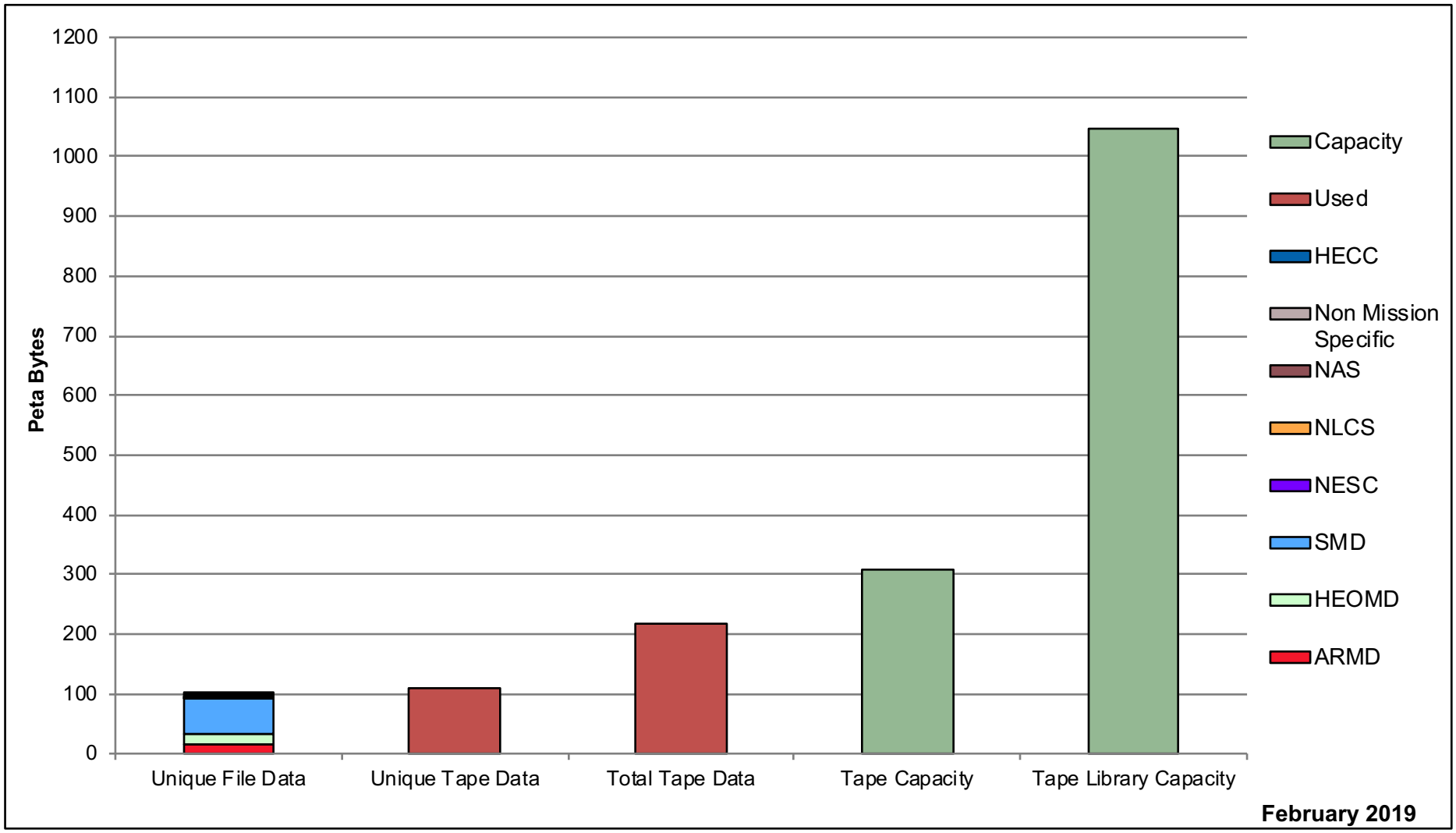


① 4 Skylake E cells (1,152 nodes, 46,080 cores) added to Electra

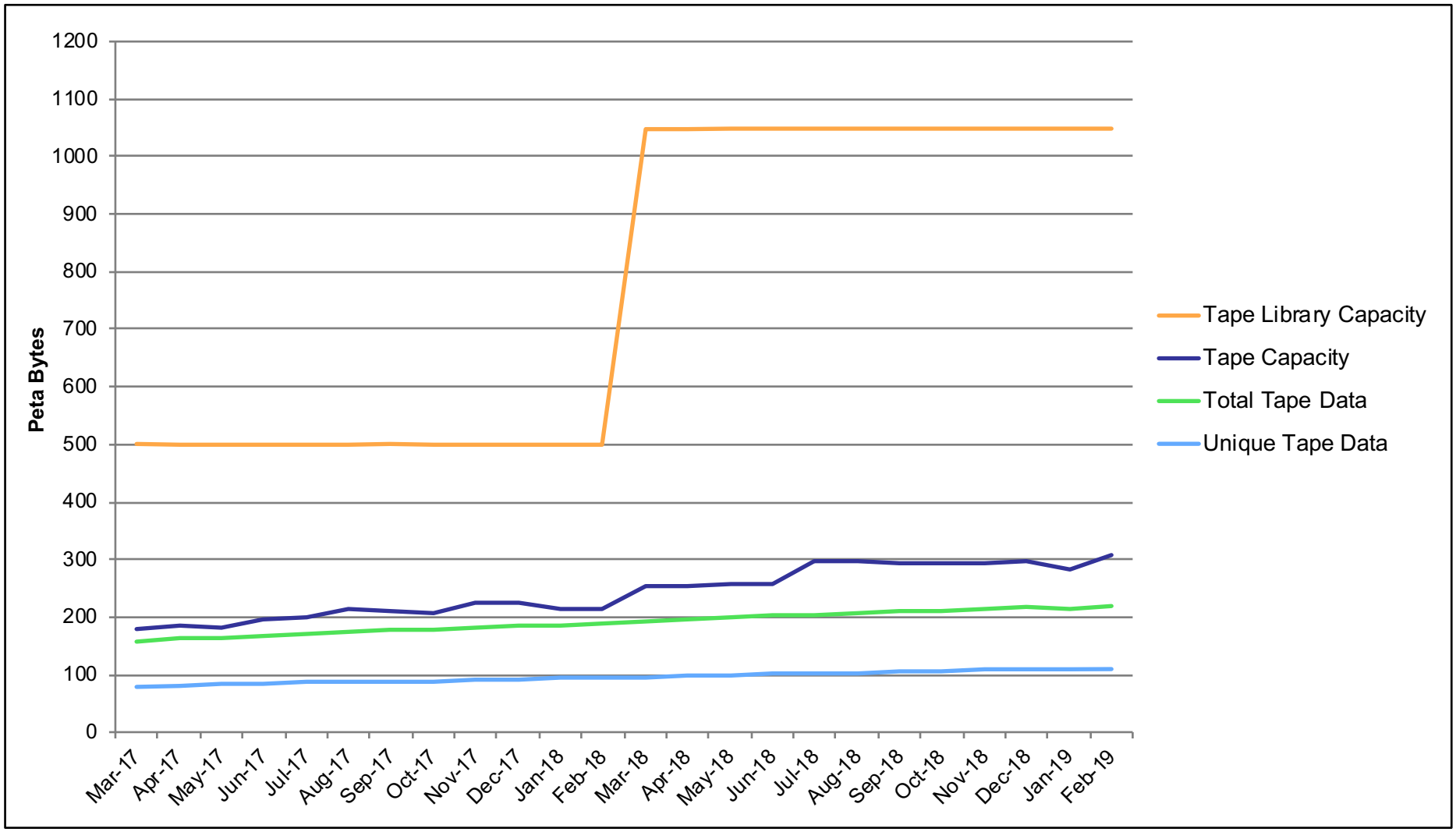
② 2 Skylake E cells (576 nodes, 23,040 cores) added to Electra; 1 rack is dedicated to ARMD

③ 2 Skylake E cells (576 nodes, 23,040 cores) added to Electra; 1 rack is dedicated to SMD

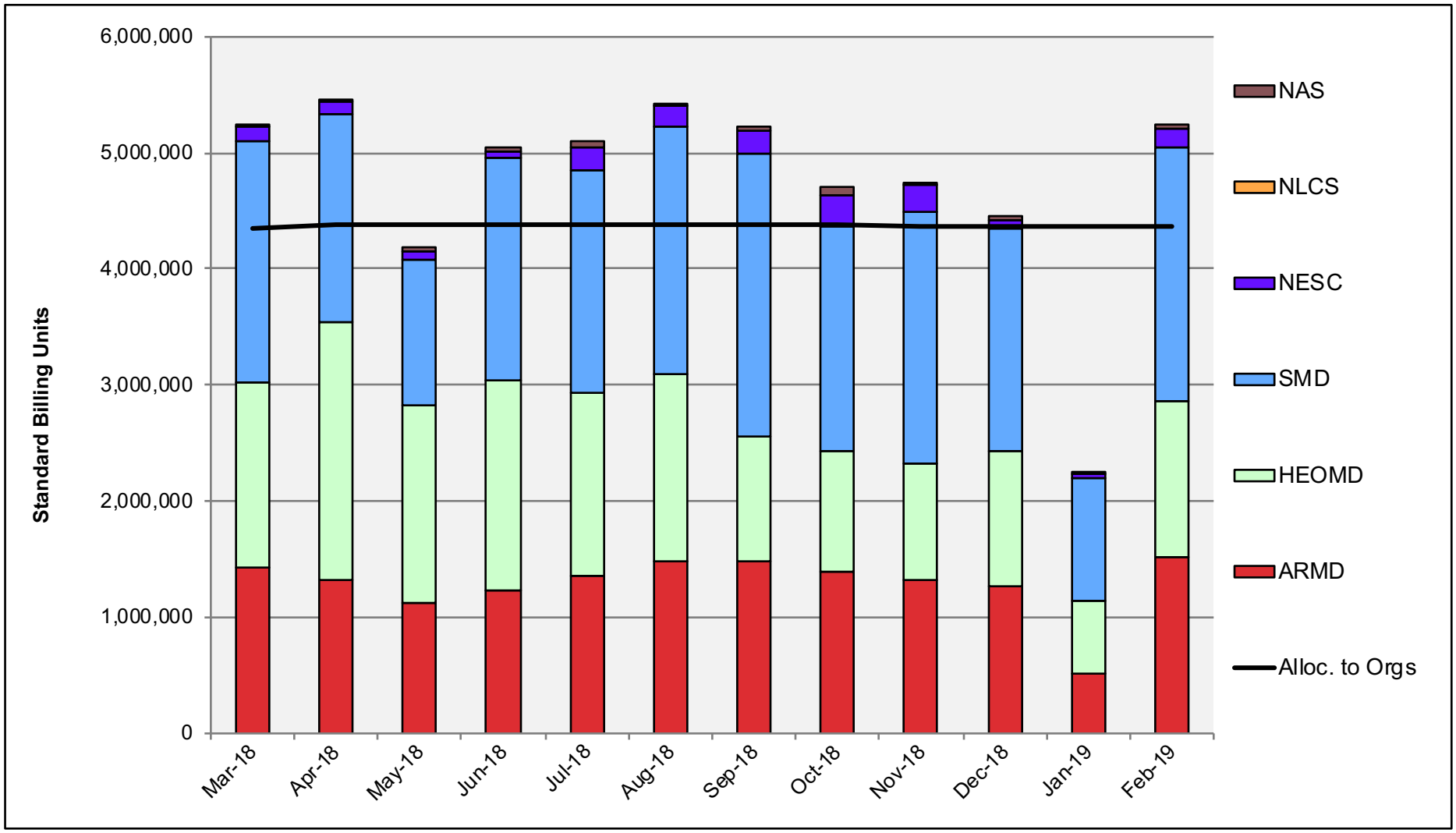
Tape Archive Status



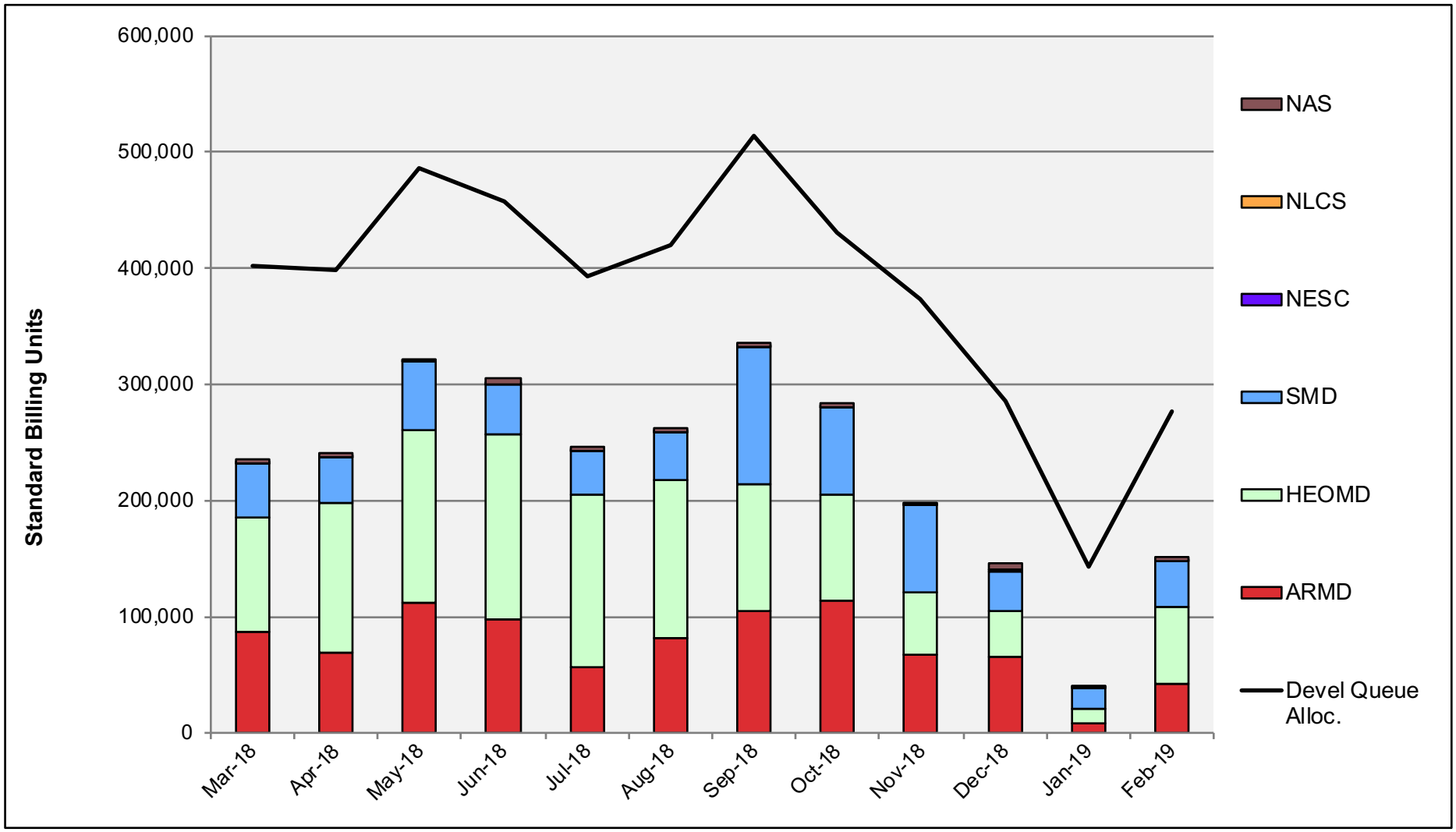
Tape Archive Status



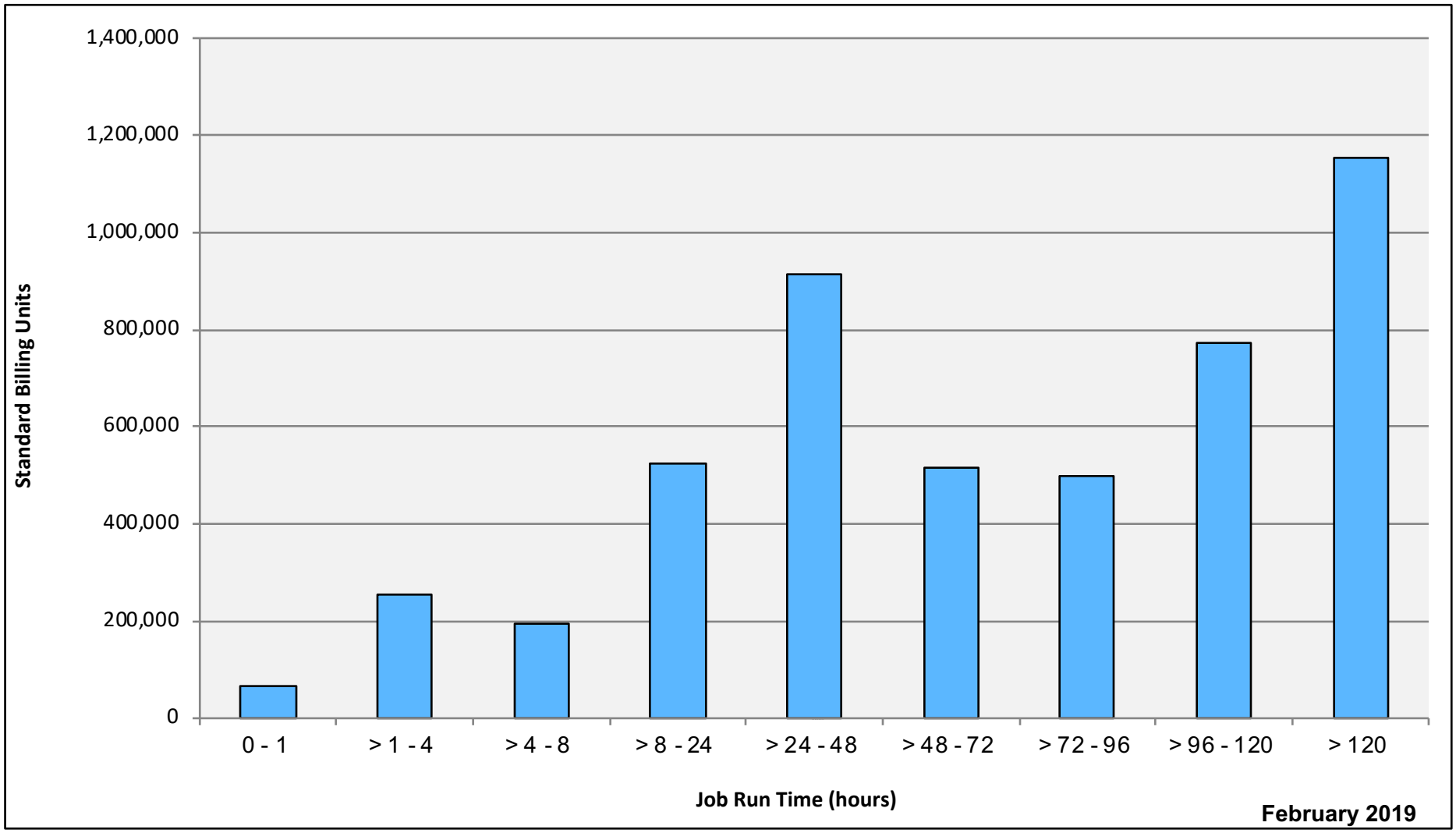
Pleiades:
SBUs Reported, Normalized to 30-Day Month



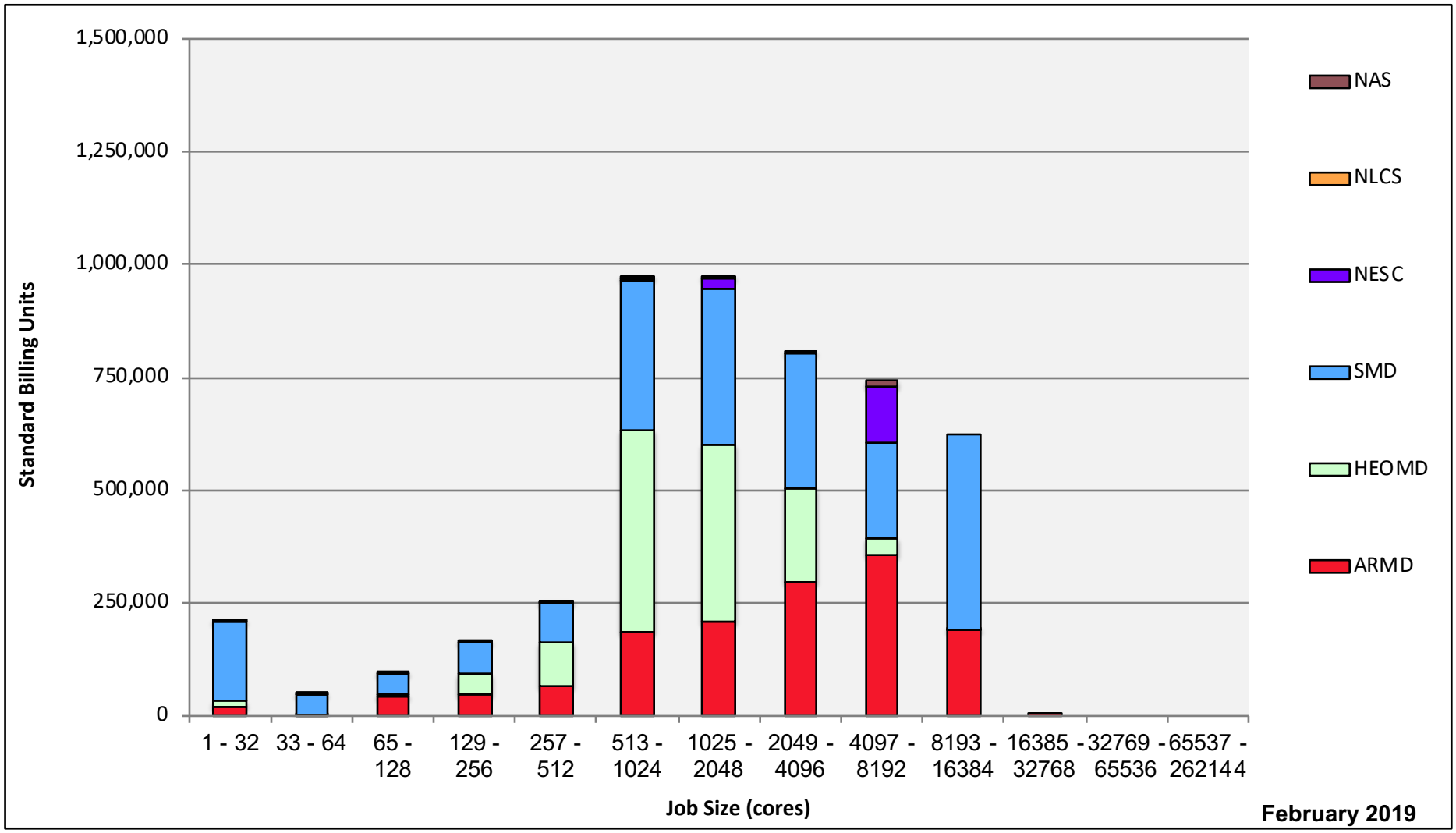
Pleiades:
Devel Queue Utilization



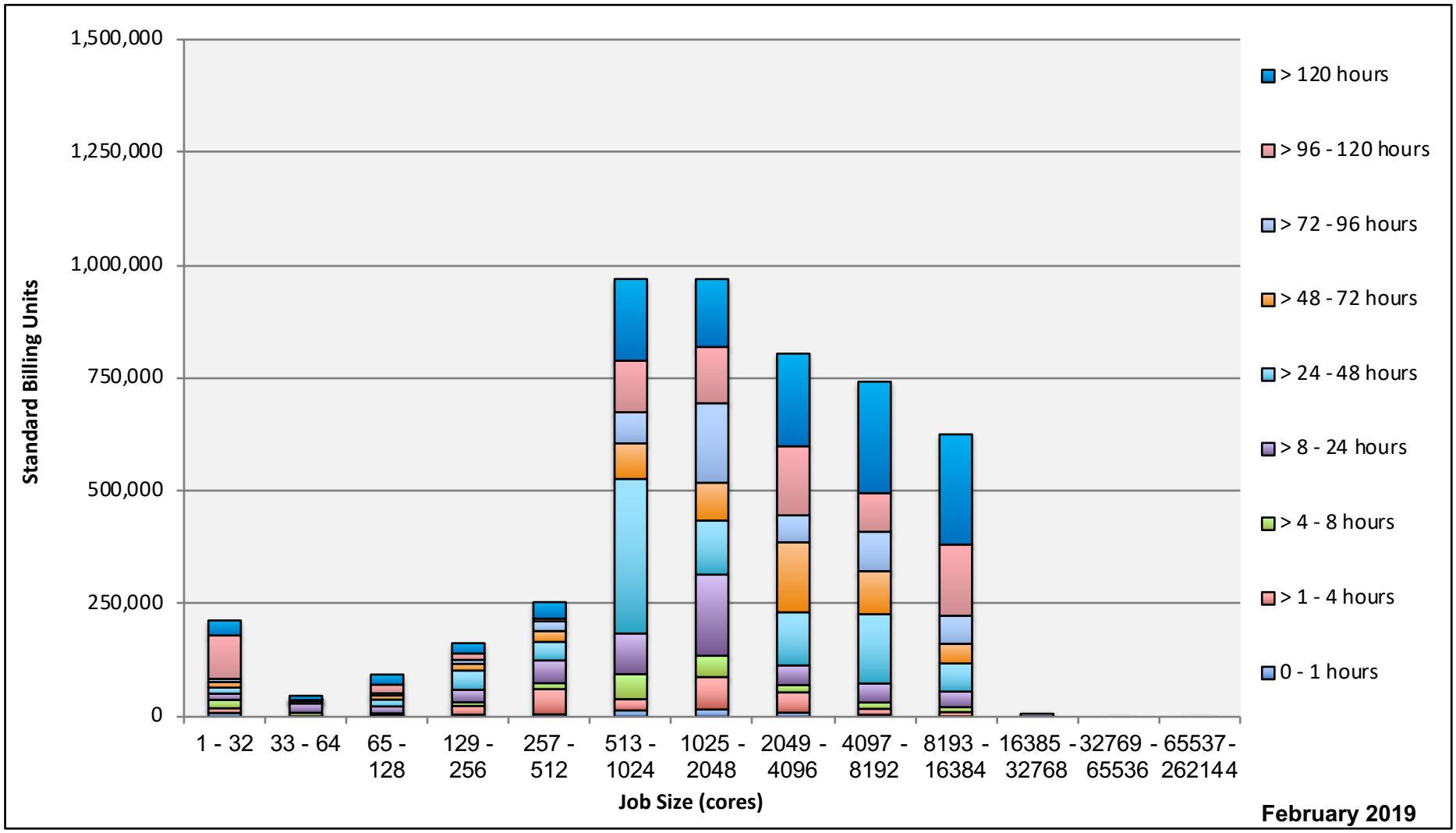
Pleiades:
Monthly Utilization by Job Length



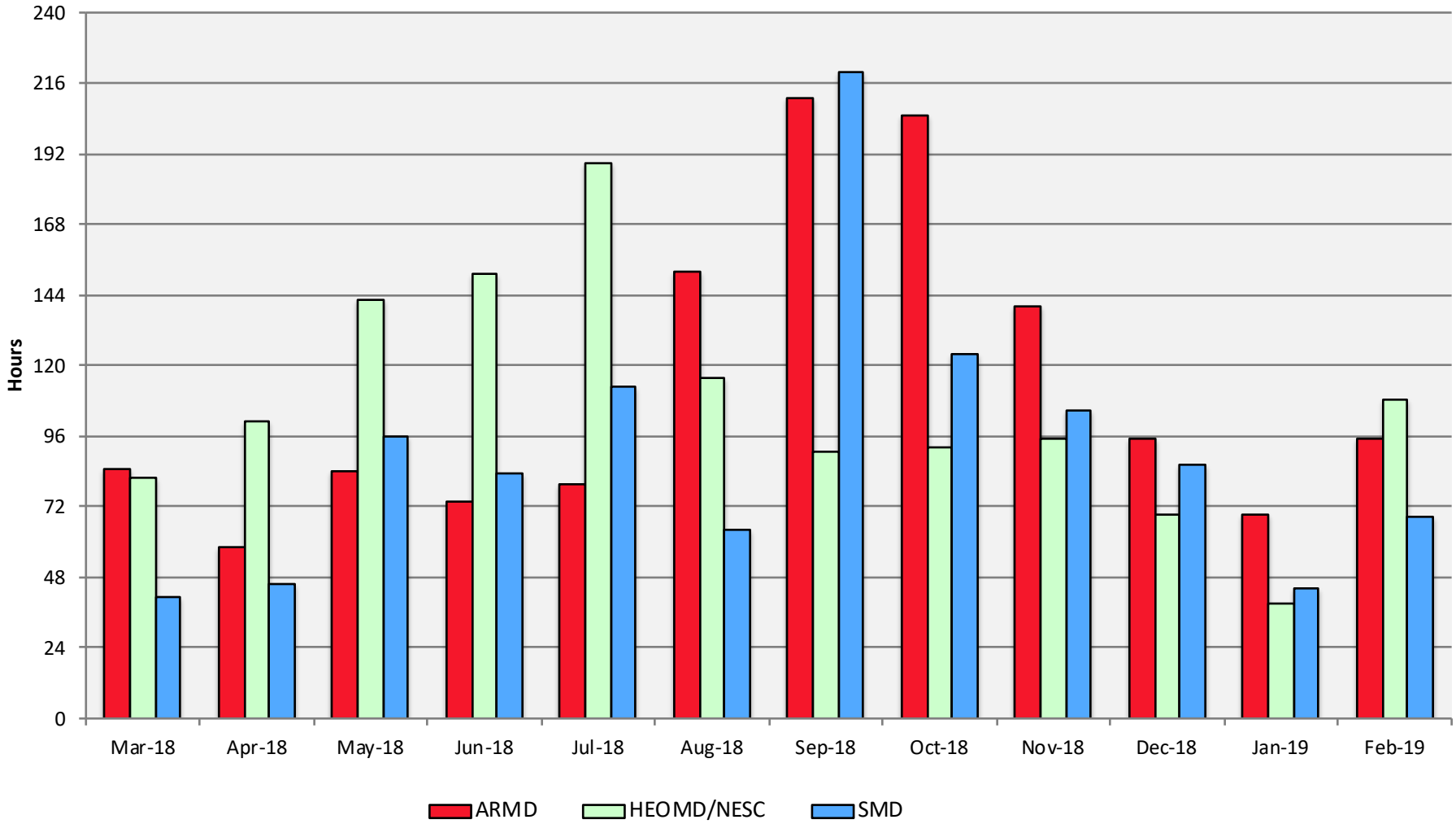
Pleiades:
Monthly Utilization by Size and Mission



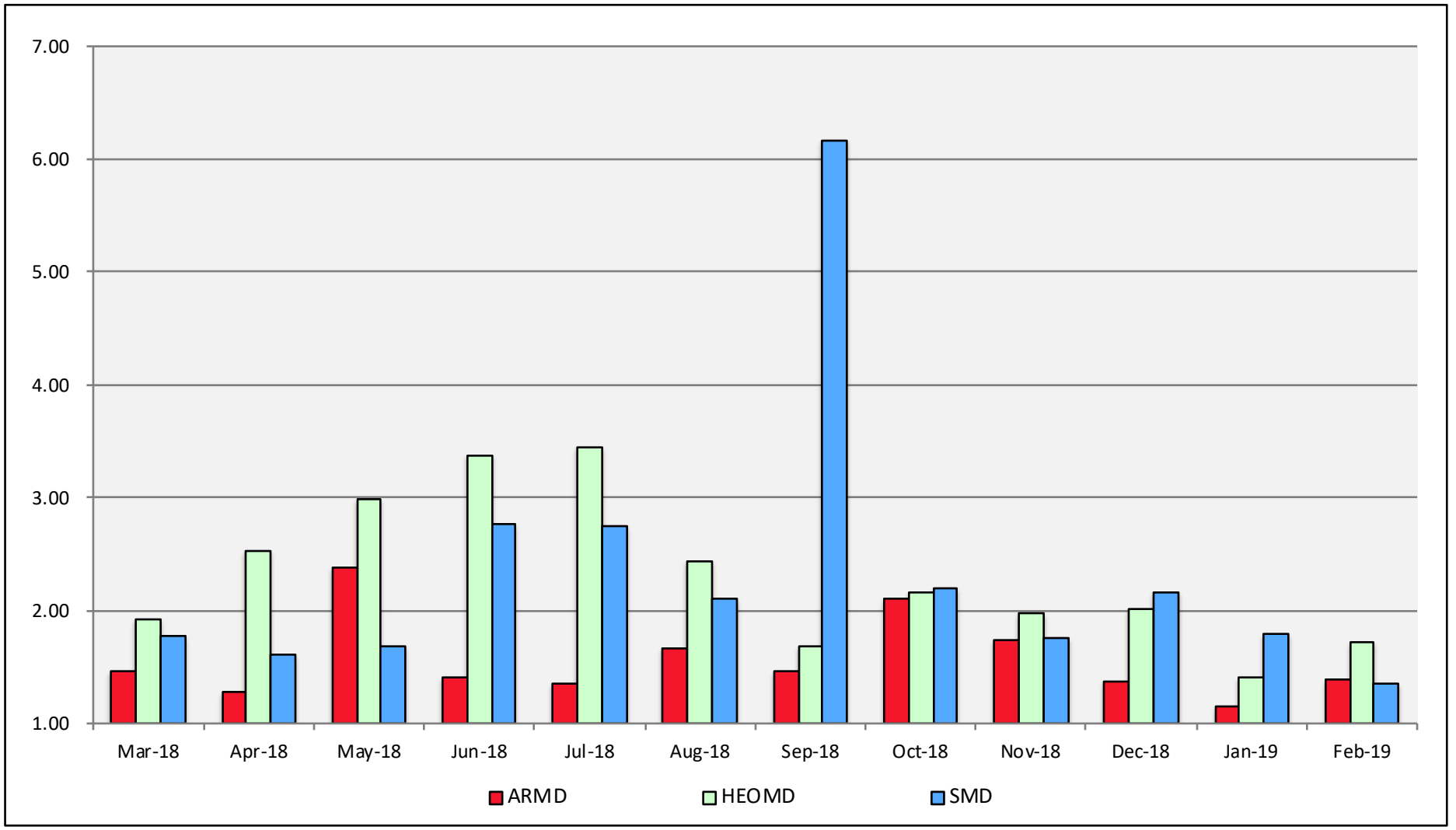
Pleiades:
Monthly Utilization by Size and Length



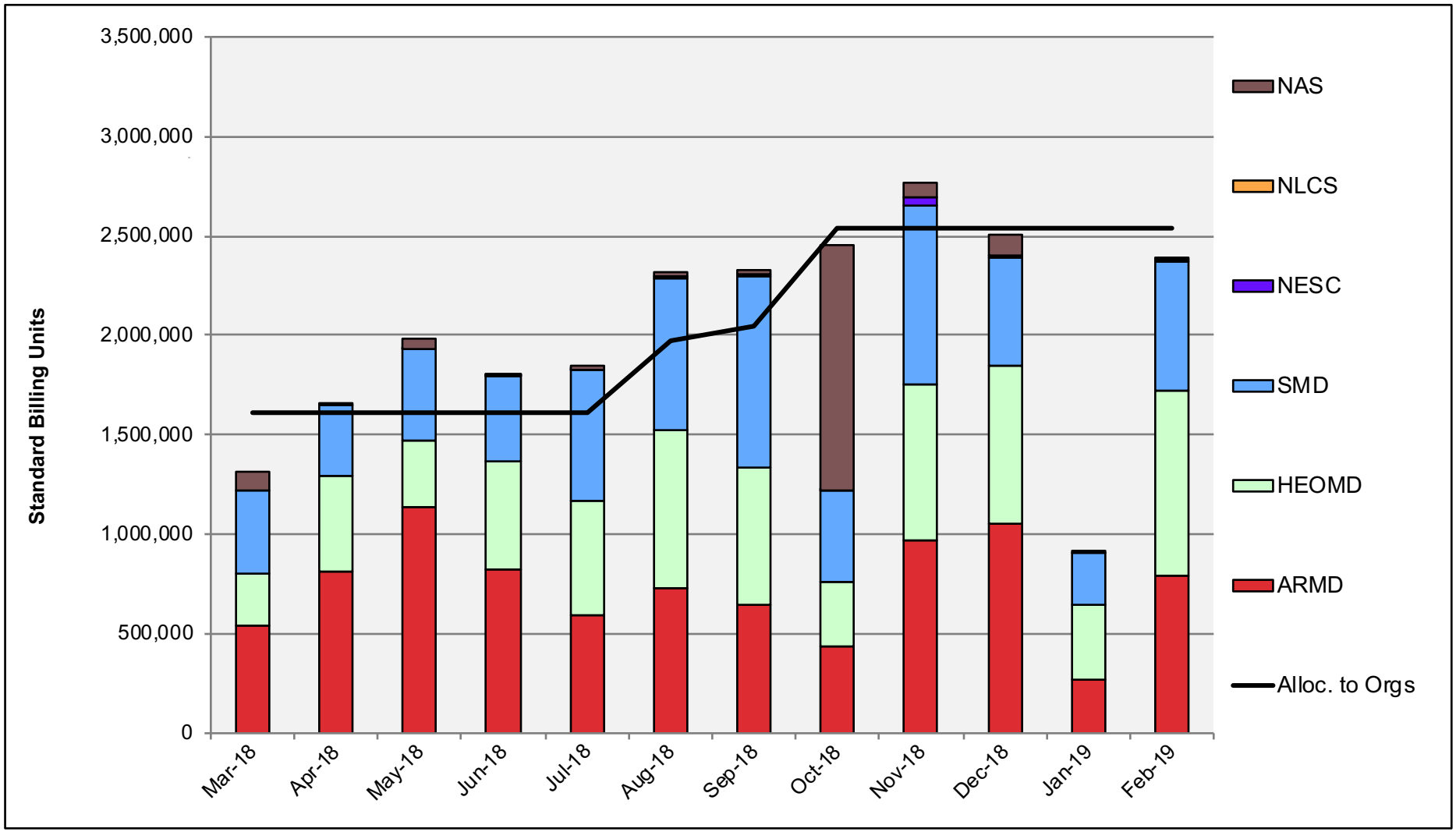
Pleiades:
Average Time to Clear All Jobs



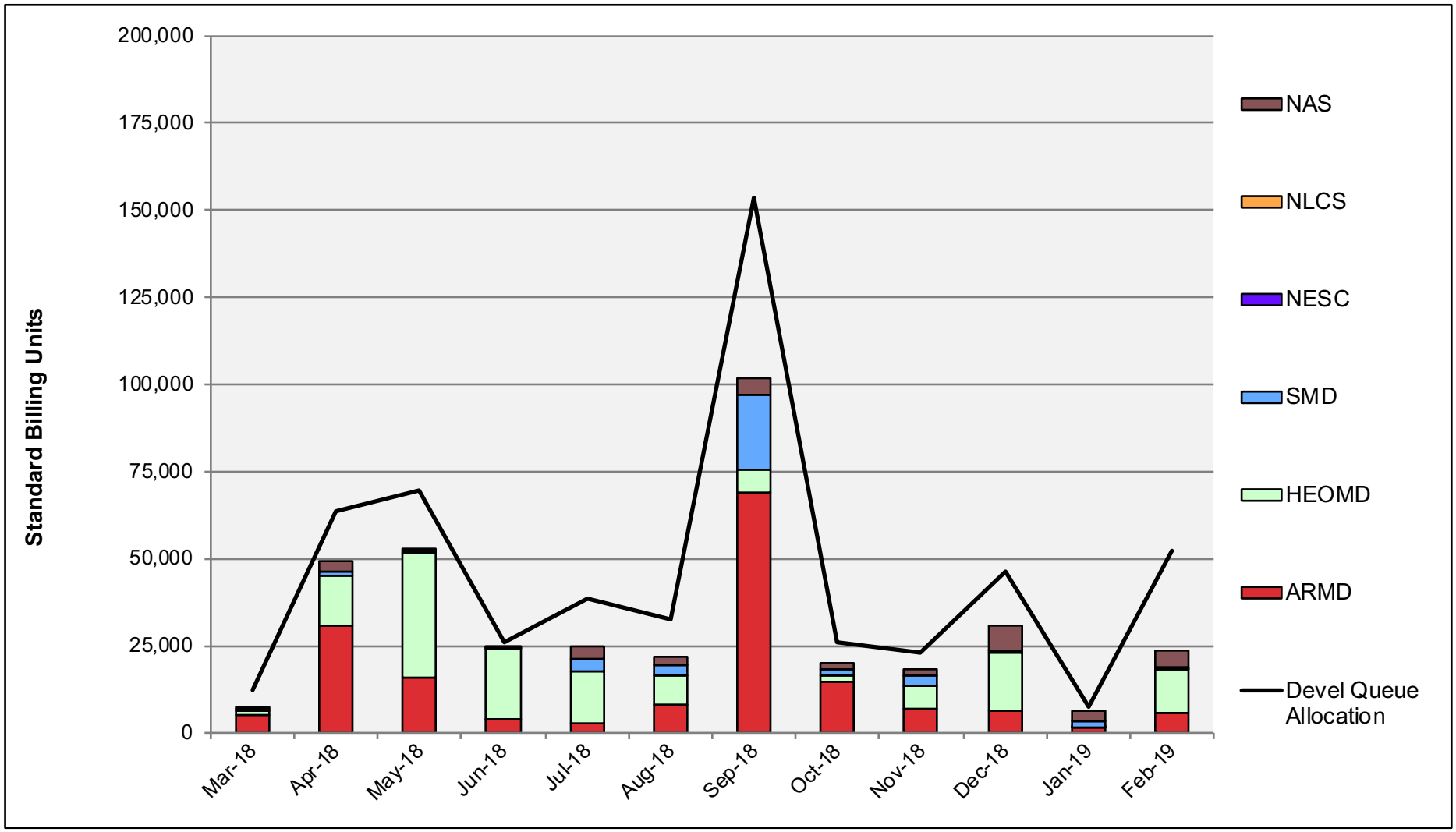
Pleiades:
Average Expansion Factor



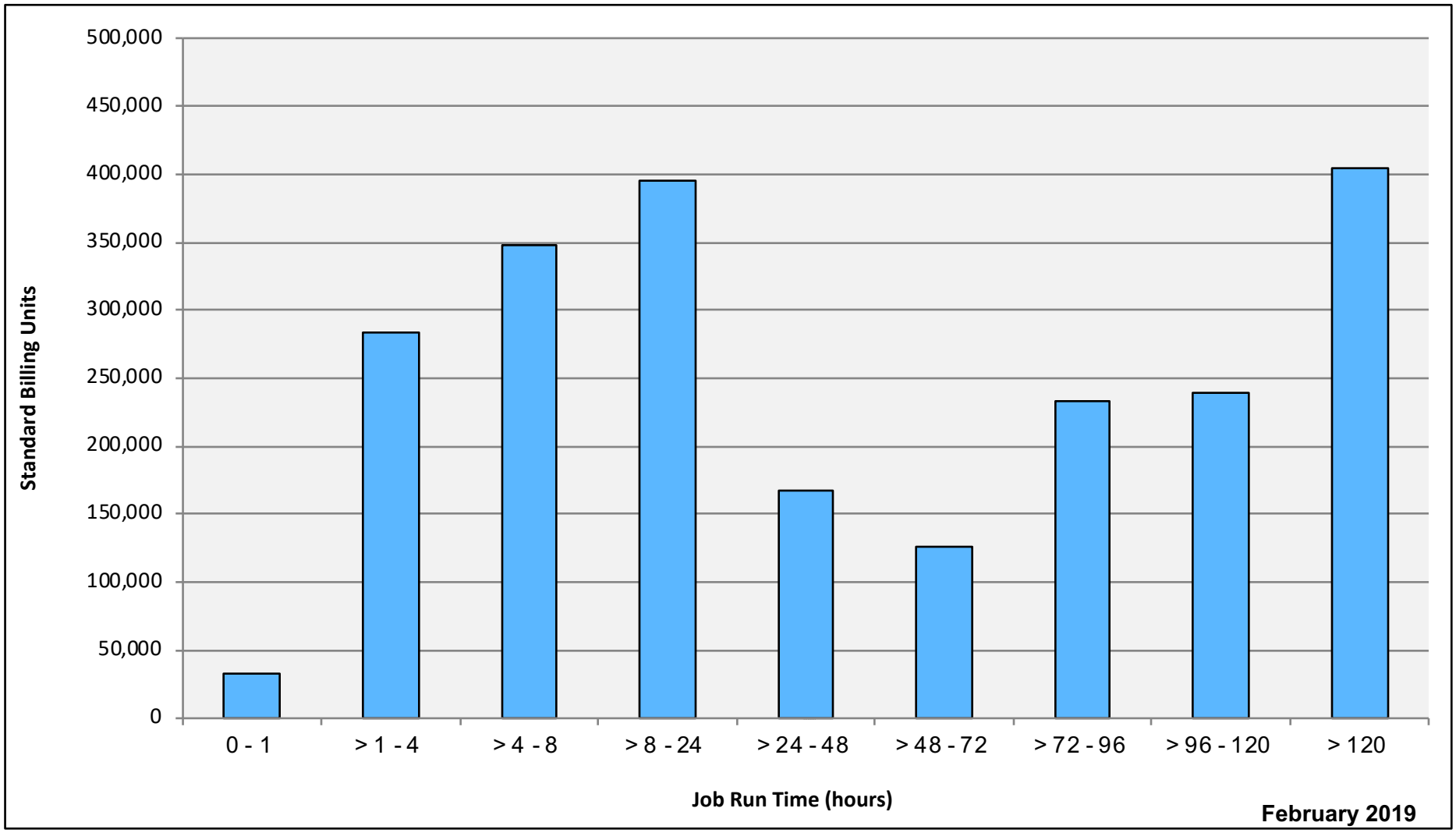
Electra:
SBUs Reported, Normalized to 30-Day Month



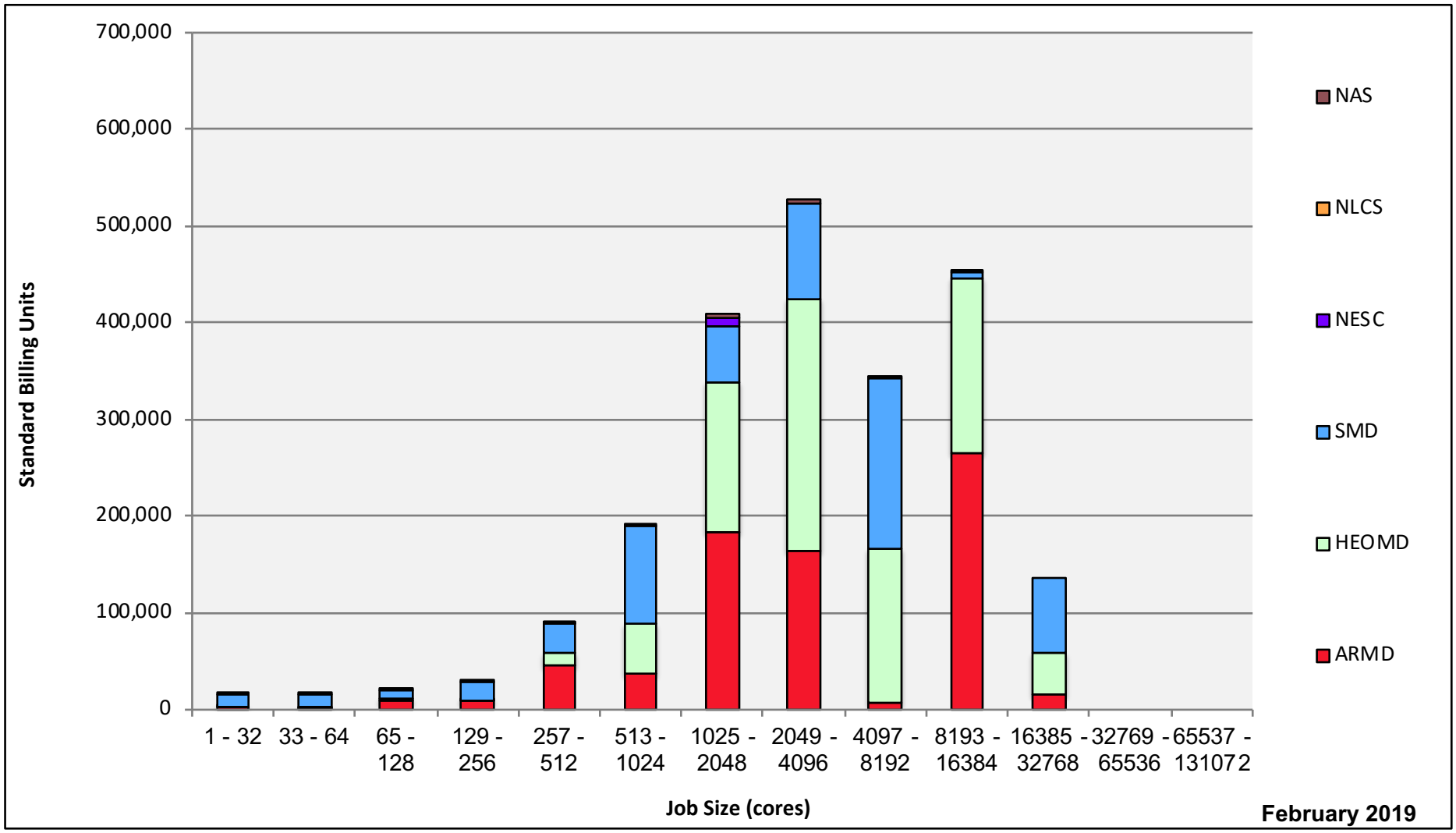
Electra:
Devel Queue Utilization



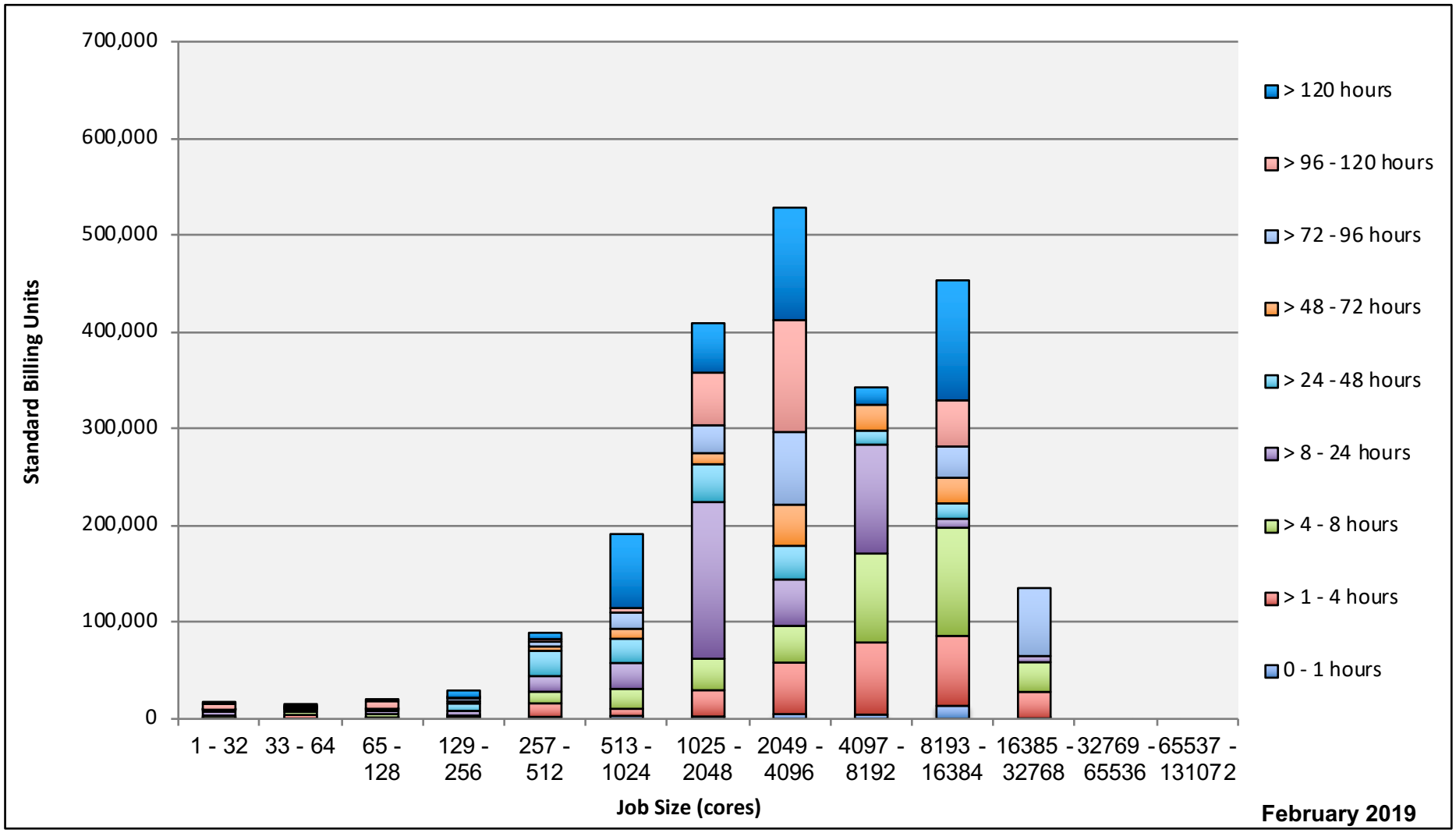
Electra:
Monthly Utilization by Job Length



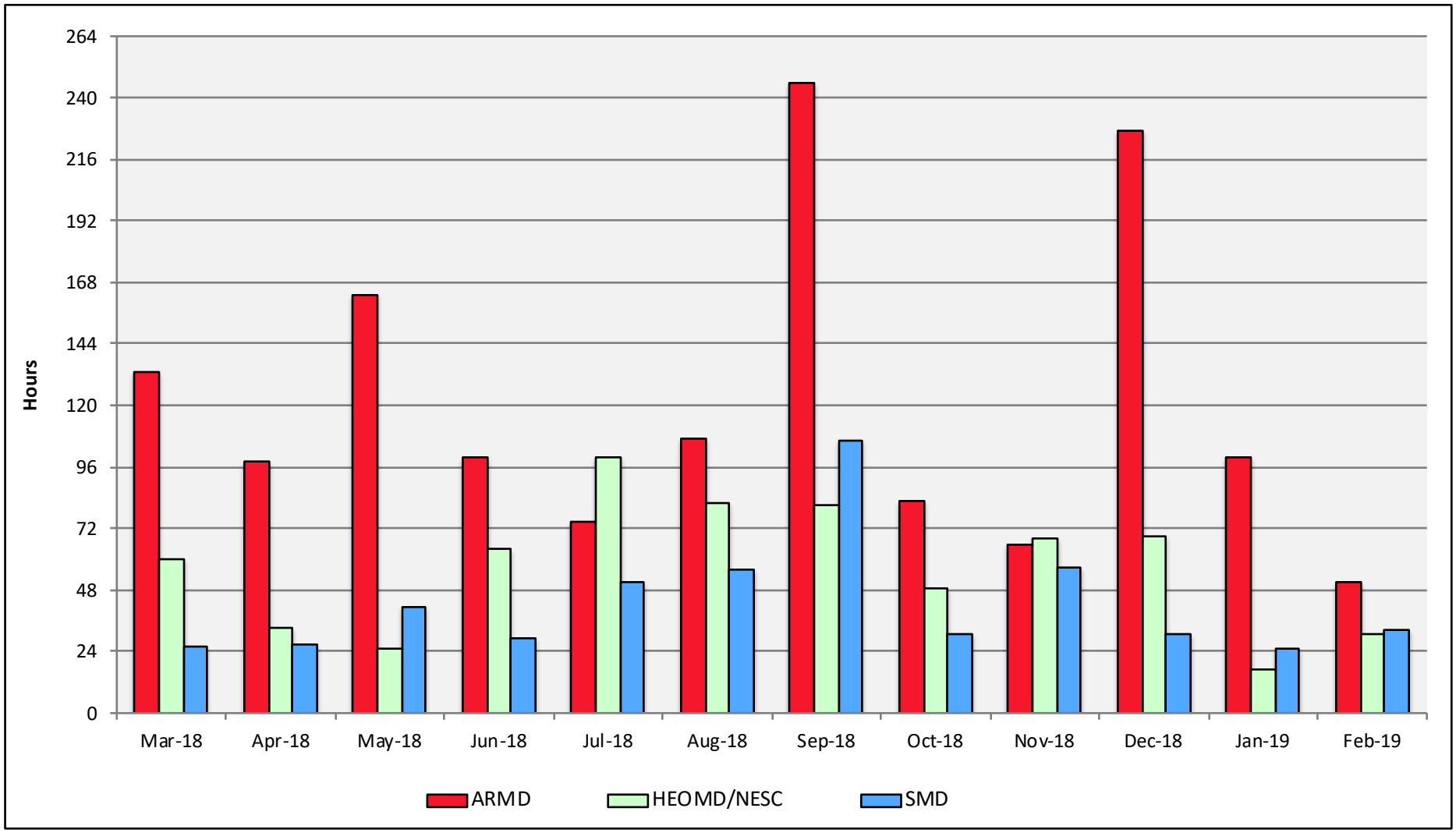
Electra:
Monthly Utilization by Size and Mission



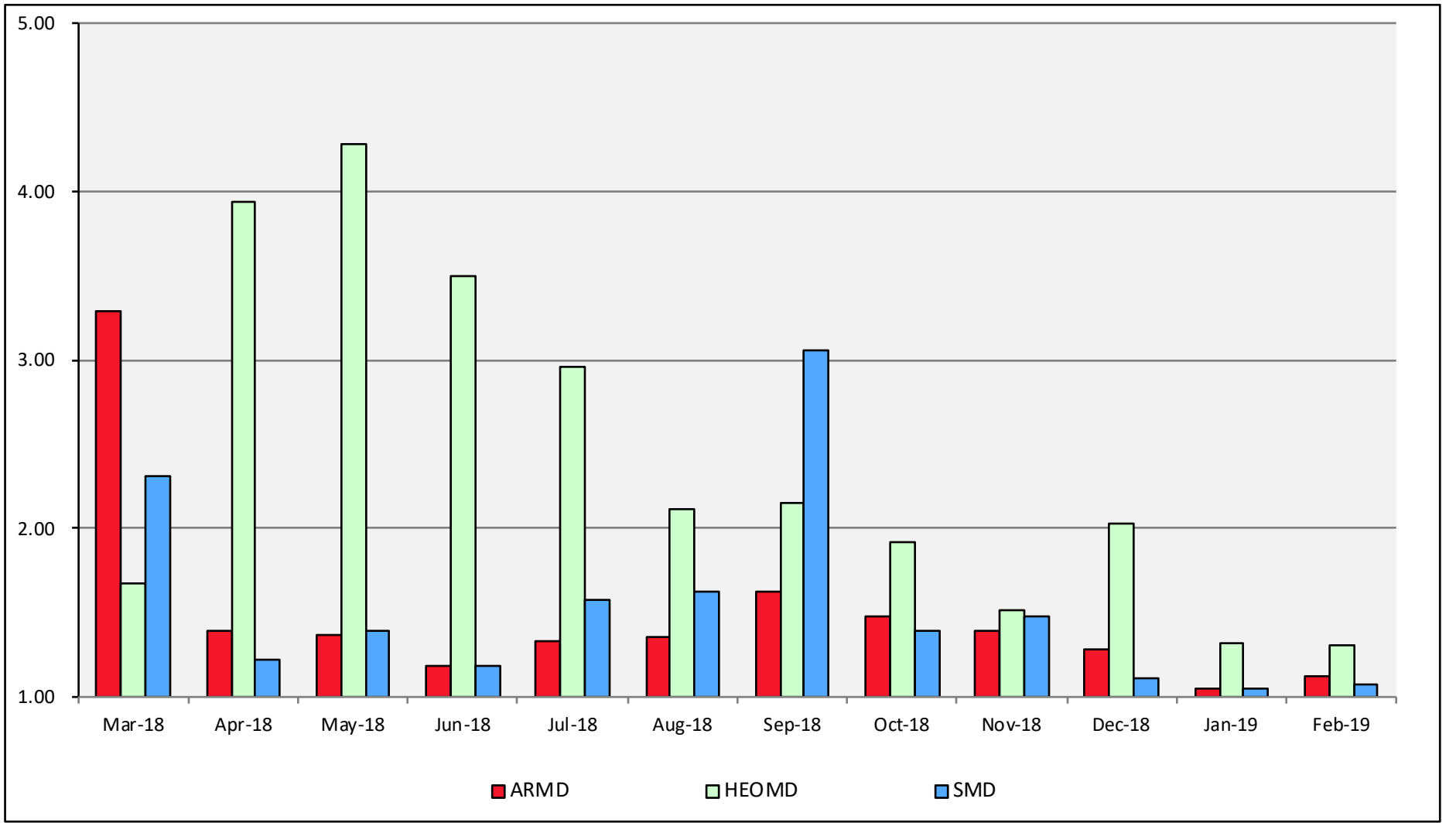
Electra:
Monthly Utilization by Size and Length



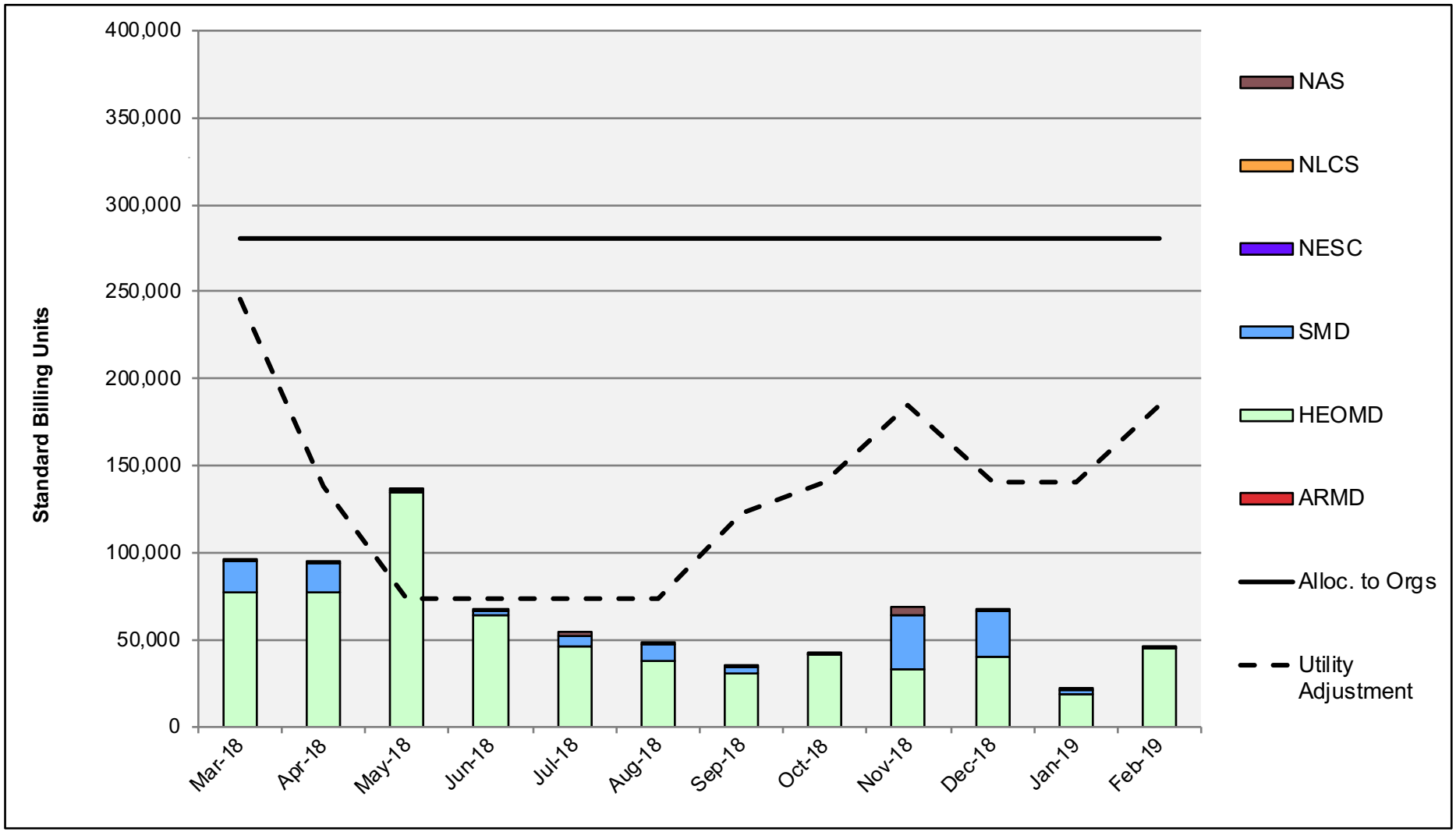
Electra:
Average Time to Clear All Jobs



Electra:
Average Expansion Factor

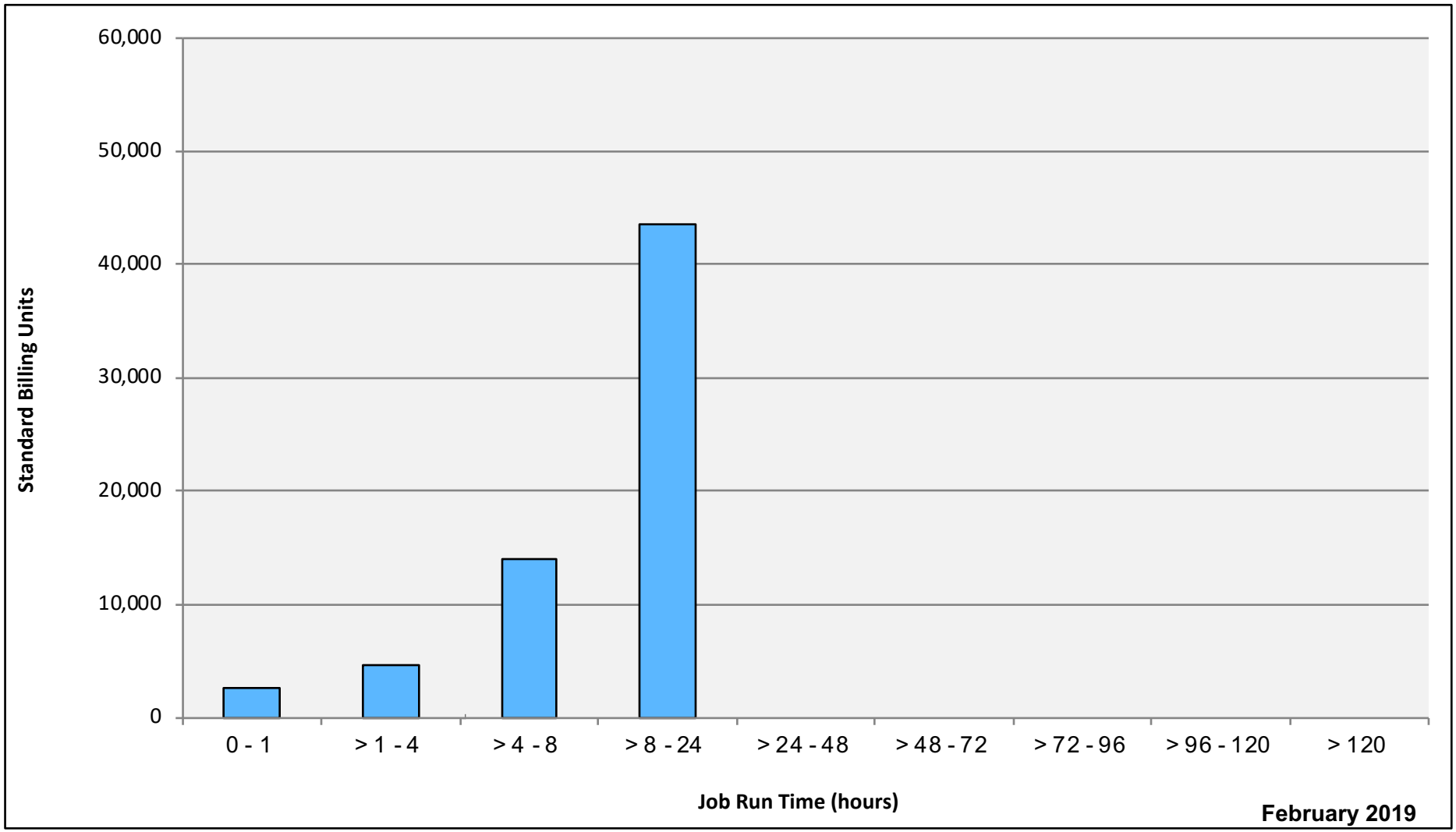


Merope:
SBUs Reported, Normalized to 30-Day Month

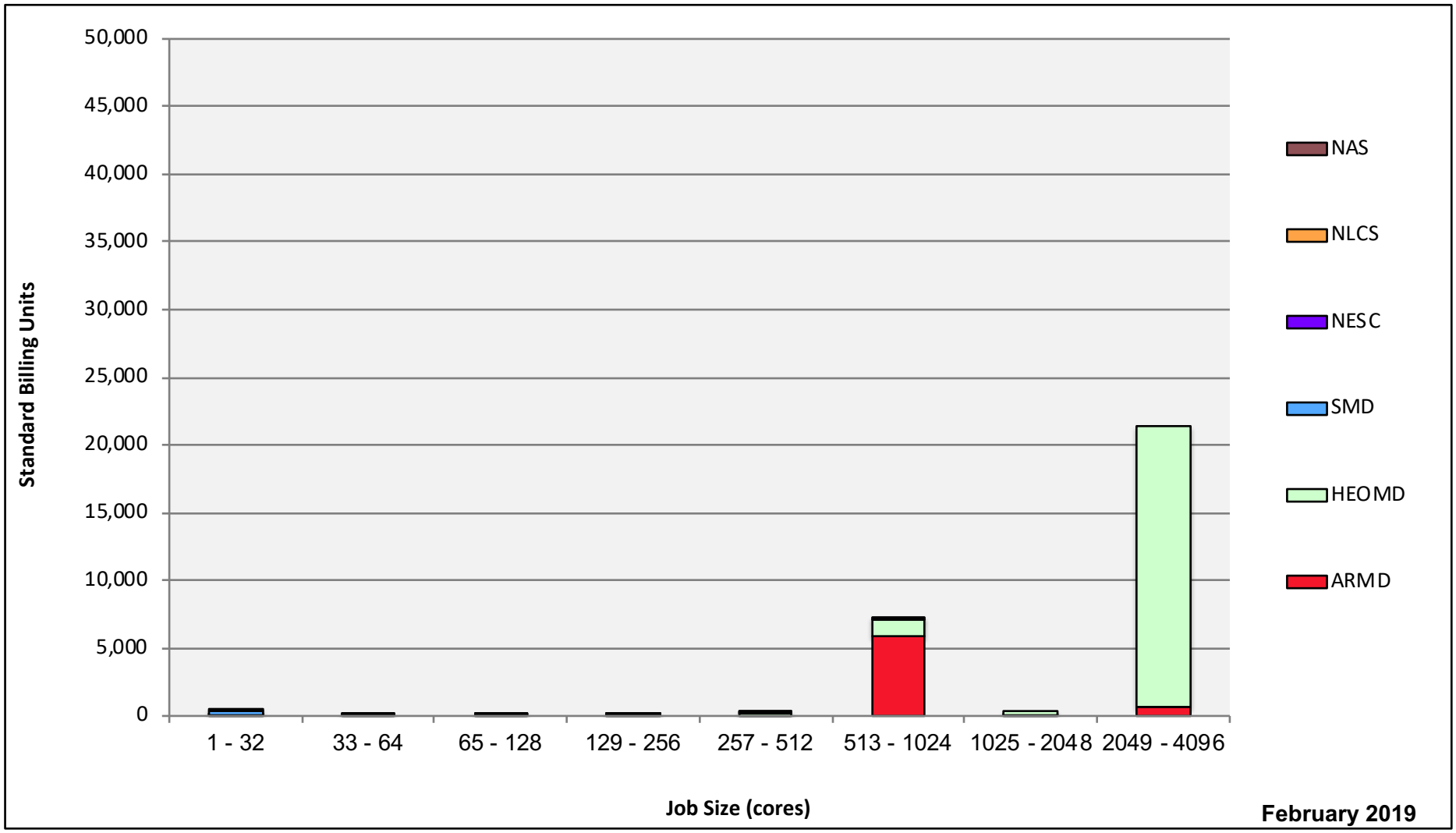


*Utility Adjustment: Multiple failures of chillers in N233A necessitated turning off a large portion of Merope

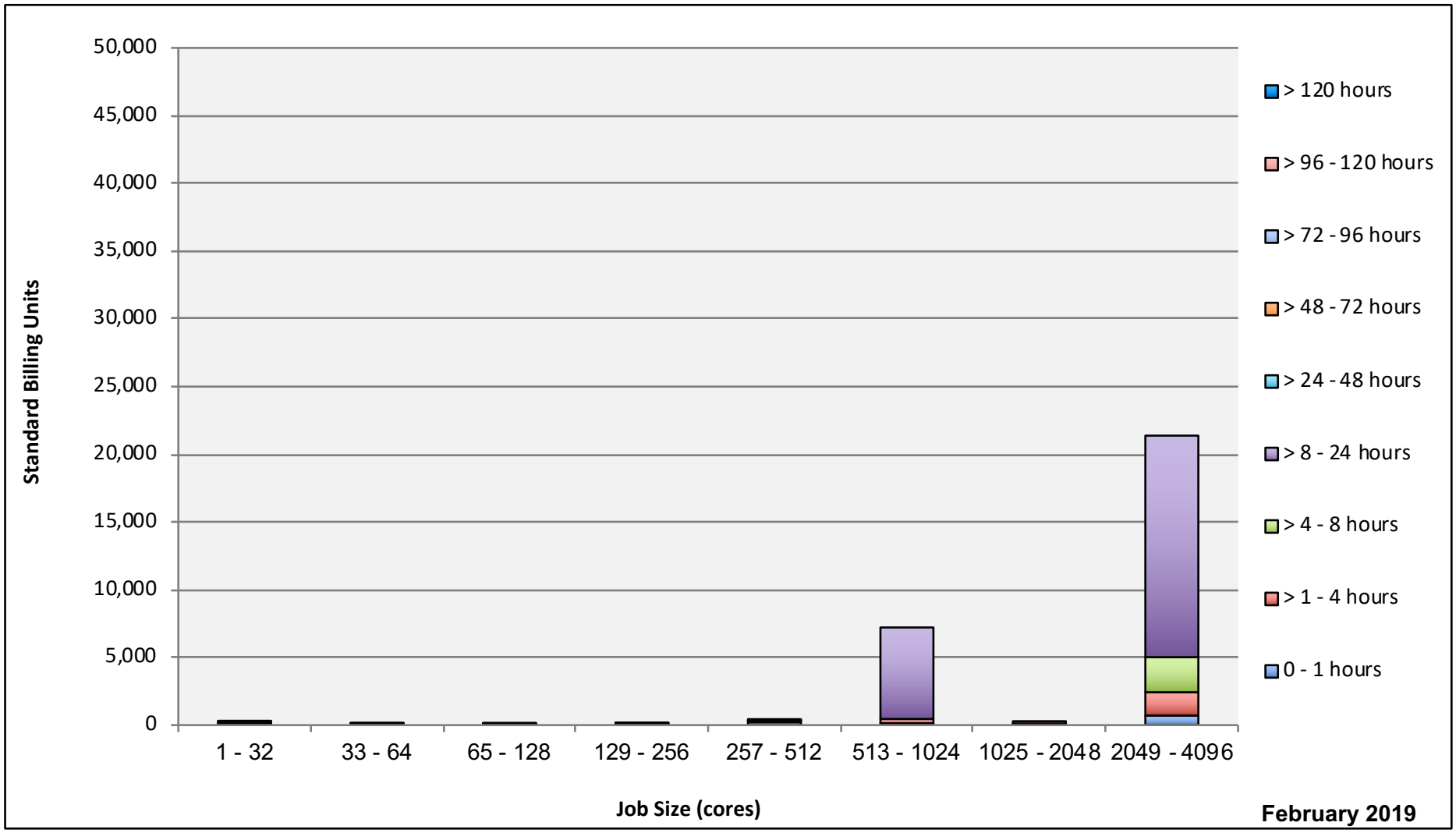
Merope:
Monthly Utilization by Job Length



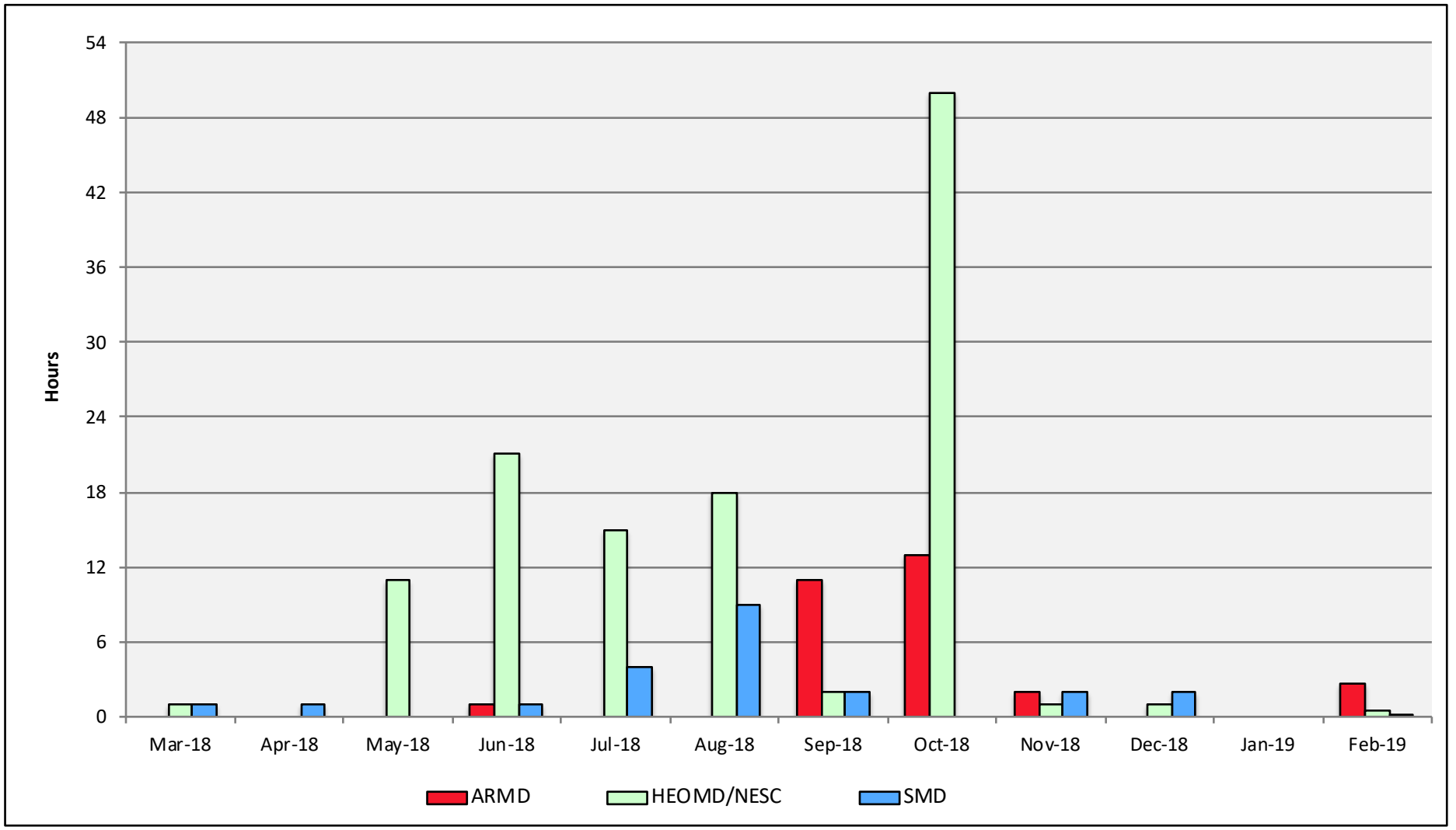
Merope:
Monthly Utilization by Size and Mission



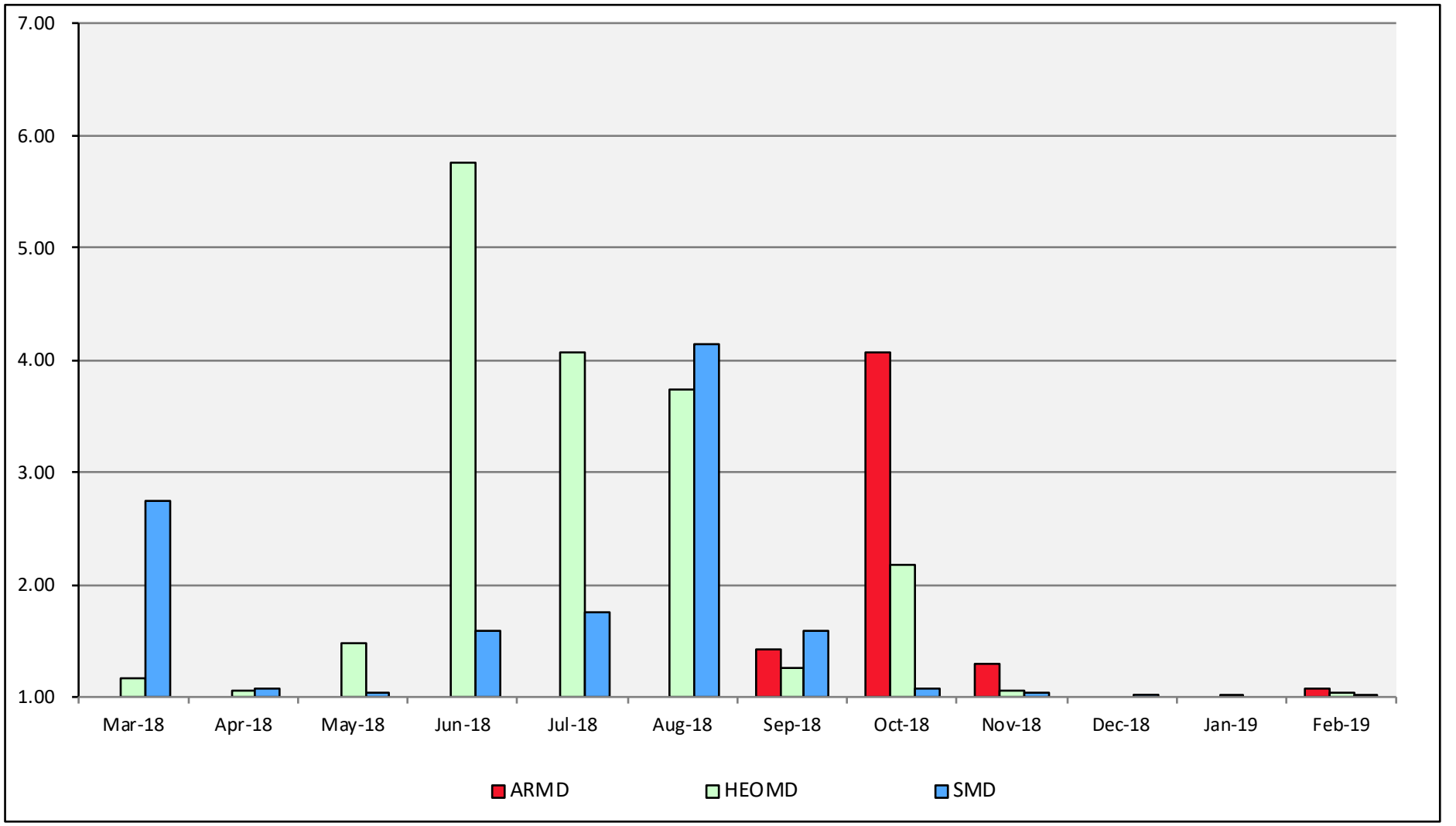
Merope:
Monthly Utilization by Size and Length



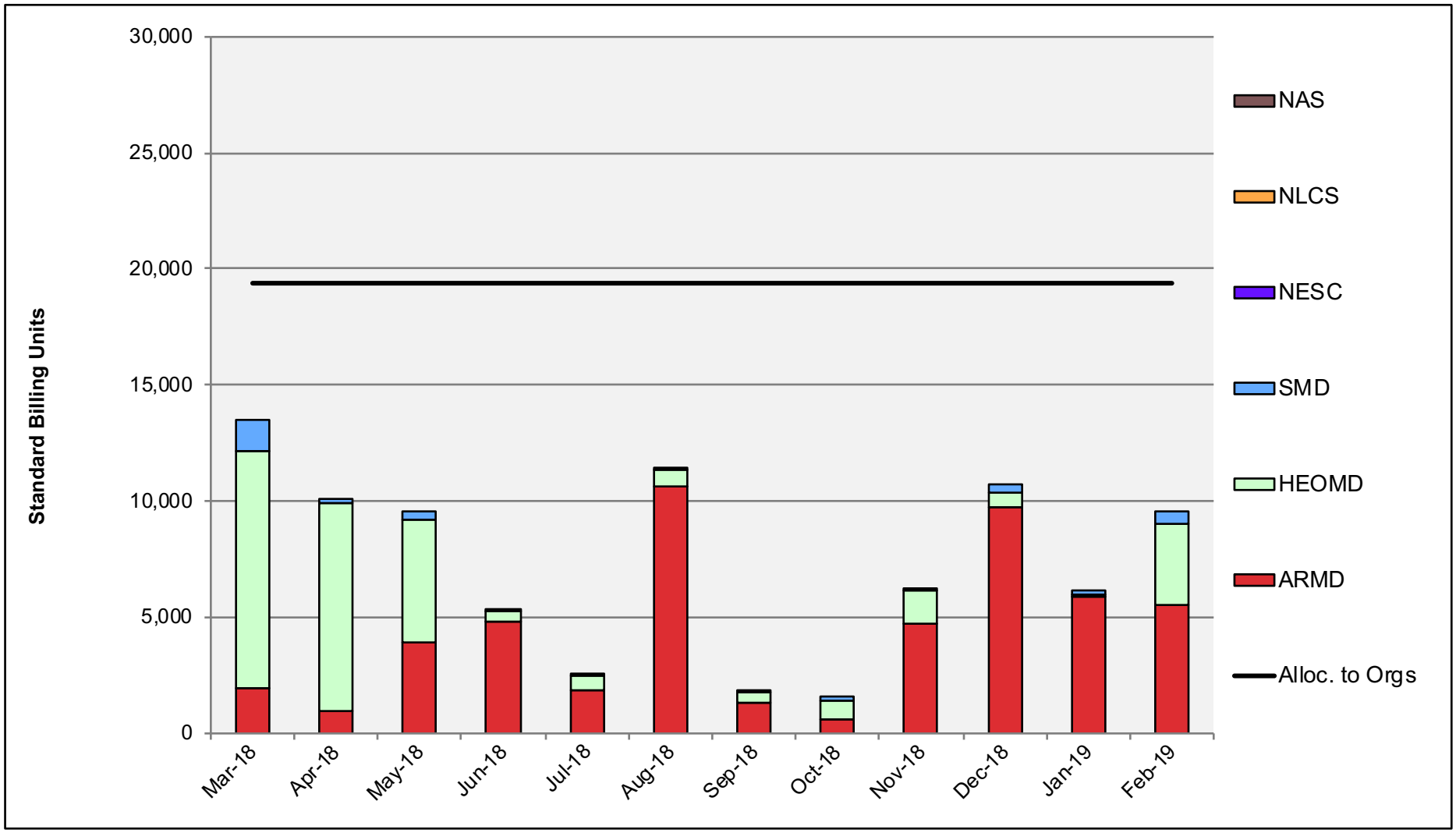
Merope:
Average Time to Clear All Jobs



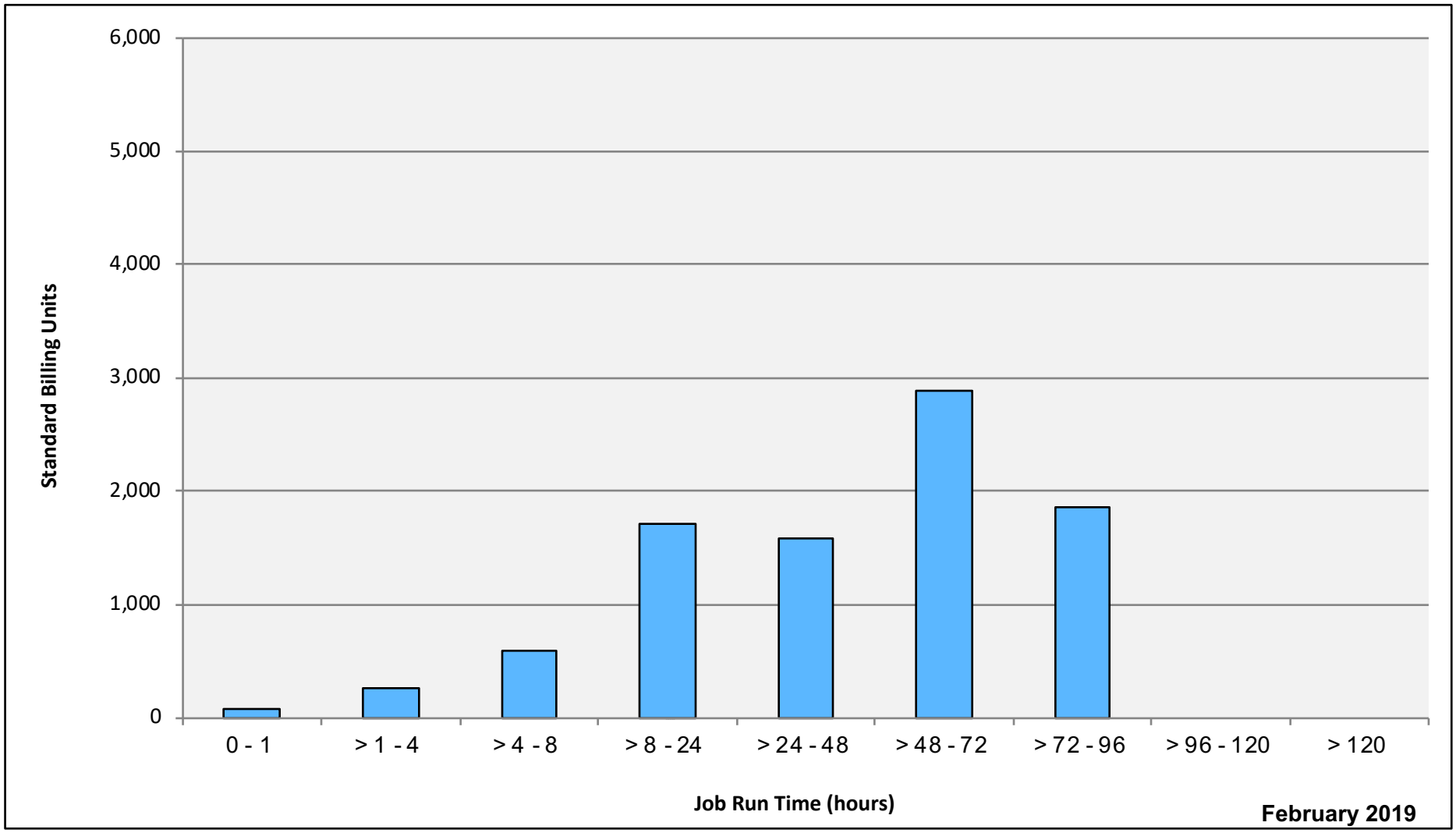
Merope:
Average Expansion Factor



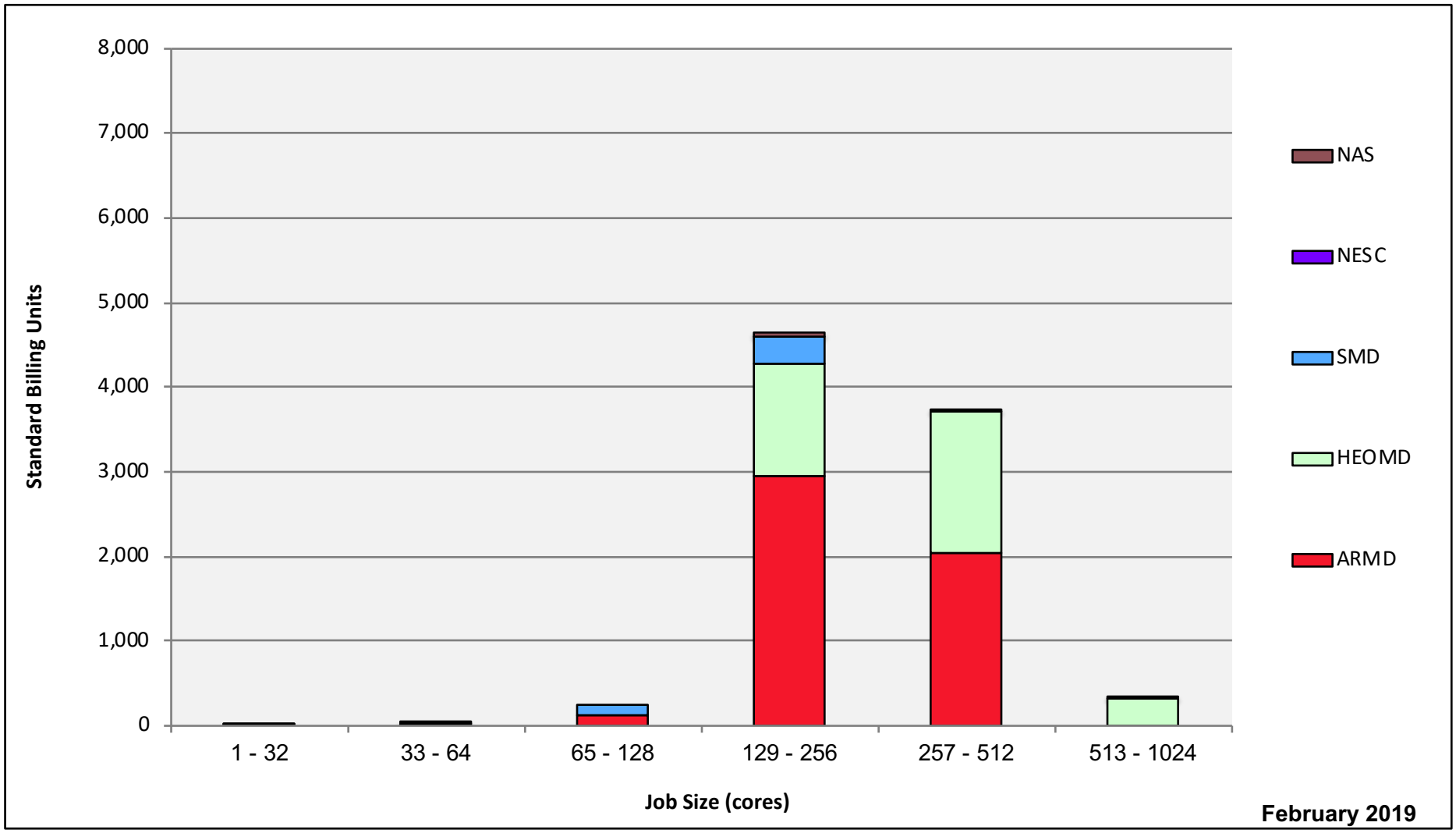
Endeavour:
SBUs Reported, Normalized to 30-Day Month



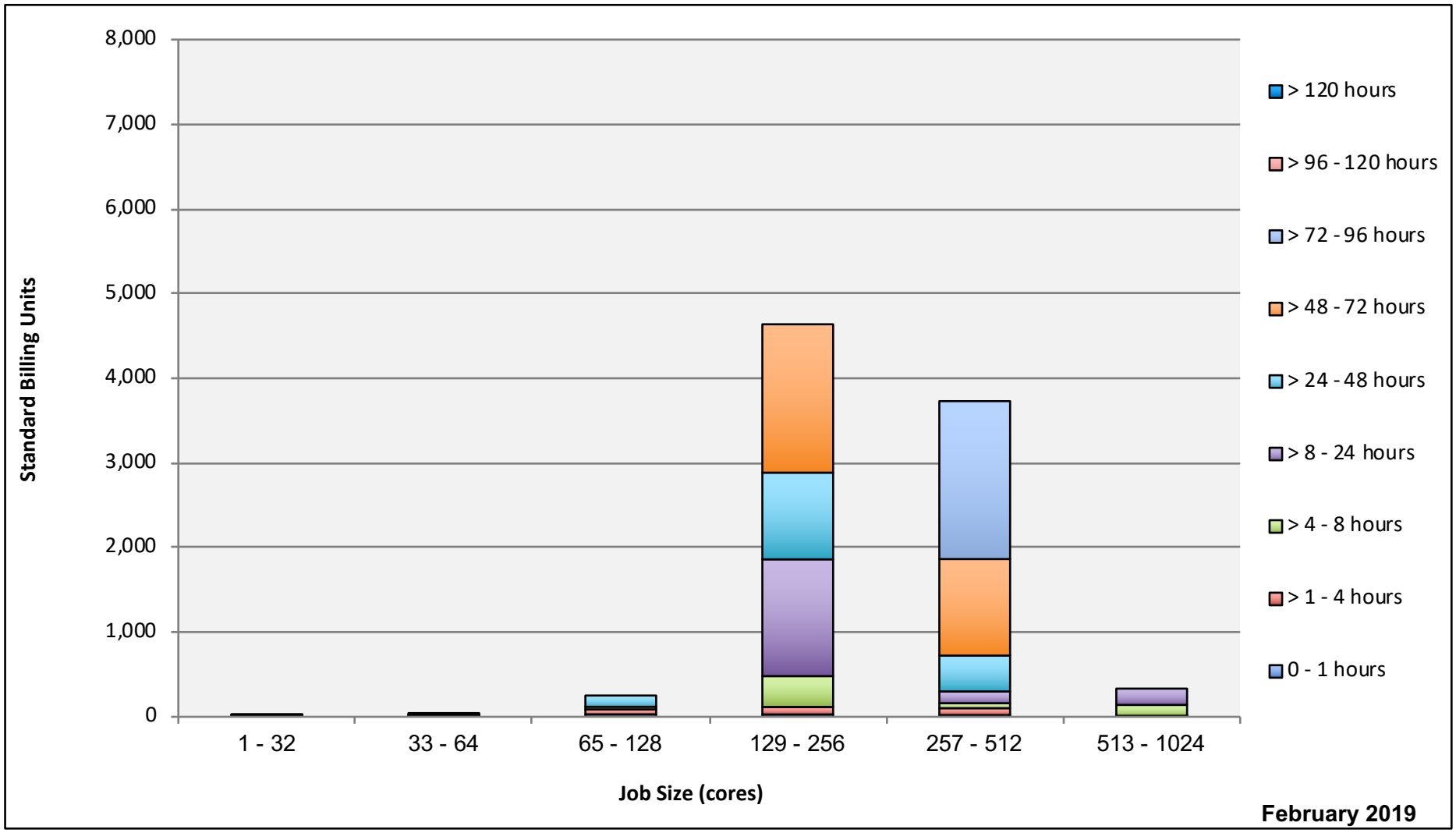
Endeavour:
Monthly Utilization by Job Length



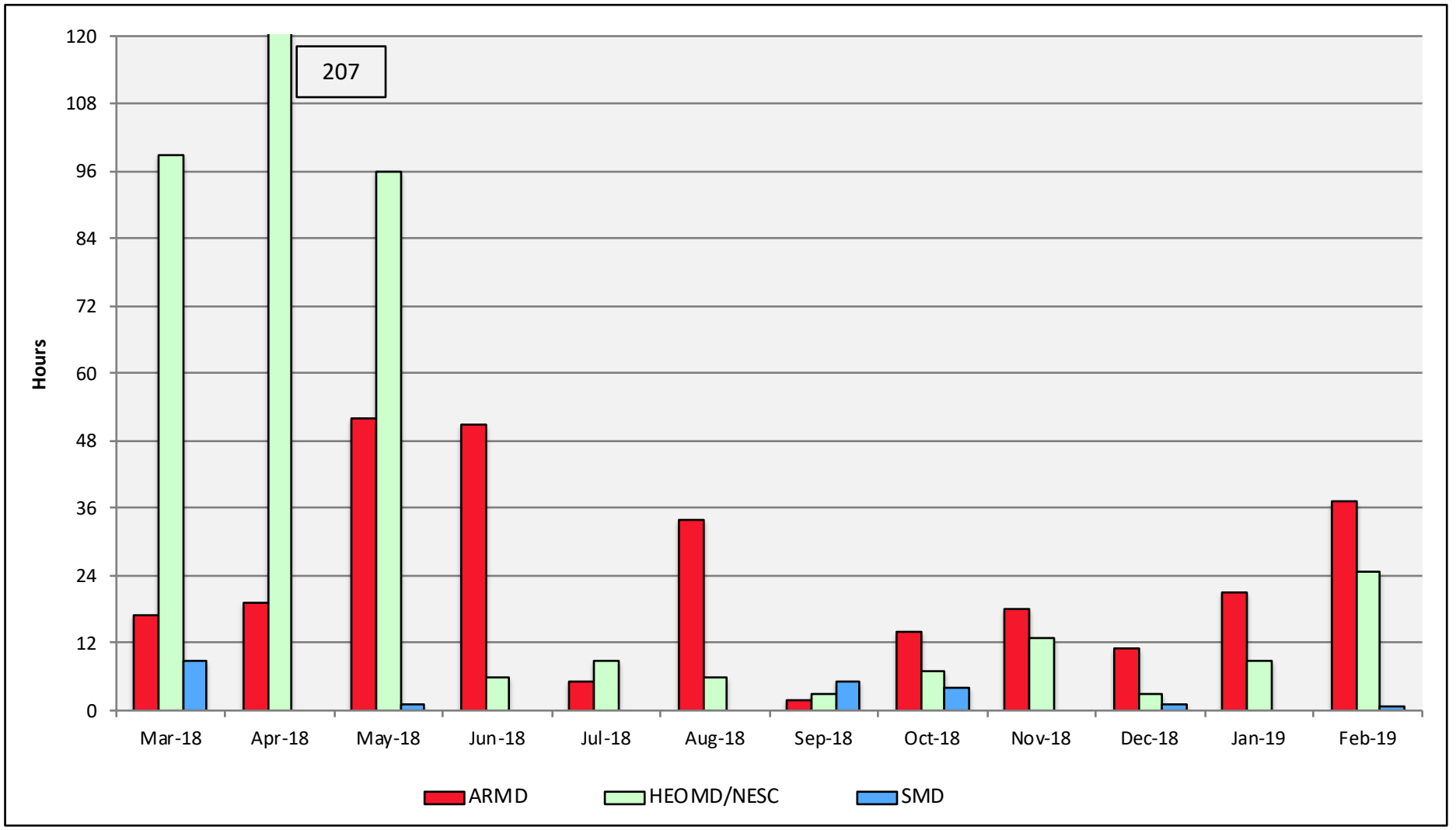
Endeavour:
Monthly Utilization by Size and Mission



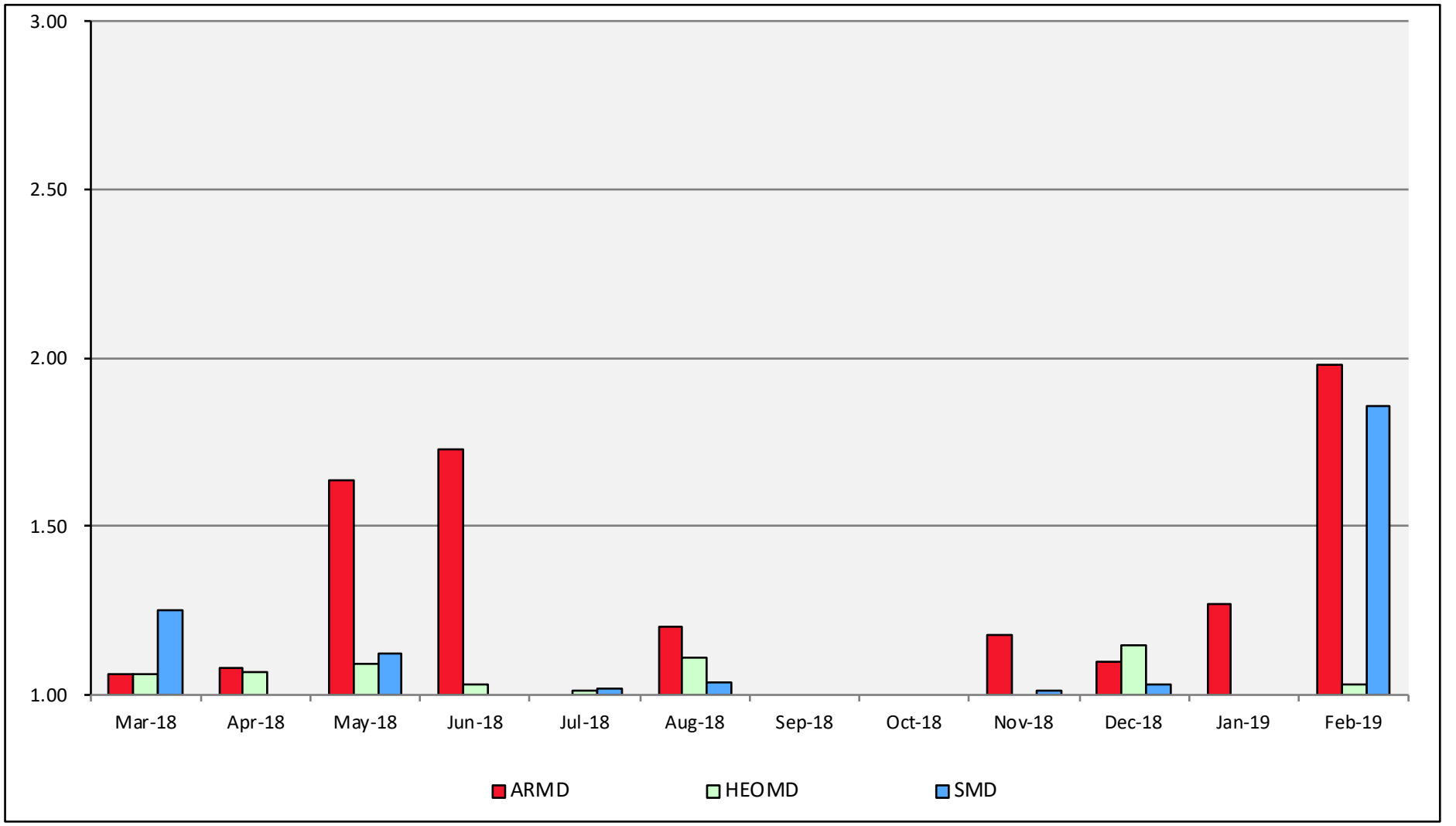
Endeavour:
Monthly Utilization by Size and Length



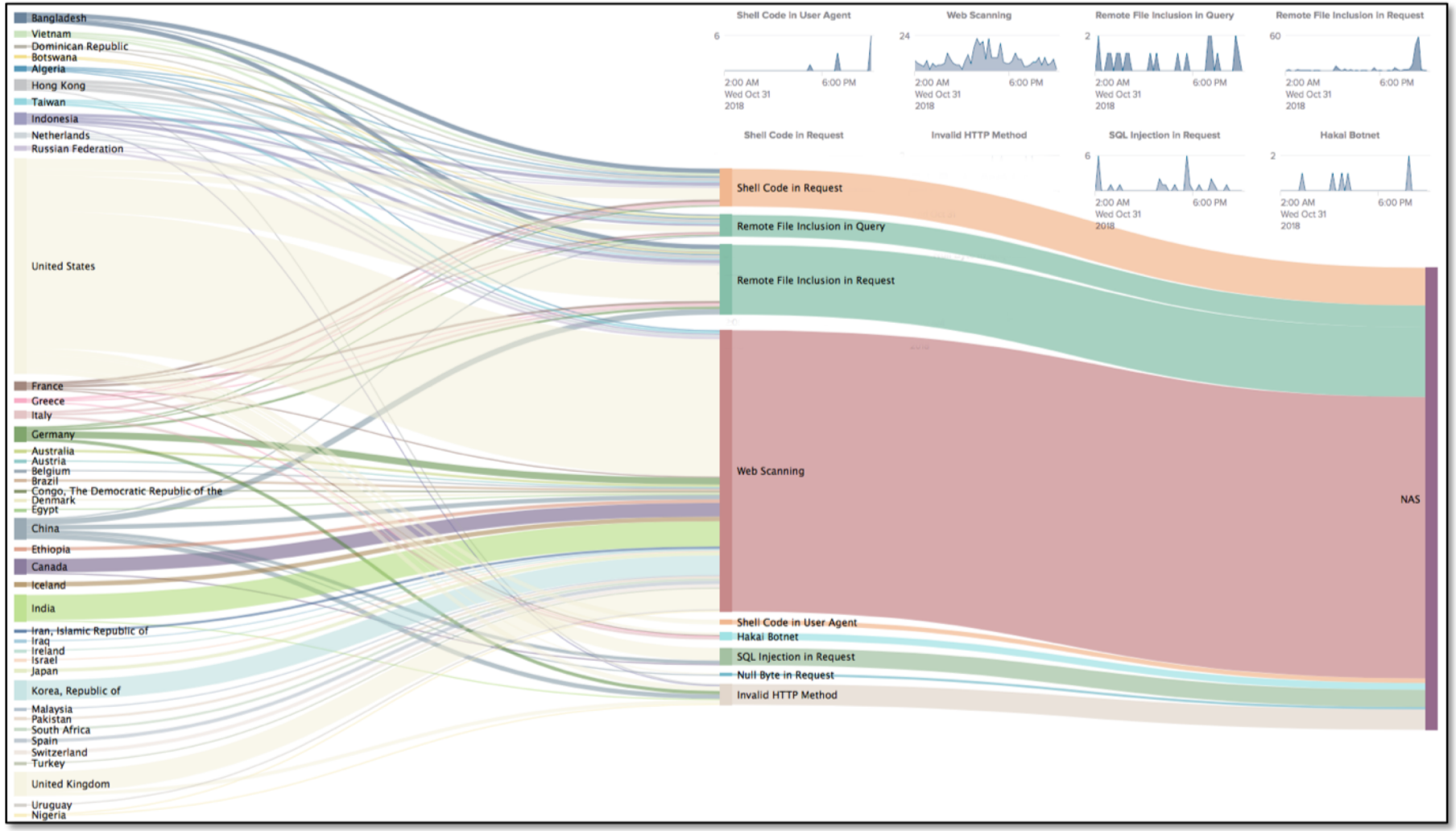
Endeavour:
Average Time to Clear All Jobs



Endeavour:
Average Expansion Factor



Composite image of two visualizations showing suspected malicious activity on HECC systems within a 24-hour period.



Click on figure to return