Project Status Report

High End Computing Capability
Strategic Capabilities Assets Program

July 10, 2018

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User Outreach Tour Aims to Improve Productivity of Researchers Supporting NASA Missions

- In June, an HECC team visited users at six NASA centers and two universities to highlight the project's extensive resources and services and establish closer user relationships.
- The team held successful discussion sessions with nearly 100 scientists and engineers who depend on HECC resources and services for their research supporting NASA missions.
  - Users had the opportunity to ask questions and receive detailed information about the full range of services available to them to improve their efficiency on HECC systems.
  - There was a particularly strong interest in code optimization services, the re-exporter capability, and node reservations.
  - Users also strongly expressed the need for more compute resources to support their research, and for more opportunities to do leading-edge computing.
- The team returned with a list of near-term action items and ideas for longer-term implementation. A summary and findings of these meetings, along with recommendations, will be provided in a report that is currently being prepared.
- The presentation slides will also be made available on the HECC website.

Mission Impact: User outreach is critical to making sure that scientists and engineers supporting NASA missions make the most of their computing allocations. Additionally, a solid understanding of our users' current and future needs is key in strategic planning for the HECC program.

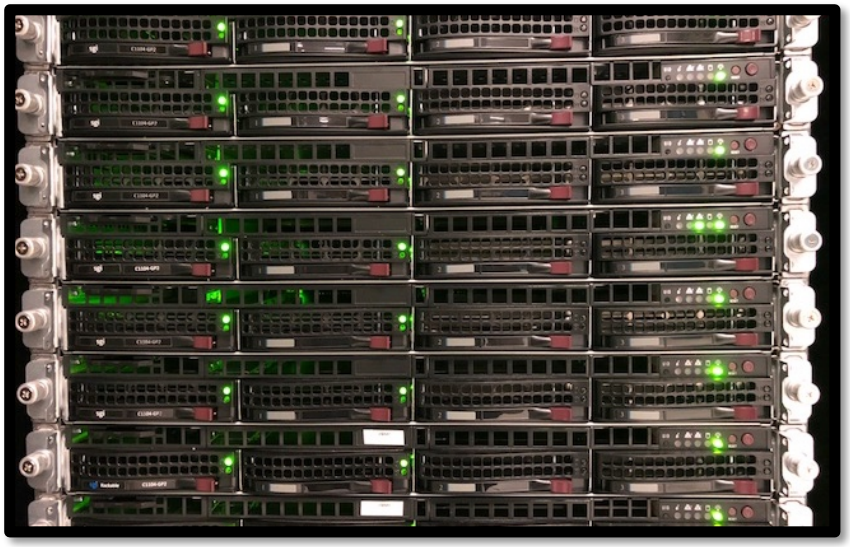
Left: Banner at University of Colorado, Boulder, one of the first stops on the tour. *Right:* Bob Hood, CSRA Application Performance & Productivity Lead, tells HECC users at MIT about the wide array of services available to them. During the tour, the HECC team met with nearly 100 researchers supporting NASA missions. *Jill Dunbar, Emily Kuhse, NASA/Ames*

POCs: Emily Kuhse, emily.kuhse@nasa.gov, (650) 604-1687; Michelle Moyer, michelle.c.moyer@nasa.gov, (650) 604-2912, NASA Advanced Supercomputing Division, CSRA, LLC

HECC Initiates New Capability: Reservable Front-End Nodes

- The Pleiades front-end systems are shared among many users to prepare and run jobs and process outputs. Sometimes, the combined activities of multiple users can exceed the capacity of the systems.
- Now, users can reserve a compute node on Pleiades or Electra for their exclusive use for such tasks, providing a guaranteed set of resources for individual users. Usage rules include:
  - Nodes can be reserved for up to three months.
  - One node per user.
  - Reserved nodes consume SBUs.
- Changes made to Portable Batch System (PBS) for this feature will apply to future modifications to support more generalized reservations.
- Knowledge Base article 556,"Reserving a Dedicated Compute Node," gives details.

Mission Impact: This new scheduling capability allows users to have a more predictable environment for preparing and running PBS jobs and processing the output on HECC supercomputers.



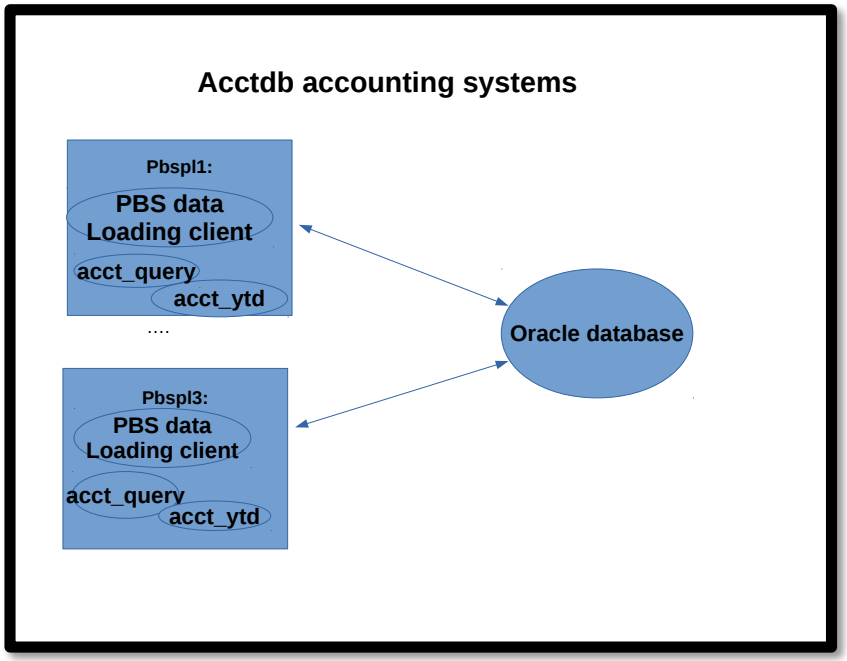
Pleiades front-end type servers; users can now reserve a dedicated node via a simple command, with options for setting reservation start time and specifying other allowed users.

POC: Dale Talcott, dale.r.talcott@nasa.gov, (650) 604-0555, NASA Advanced Supercomputing Division, CSRA LLC

Tools Team Enhances PBS Client to Track Jobs in Reservation Queues

- The HECC Tools Team completed a modification of the PBS data-loading client program to track reservation jobs and create usage records for the duration of user system reservations. This provides accurate system usage information by charging for the reserved resources regardless of whether they are used.
- Jobs that actually run under reservations are tracked but not individually charged because, with this modification, the reservation is now charged daily for the reservation's utilization that day.
- Reservations can be cancelled at any time by the user, and the PBS client will update the reservation end-time accordingly.
- This accounting feature eliminates the manual process previously used to create records for any unused resources in user reservations.

Mission Impact: The enhanced HECC resource accounting system improves efficiency by providing an automated mechanism to accurately track and charge resource reservations and system usage, and eliminating the manual process to track and record unused reservations.



The PBS data-loading client provides a mechanism to track the resource usage information for regular jobs and reservations.

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

Cluster Management Software Updated for Pleiades Sandy Bridge Nodes

- HECC and HPE engineers migrated the Pleiades Sandy Bridge nodes to a newer version of the HPE cluster management software.
- The work was completed within a PBS reservation of the Sandy Bridge nodes, keeping the rest of Pleiades available for users to continue processing their jobs.
- During the Electra system update in March, a number of issues were identified that HPE worked to correct. As a result of that work, there were no significant issues encountered with the Sandy Bridge update.
- An issue with how the cluster management software resolves external Domain Name System (DNS) occurred; it was quickly identified and worked around by the HPE cluster management engineers that were on site.
- The remaining architecture types—Ivy Bridge, Haswell, and Broadwell—will be migrated in the near future, using reservations to minimize the impact on users.

Mission Impact: Improvements to the cluster management software enable HECC engineers to focus on other aspects of the systems for agency users.

HECC updated 1,936 Sandy Bridge nodes on Pleiades with the latest version of the HPE SGI Management Center.

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

HECC Facilities Pass OSHA and Ames Safety Audits with Flying Colors!

- HECC facilities engineers frequently work in potentially dangerous environments with high-power electrical equipment, including construction zones, cooling towers, and supercomputing floors. As such, the Facilities team takes safety extremely seriously.
- In May, HECC facilities were audited by two safety groups from OSHA and Ames. In both cases, the auditors had no findings and noted a number of best practices, including:
  - In-house manufactured wheel locks for rolling carts that did not have built-in wheel locking mechanisms.
  - Netting on storage shelves to prevent contents from falling (for example during an earthquake) and injuring someone.
  - In-house manufactured wall-mounted straps to keep five-gallon water dispensers from tipping over.
  - Wall-mounted straps in hallways to keep heavy equipment from tipping over and/or blocking egress during an earthquake.
  - Starting each HECC Facilities meetings with a "Safety Minute" to address any safety-related issues.
- The Facilities team also conducts a number of safety classes for building occupants throughout the year.
- Auditors were quite pleased with the HECC safety measures and processes for the supercomputing environment, and indicated that they will be including these best practices in their reports.

Mission Impact: For NASA and HECC, safety is priority one. By adhering to safety standards, implementing safety best practices, and conducting safety outreach to staff, HECC Facilities Engineering staff helps keep work-related injuries to an absolute minimum.

HECC Facilities Engineers designed, built, and implemented wheel-locks for rolling carts that did not have built-in wheel locks, to prevent the carts from rolling and blocking egress during an earthquake.

POCs: Mark Tangney, mark.l.tangney@nasa.gov, (650) 604-4415, NASA Advanced Supercomputing (NAS) Division;
Ana Grady-Hiser, ana.l.grady-hiser@nasa.gov, (650) 604-4607, NAS Division

HECC Successfully Completes Annual Equipment Inventory in 2018

- Property custodians responsible for HECC/NAS property completed the 2018 Annual Equipment Inventory of 1,211 pieces of decaled equipment, with a 99.92% scan rate.
- One item was not located. To close out this item, a Property Survey Report (Form NF598) was completed to identify the asset as missing equipment and have it removed from the NASA property database.
- The Property staff's active tracking and updating of the HECC/NAS data created an efficient and successful inventory. Ongoing tracking and management of equipment during FY18 included:
  - Tagged 75 new pieces of equipment.
  - Excessed 76 controlled pieces of equipment.
  - Closed 653 tickets, most relating to equipment location and ownership updates.

Mission Impact: Accurate tracking of assets through their life cycle, and removal of NASA data prior to system disposal, ensures control of government equipment and prevents loss of NASA data.

During the annual equipment inventory, HECC property custodians account for all equipment associated with the NASA Advanced Supercomputing (NAS) facility, including all components of the supercomputers and related resources such as the hyperwall visualization system.

POC: Judy Kohler, judy.j.kohler@nasa.gov, (650) 604-4303, NASA Advanced Supercomputing Division, CSRA LLC

Pleiades Simulations Help Researchers Journey to the Center of Massive Stars*

- Heliophysicists at NASA Ames are running large simulations of stars more massive than the Sun to help them understand the stellar magnetic fields that play a pivotal role in the structure and evolution of stars—including the Sun.
- Using their 3D magnetohydrodynamics code Stellarbox, the Ames researchers can simultaneously simulate different parts of stars of many sizes, masses, and rotation rates—from the atmosphere, to the surface, and into the deep interior.
- Because of their greater masses, the convective zones of these stars are thinner than the Sun's, so the zones can be simulated in their entirety, from the surface down to the boundary of the stellar core.
- Such deep simulations are not yet feasible for the Sun at the level of detail needed for complete confidence and understanding, but the simulation of more massive stars provides a valuable window into solar phenomena.

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

Mission Impact: Simulations enabled by HECC resources provide a better understanding of stellar winds and the interplanetary medium that affects many areas of space science: in particular, predicting strong solar outbursts that can adversely affect deep-space missions and near- and on-Earth technological assets.

Vertical (radially outward) velocity for a star 1.47 times the mass of the Sun at the tachocline—the interface between the outer convective zone and the stellar core. The negative velocities (dark colors) constitute so-called "convective overshoot," a phenomenon known to occur on the Sun. *Irina Kitiashvili, NASA/Ames*

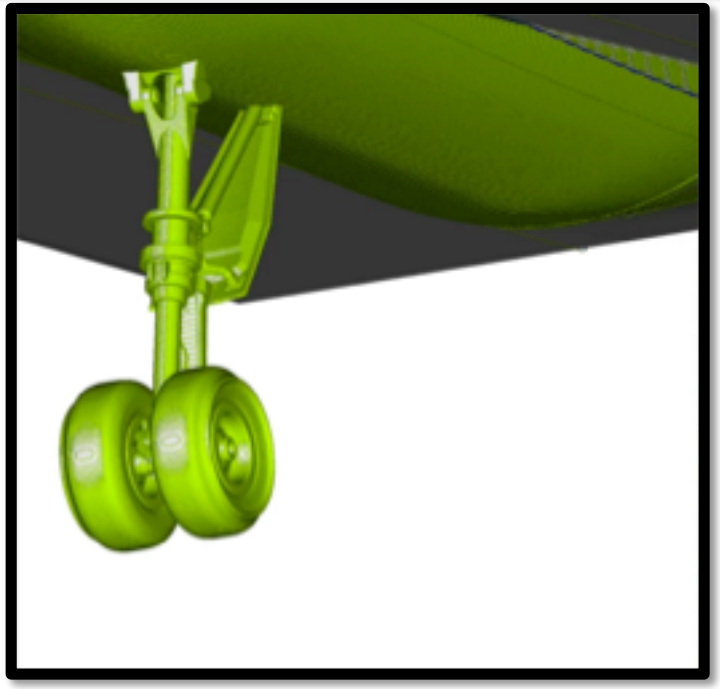
POCs: Alan Wray, alan.a.wray@nasa.gov, (650) 604-6066, NASA Advanced Supercomputing Division

Pleiades Enables Lattice Boltzmann Simulations for Airframe Noise Predictions*

- Aerosciences researchers at NASA Ames ran simulations on Pleiades to explore revolutionary techniques for reducing the computational time for predicting airframe noise.
- The researchers used an ultra-high-performance Lattice Boltzmann (LB) method, incorporated into the Launch Ascent and Vehicle Aerodynamics (LAVA) software.
- Using Pleiades, they applied both LB and Cartesian Navier-Stokes (NS) approaches within the LAVA framework to simulate a massively separated aircraft landing gear.
  - Compared results with test measurements from transducers at strategic locations on the gear components where the primary noise sources were believed to be located.
  - Pressure fluctuations predicted by both the LB and NS approaches were largely consistent.
  - LB approach achieved a ~15-times speed-up over the higher-order NS discretization, with no reduction in accuracy.
- These fast, high-fidelity landing gear noise simulations are only possible with a large cluster system like Pleiades.

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

Mission Impact: The goal of these high-fidelity methods and simulations is to increase the predictive use of computational aeroacoustics capabilities for next-generation aviation concepts.

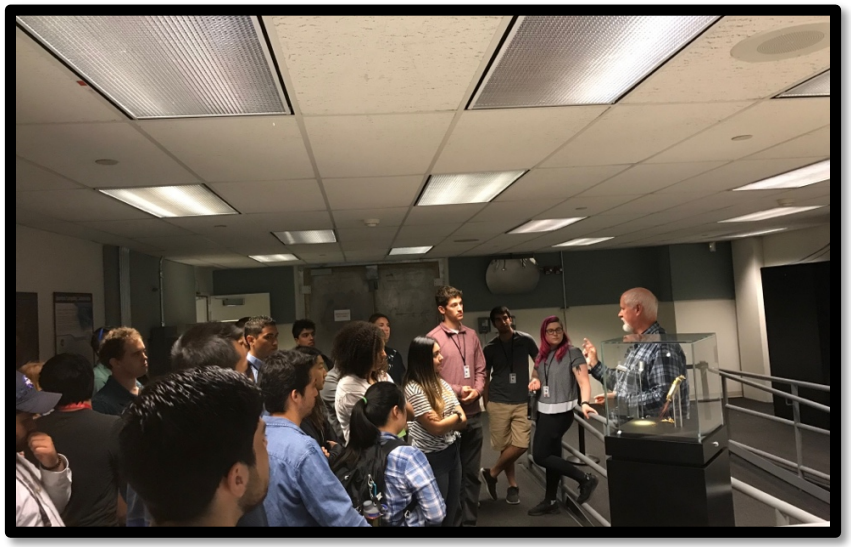


Simulation of landing gear noise using the Launch, Ascent and Vehicle Aerodynamics (LAVA) Cartesian Lattice-Boltzmann discretization.
Michael Barad, Joseph Kocheemoolayil, NASA/Ames

POCs: Michael Barad, michael.f.barad@nasa.gov, (650) 604-0550;
Cetin Kiris, cetin.c.kiris@nasa.gov, (650) 604-4485, NASA Advanced Supercomputing Division

HECC Facility Hosts Several Visitors and Tours in June 2018

- HECC hosted 16 tour groups in June; guests learned about the agency-wide missions being supported by HECC assets, and some groups also viewed the D-Wave 2000Q quantum system. Visitors this month included:
  - Renee Wynn, NASA Chief Information Officer.
  - Casper Klynge, Ambassador of Denmark, and his international staff.
  - Shlomi Kofman, Israel's Consul General to the Pacific Northwest;
  - Managers and teachers from Chabot Space and Science Center.
  - Visitors from "Weather News International," a weather services company in Japan.
  - Attendees of the Agency Model Based System Engineering Workshop.
  - Students form San Jose State University and Cabrillo College who are studying aerospace and mechanical engineering; they were hosted by the Ames Women's Influence Network.
  - 55 attendees from the NASA Ames Minority University Research and Education Project Summer Workshop.
  - 75 attendees from the Ames 2018 Summer Internship Program.



Far right: Christopher Buchanan, networking, security, and facilities contractor lead, gave NASA Ames summer interns a tour of quantum computer room and the main computer room at the NAS facility, along with an overview of the HECC project.

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

Papers

- **"Strongly Localized Magnetic Reconnection by the Super-Alfvenic Shear Flow**," Y.-H. Liu, M. Hesse, F. Guo, H. Li, T. Nakamura, arXiv:1806.00533 [physics.plasm-ph], June 1, 2018. * *https://arxiv.org/abs/1806.00533*
- "**A Versatile Numerical Method for the Multi-Fluid Plasma Model in Partially- and Fully-Ionized Plasmas**," A. Alvarez-Laguna, N, Ozak, N. Mansour, H. Deconinck, S. Poedts, Journal of Physics: Conference Series, vol. 1031, June 1, 2018. * *http://iopscience.iop.org/article/10.1088/1742-6596/1031/1/012015/meta*
- **"Preferential Accretion in the Supermassive Black Holes of Milky Way-size Galaxies Due to Direct Feeding by Satellites**," N. Sanchez, et al., The Astrophysical Journal, vol. 860, no. 1, June 7, 2018. * *http://iopscience.iop.org/article/10.3847/1538-4357/aac015/meta*
- "**A Kinematical Detection of Two Embedded Jupiter-mass Planets in HD 163296**," R. Teague, et al., The Astrophysical Journal Letters, vol. 860, no. 1, June 13, 2018. * *http://iopscience.iop.org/article/10.3847/2041-8213/aac6d7/meta*
- "**Inferring Connectivity Range in Submerged Aquatic Populations (*Ruppia* L.) Along European Coastal Lagoons from Genetic Imprint and Simulated Dispersal Trajectories**," L. Triest, et al., Frontiers in Plant Science, vol. 9, June 13, 2018 * *https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6008504/*
- "**Formation of Giant Planets**," G. D'Angelo, J. Lissauer, arXiv:1806.05649 [astro-ph.EP], June 14, 2018. * *https://arxiv.org/abs/1806.05649*

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

Papers (cont.)

- "**Field-Aligned Currents Originating From the Magnetic Reconnection Region: Conjugate MMS-ARTEMIS Observations**," A. Artemyev, et al., Geophysical Research Letters, published online June 14, 2018. *
  https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/2018GL078206
- "**Quasi-Periodic Orbits in the Five-Dimensional Nondissipative Lorenz Model: The Role of the Extended Nonlinear Feedback Loop**," S. Faghih-Naini, B.-W. Shen, International Journal of Bifurcation and Chaos in Applied Sciences and Engineering, vol. 28, issue 6, June 15, 2018. *
  https://www.worldscientific.com/doi/abs/10.1142/S0218127418500724
- "**Order Out of Chaos: Slowly Reversing Mean Flows Emerge from Turbulently Generated Internal Waves**," L.-A. Couston, D. Lecoanet, B. Favier, M. Le Bars, arXiv:1806.06536 [physics.flu-dyn], June 18, 2018. *
  https://arxiv.org/abs/1806.06536
- "**Evaluation of Potential Sources of a Priori Ozone Profiles for TEMPO Tropospheric Ozone Retrievals**," M. Johnson, et al., Atmospheric Measurement Techniques, vol. 11, June 19, 2018. *
  https://www.atmos-meas-tech.net/11/3457/2018/
- "**Mesoscopic Friction and Network Morphology Control the Mechanics and Processing of Carbon Nanotube Yarns**," Y. Wang, H. Xu, G. Drozdov, T. Drumitrica, Carbon, vol. 139, published online June 19, 2018. *
  https://www.sciencedirect.com/science/article/pii/S0008622318306055

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Papers (cont.)

- "**Consequences of Treating the Solar Magnetic Field as a Dipole on the Global Structure of the Heliosphere and Heliosheath**," A. Michael, M. Opher, G. Tóth, The Astrophysical Journal, vol. 860, no. 2, June 25, 2018. *
  http://iopscience.iop.org/article/10.3847/1538-4357/aac3dd/meta
- "**A Search for Candidate Li-Rich Giant Stars in SDSS DR10**," D. Carbon, R. Gray, B. Nelson, C. Henze, arXiv:1806.10295 [astro-ph.SR], June 27, 2018. *
  https://arxiv.org/abs/1806.10295
- **AIAA Aviation Forum**, Atlanta, Georgia, June 25–29, 2018.
  - "**Airframe Noise Simulations of a Full-Scale Aircraft**," J. Appelbaum, B. Duda, E. Fares, M. Khorrami. *
    https://arc.aiaa.org/doi/10.2514/6.2018-2973
  - "**Simulations of a Full-Scale Aircraft with Installed Airframe Noise Reduction Technologies**," R. Ferris, J. Appelbaum, M. Khorrami. *
    https://arc.aiaa.org/doi/10.2514/6.2018-2974
  - "**Comparison of Measured and Simulated Acoustic Signatures for a Full-Scale Aircraft with and without Airframe Noise Abatement**," M. Khorrami, P. Ravetta, D. Lockard, B. Duda, R. Ferris. *
    https://arc.aiaa.org/doi/10.2514/6.2018-2975
  - "**Wall-Resolved Large-Eddy Simulations of Transonic Shock-Induced Flow Separation**," A. Uzun, M. Malik. *
    https://arc.aiaa.org/doi/10.2514/6.2018-3854
  - "**Generating a Grid for Unstructured RANS Simulations of Jet Flows**," V. Dippold. *
    https://arc.aiaa.org/doi/10.2514/6.2018-3223

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

Papers (cont.)

- **AIAA Aviation Forum** (cont.)
  - '**Transition Delay via Vortex Generators in a Hypersonic Boundary Layer at Flight Conditions**," P. Paredes, M. Choudhari, F. Li. *
    https://arc.aiaa.org/doi/10.2514/6.2018-3217
  - "**Evaluation of Inflow Turbulence Methods in Large-Eddy Simulations of a Supersonic Boundary Layer**," M. Mankbadi, M. Vyas, J. DeBonis, N. Georgiadis. *
    https://arc.aiaa.org/doi/10.2514/6.2018-3404
  - "**Analysis of Simulated and Experimental Noise Sources of the Boeing 777 Main Gear Model via CLEAN in 3D**," P. Ravetta, M. Khorrami, B. Köng, E. Fares. *
    https://arc.aiaa.org/doi/10.2514/6.2018-3470
  - "**Effect of Distributed Patch of Smooth Roughness Elements on Transition in a High-Speed Boundary Layer**," M. Choudhari, P. Paredes. *
    https://arc.aiaa.org/doi/10.2514/6.2018-3532
  - "**Görtler Instability and Its Control via Surface Suction Over an Axisymmetric Cone at Mach 6**," F. Li, M. Choudhari, P. Paredes, S. Schneider, P. Portoni. *
    https://arc.aiaa.org/doi/10.2514/6.2018-3069
  - "**Direct Numerical Simulation of Acoustic Disturbances in the Rectangular Test Section of a Hypersonic Wind Tunnel**," C. Deegan, L. Duan, M. Choudhari. *
    https://arc.aiaa.org/doi/10.2514/6.2018-3219

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

Presentations

- "**Scale Resolving Simulations of Low Pressure Turbine Cascades with Wall Roughness Using a Spectral Element Method**," A. Garai, L. Diosady, S. Murman, N. Madavan (presenter), presented at the Turbomachinery Technical Conference & Exposition, Oslo, Norway, June 11–15, 2018.
- **6th European Conferences on Computational Mechanics (ECCM)/7th European Conference on Computational Fluid Dynamics (ECFD)**, Glasgow, Scotland, June 11–15, 2018.
  - "**Validation of Algebraic Models for VPG and Dissipation Terms in RANS and FANS Equations**," S. Poroseva, S. Murman.
  - "**Recent Developments for the Eddy Solver**," S. Murman, L. Diosady, A. Garai, C. Carton de Wiart, P. Blonigan, D. Ekelschot.
  - "**Assessment of a DGSEM/WMLES Approach on Flows Featuring Adverse/Favorable Pressure Gradients and Separation**," C. Carton de Wiart.
- **AIAA Aviation Forum**, Atlanta, Georgia, June 25–29, 2018.
  - "**Distributed-Flap Layout Trade Study on a Highly Flexible Common Research Model**," D. Rodriguez, M. Aftosmis, M. Nemec, G. Anderson.
    https://arc.aiaa.org/doi/10.2514/6.2018-3639
  - "**Efficient Simulations of Multi-Rotor Vehicles with Low Reynolds Number Propellers**," J. Chiew, M. Aftosmis.
    https://arc.aiaa.org/doi/10.2514/6.2018-4119
  - "**Lift Characterization Study of a Two-Element Three-Segment Variable Camber Airfoil**," U. Kaul, . Nguyen.
    https://arc.aiaa.org/doi/10.2514/6.2018-2835

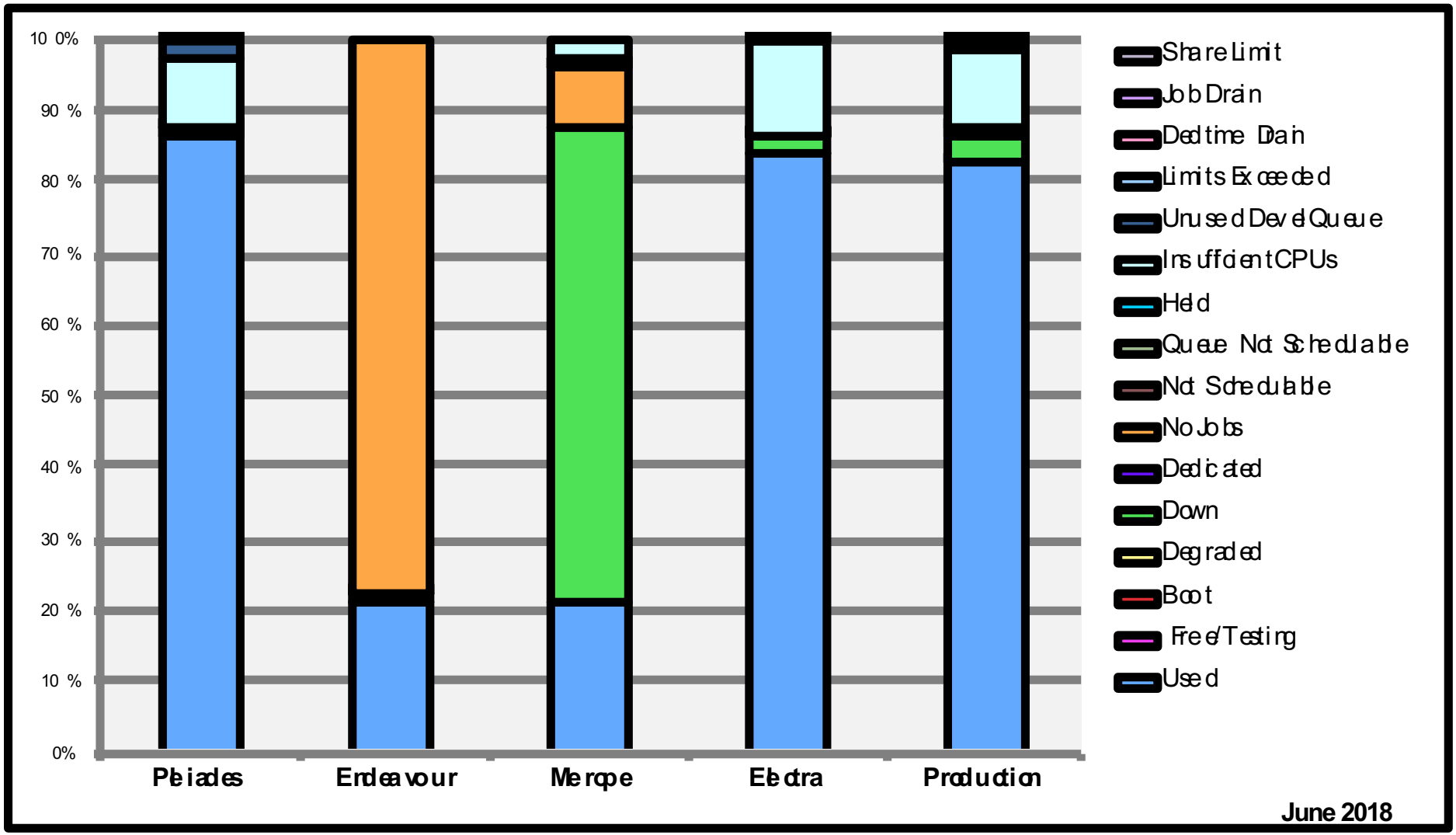
Presentations (cont.)

- **AIAA Aviation Forum** (cont.)
  - "**Adjustments of Uncertainty Quantifications for SLS Aerodynamic Sectional Loads**," D. Dalle, S. Rogers, H. Lee, J. Meeroff.
    https://arc.aiaa.org/doi/10.2514/6.2018-3640
  - "**Implementation and Assessment of the Amplification Factor Transport Laminar-Turbulent Transition Model**," M. Denison, T. Pulliam.
    https://arc.aiaa.org/doi/10.2514/6.2018-3382
  - "**Analysis of Uncertainty Sources in DNS of a Turbulent Mixing Layer Using Nek5000**," J. Colmenares, S. Poroseva, Y. Peet, S. Murman.
    https://arc.aiaa.org/doi/10.2514/6.2018-3226
  - "**Application of Lattice Boltzmann and Navier-Stokes Methods to NASA's Wall Mounted Hump**," G.-D. Stich, J. Housman, J. Kocheemoolayil, M. Barad, C. Kiris.
    https://arc.aiaa.org/doi/10.2514/6.2018-3855
- "**Computational Schlieren with Comparisons to Experiment**," P. Moran, presented at the International Symposium on Flow Visualization 2018, June 26-29, 2018.

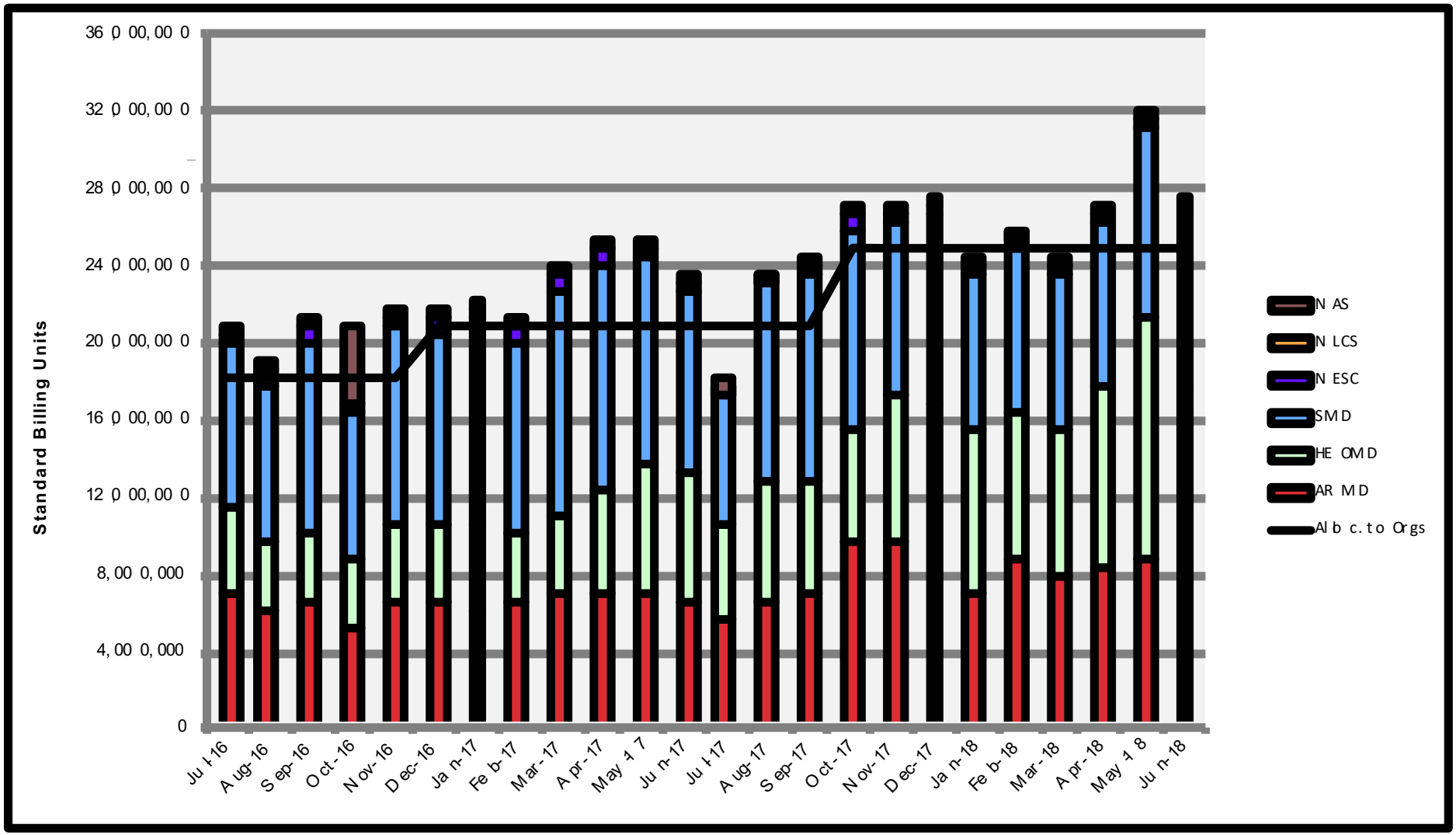
News & Events

- **Maximizing Performance of HiFUN CFD Solver in Intel Xeon Scalable Processor with Intel MPI Library**, *InsideHPC*, June 12, 2018—Developers of HiFUN, a CFD applications designed to take full advantage of massively parallel HPC platforms, ran performance tests using NASA's Pleiades supercomputer across 10,000 cores. *https://insidehpc.com/2018/06/maximizing-performance-hifun-cfd-solver/*
- **New and Improved Way to Find Baby Planets**, *Carnegie Science*, June 13, 2018—New work from an international team of astronomers used archival radio telescope data and NASA supercomputers to develop a new method for finding very young extrasolar planets. *https://carnegiescience.edu/news/new-and-improved-way-find-baby-planets*
  - **New and Improved Way to Find Baby Planets**, *EurekAlert!* June 13, 2018. *https://www.eurekalert.org/pub_releases/2018-06/cifs-nai061318.php*
- **Donovan Mathias and Eric Stern Talk About Asteroid Threats**, *NASA Ames Podcast*, June 22, 2018—A conversation with Donovan Mathias, aerospace engineer in the NASA Advanced Supercomputing Division, and Eric Stern, a research scientist at NASA Ames who supports the agency's Planetary Defense initiative. *https://www.nasa.gov/ames/nisv-podcast-ep96-donovan-mathias-and-eric-stern*
  - **Asteroid Day is June 30 – Do You Know Where Your NEOs Are?** *SUSE Blog*, June 24, 2018. *https://www.suse.com/c/asteroid-day-is-june-30-do-you-know-where-your-neos-are/*
- **Scientists Use Supercomputers to Predict Asteroid Damage on Earth**, *NAS Video Feature*, June 29, 2018—Simulations of hypothetical impact scenarios run on the Pleiades supercomputer help calculate risks and assess possible damage that might occur when asteroids enter Earth's atmosphere. *https://www.nas.nasa.gov/publications/articles/feature_asteroid_impact_atap.html*

HECC Utilization



HECC Utilization Normalized to 30-Day Month



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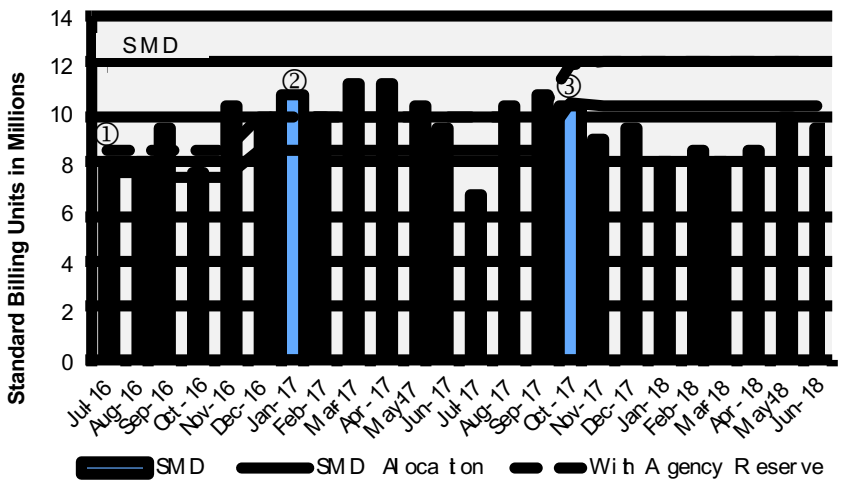
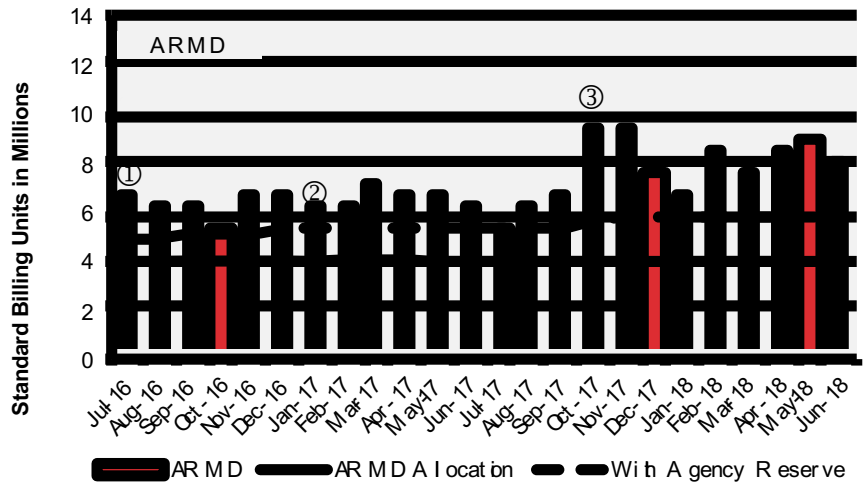
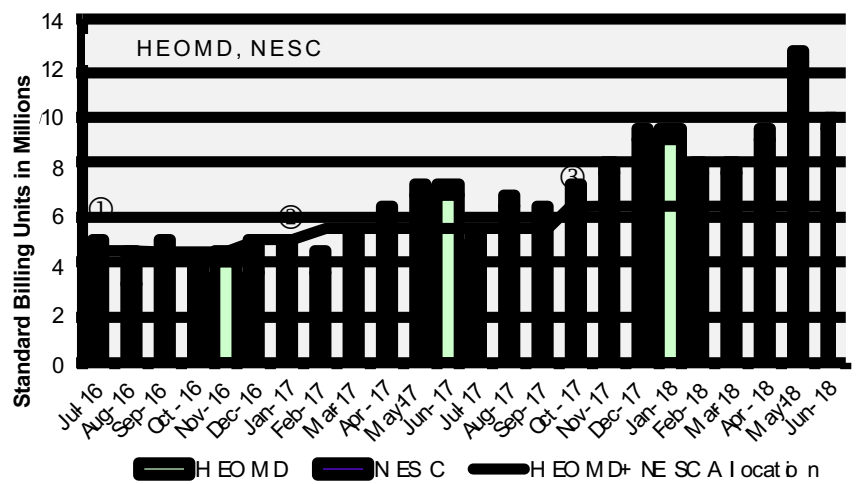




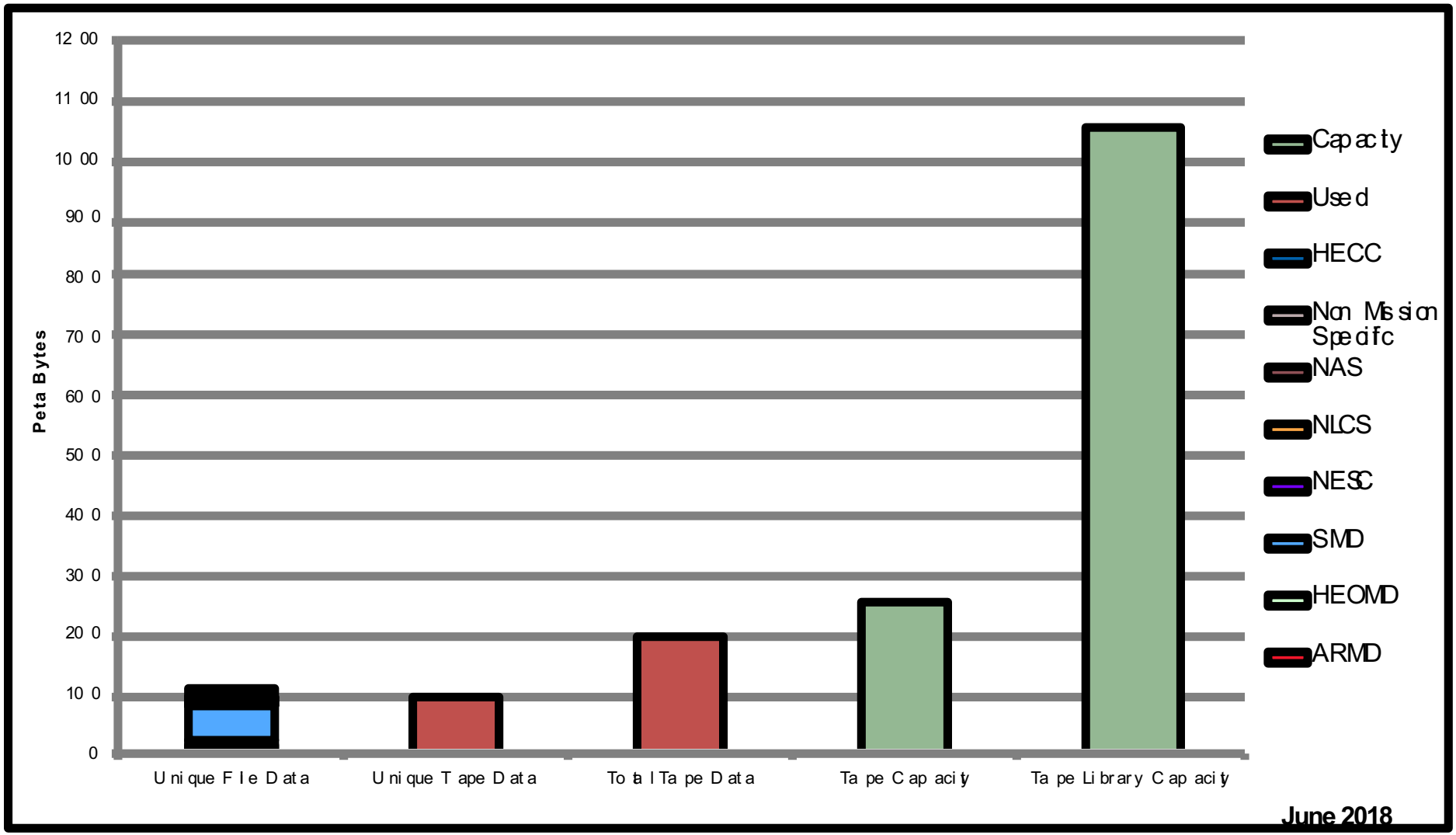


① 14 Broadwell racks added to Pleiades

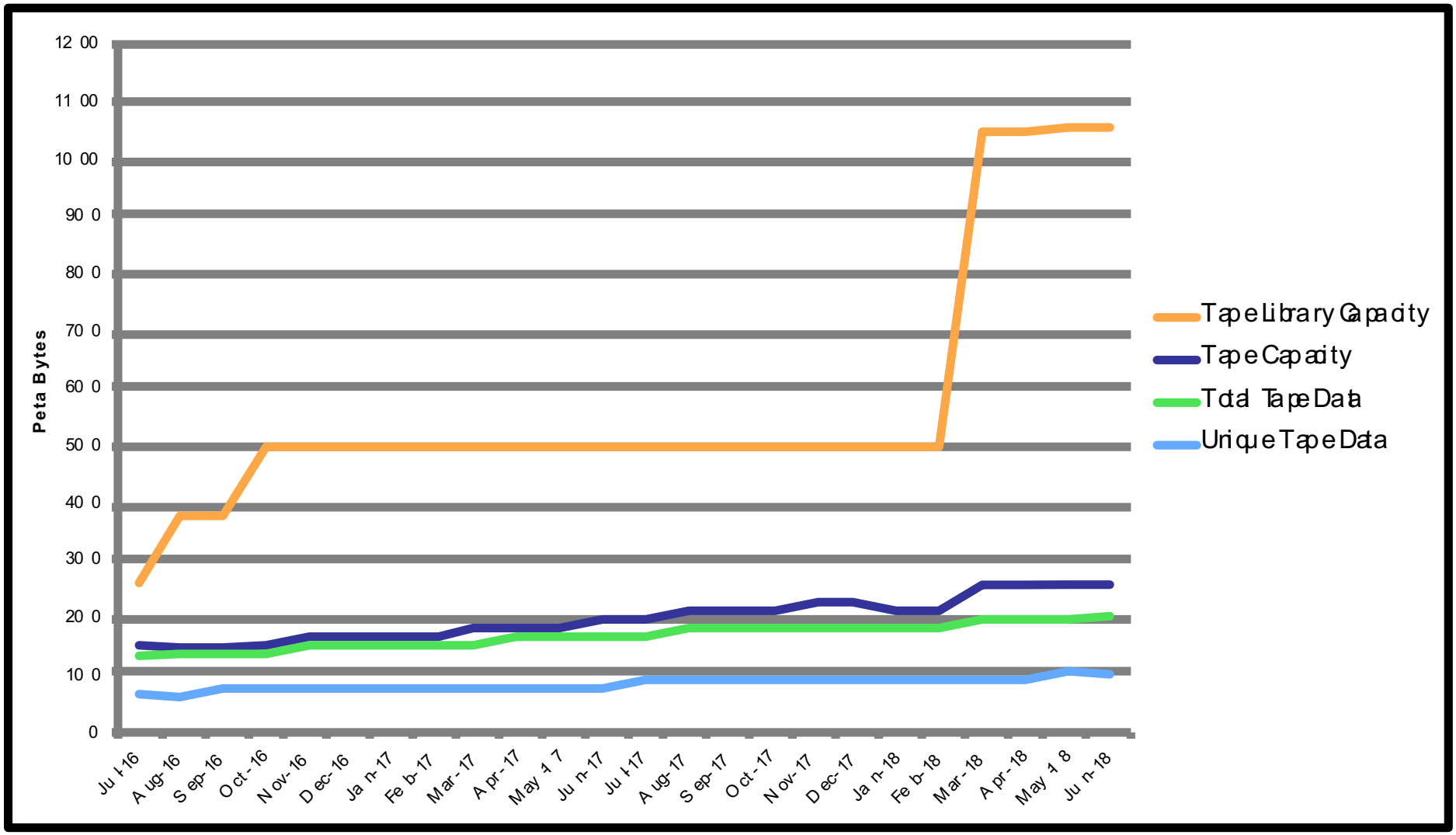
② 16 Broadwell racks added to Electra, 20 Westmere half racks added to Merope

③ 4 Skylake E cells (16 D Rack Equivalence) added to Electra

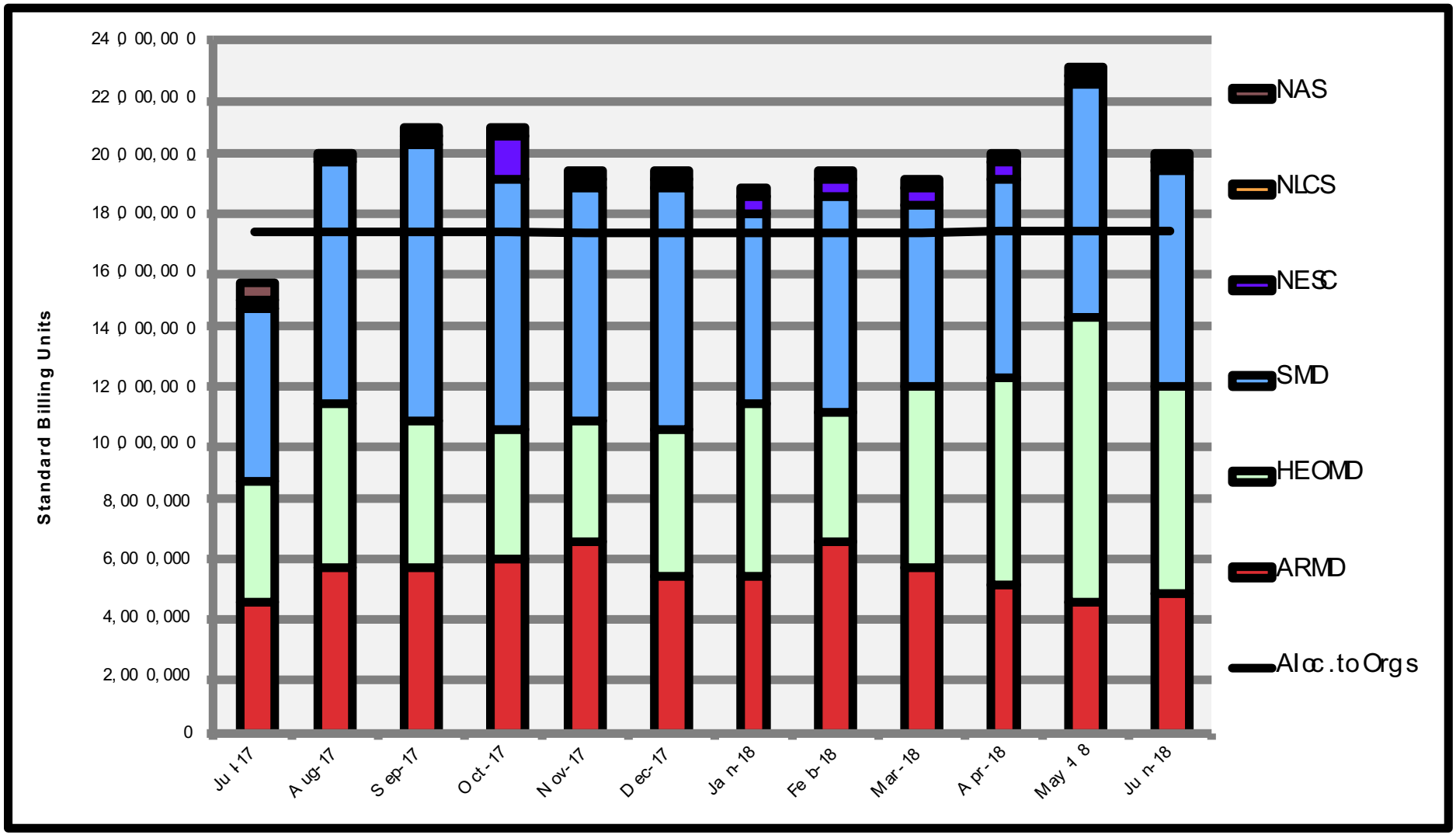
Tape Archive Status



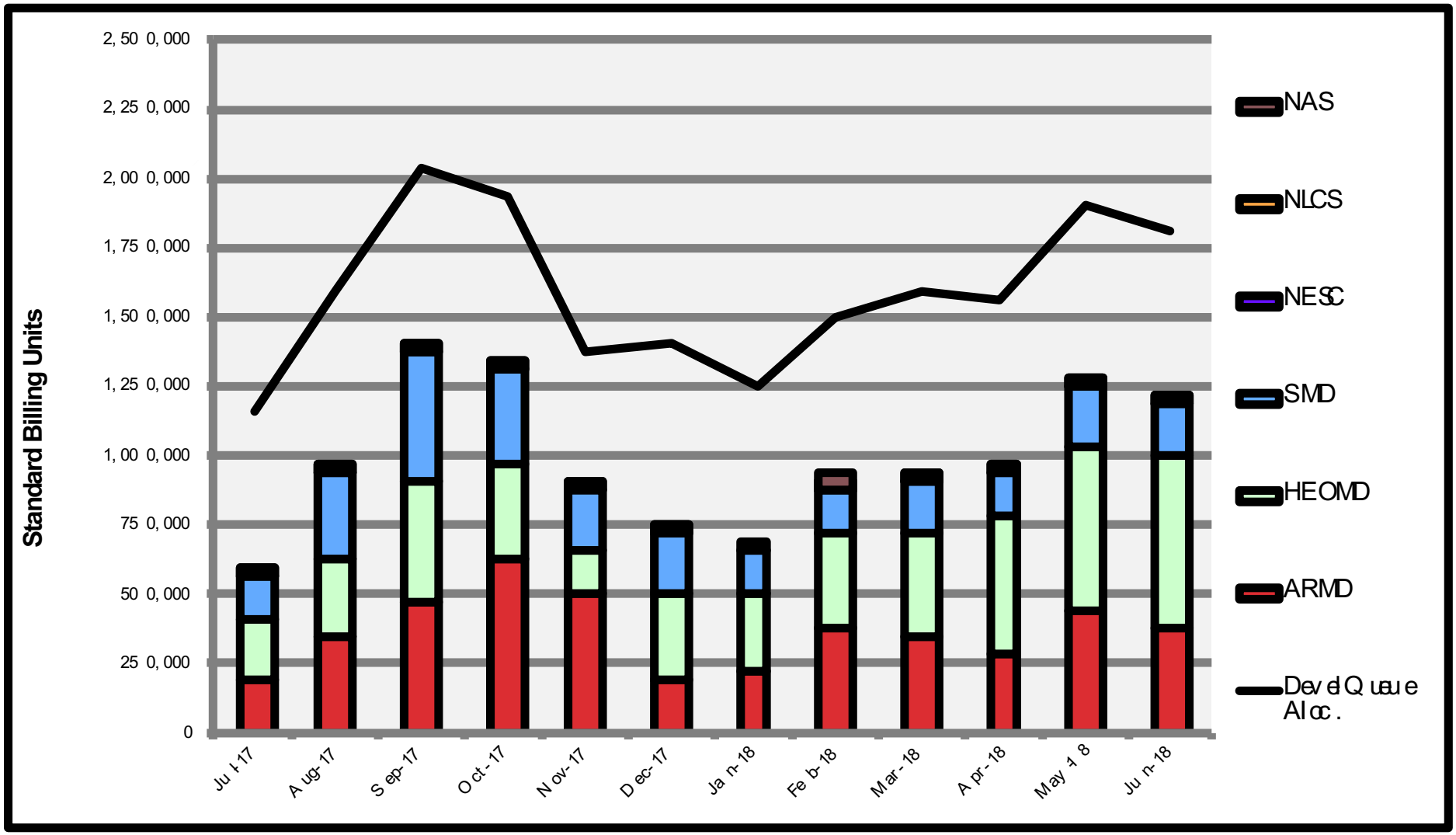
Tape Archive Status



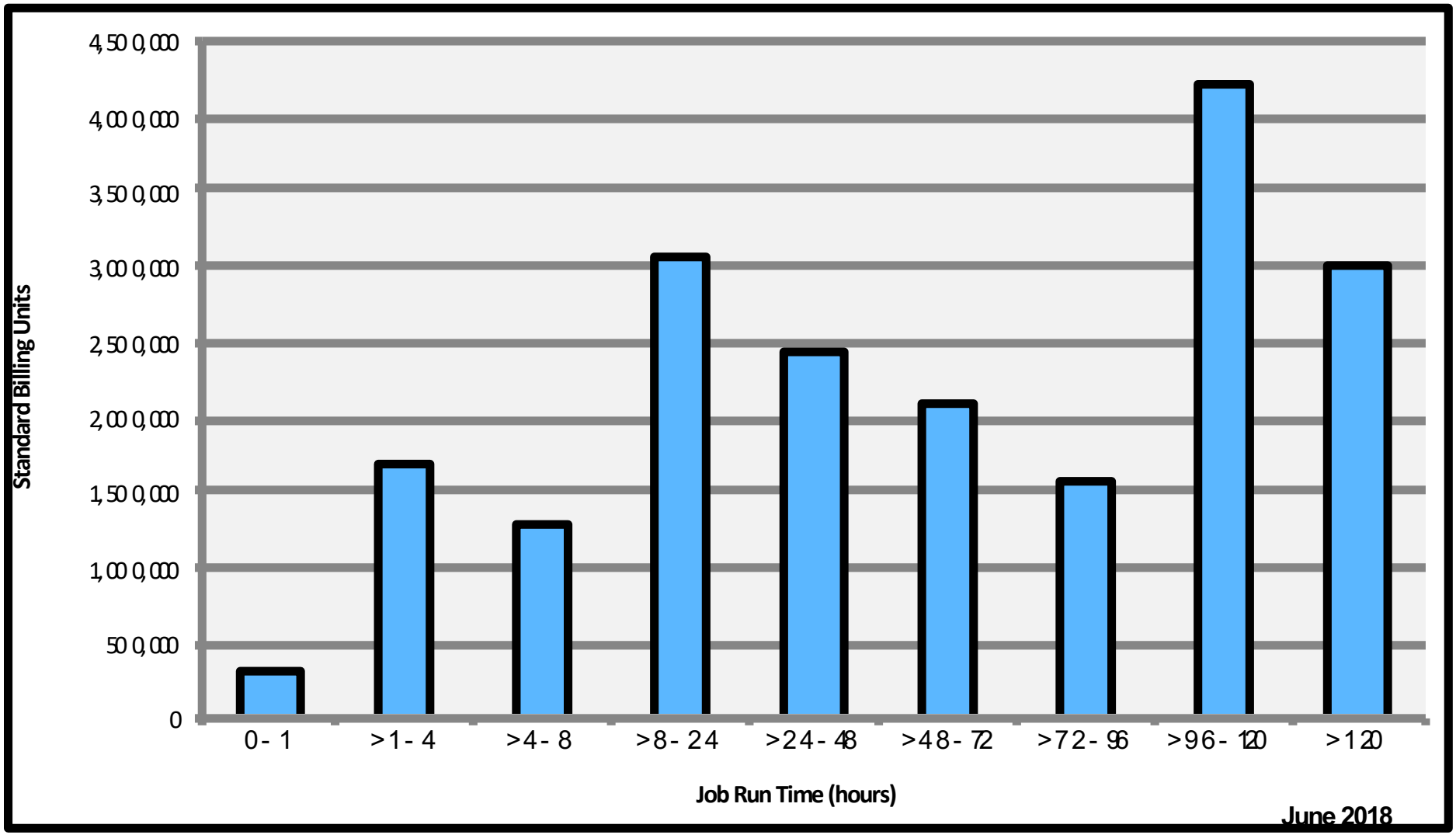
Pleiades:
SBUs Reported, Normalized to 30-Day Month



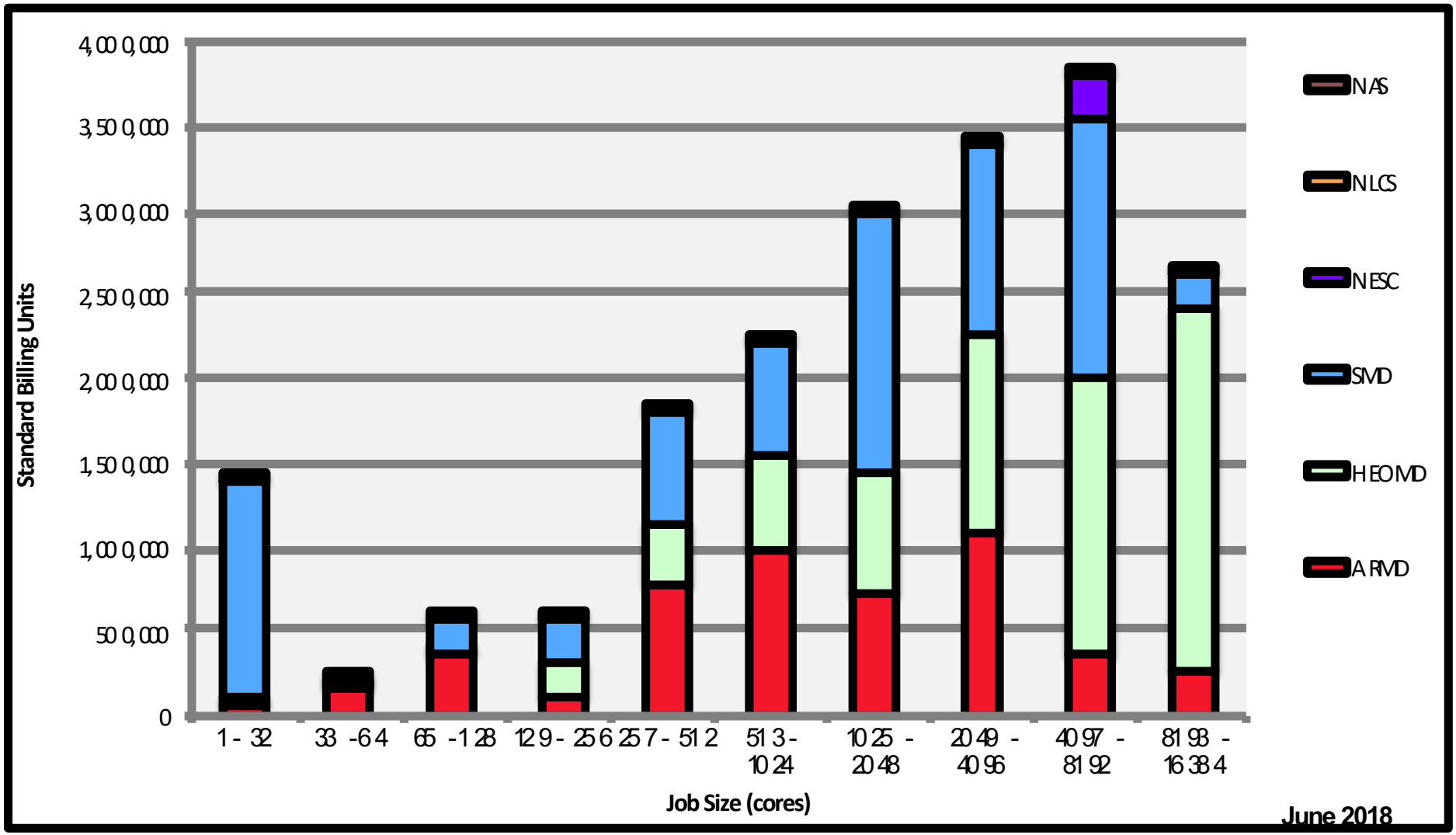
Pleiades:
Devel Queue Utilization



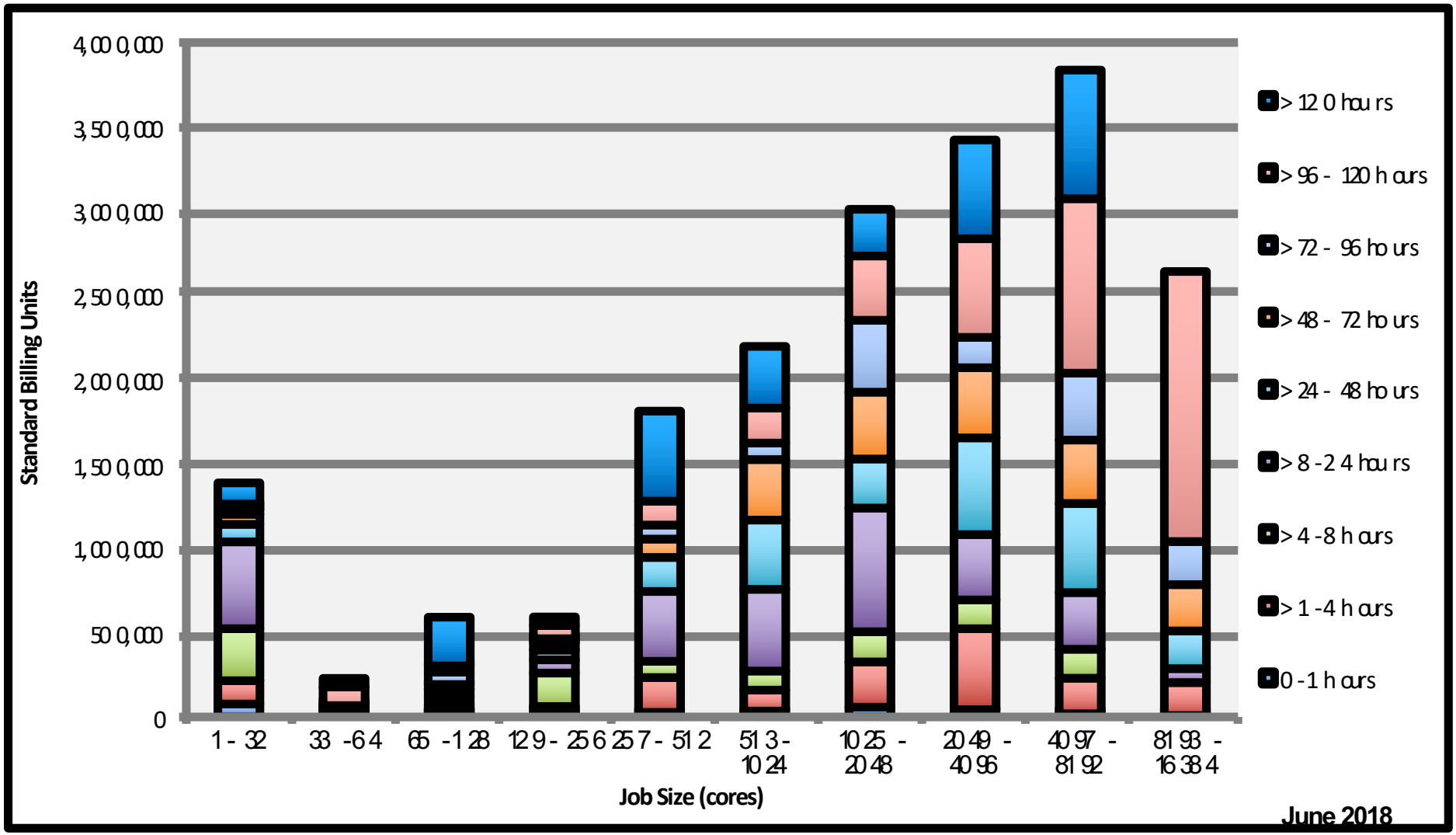
Pleiades:
Monthly Utilization by Job Length



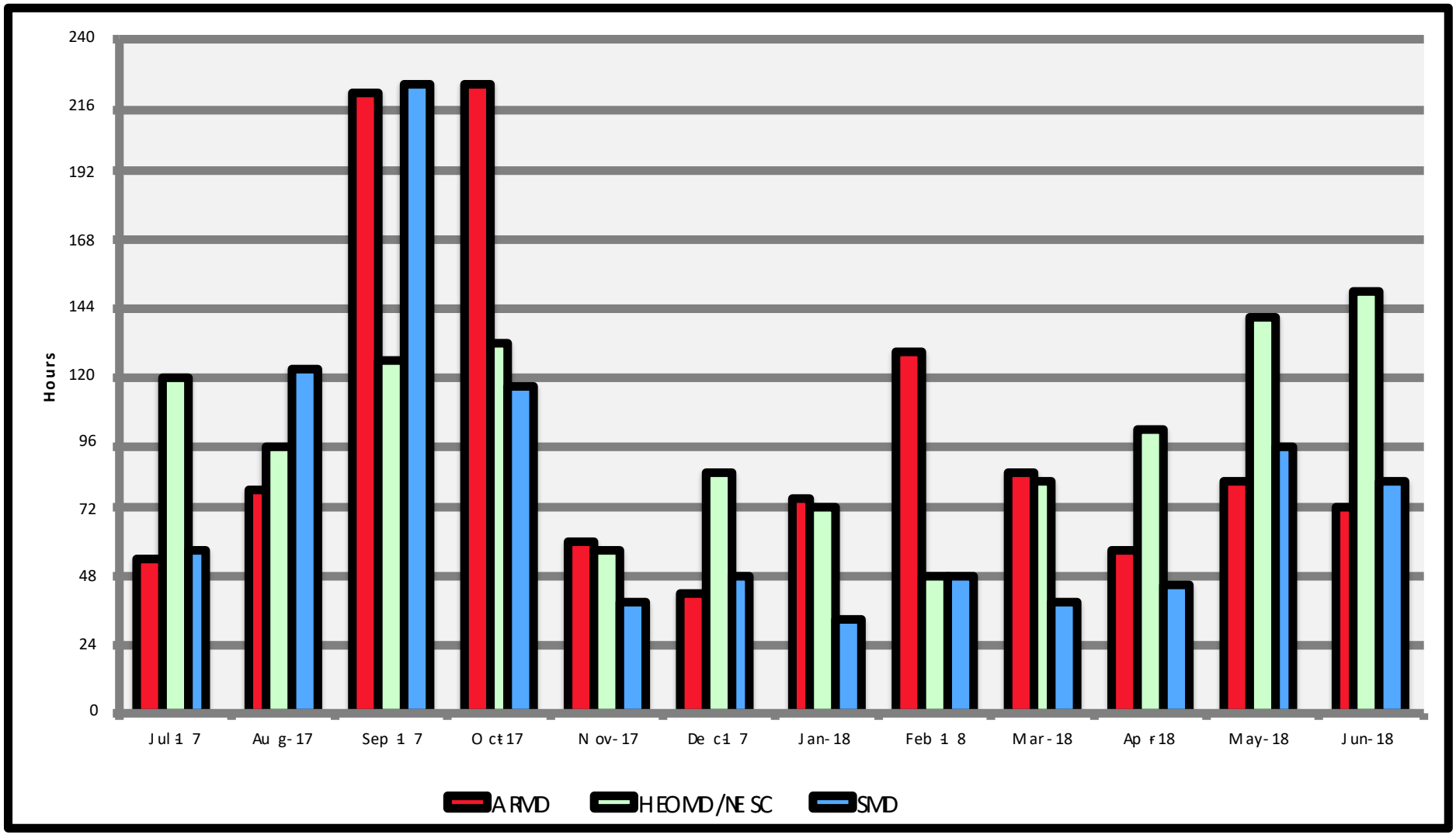
Pleiades:
Monthly Utilization by Size and Mission



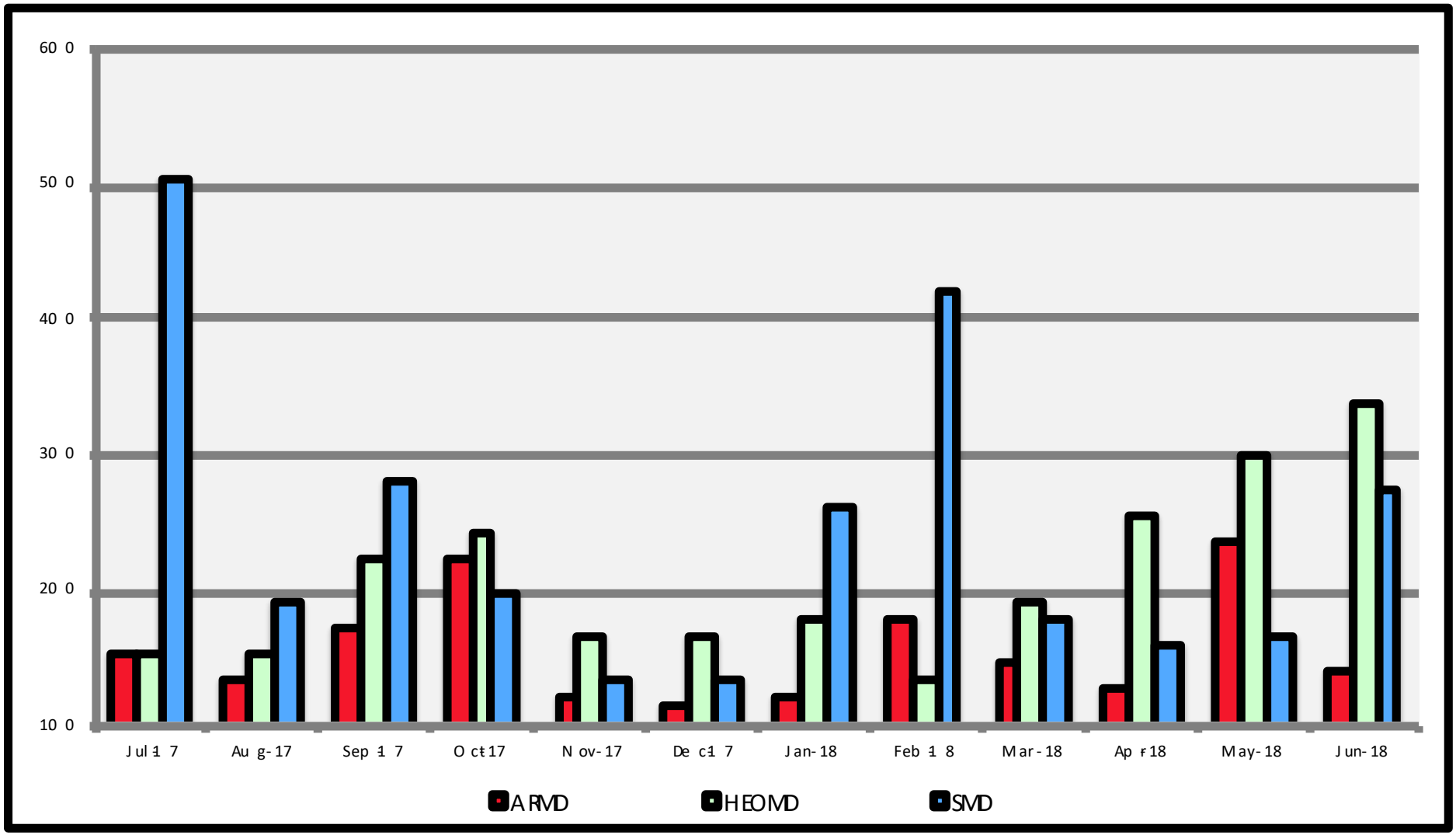
Pleiades:
Monthly Utilization by Size and Length



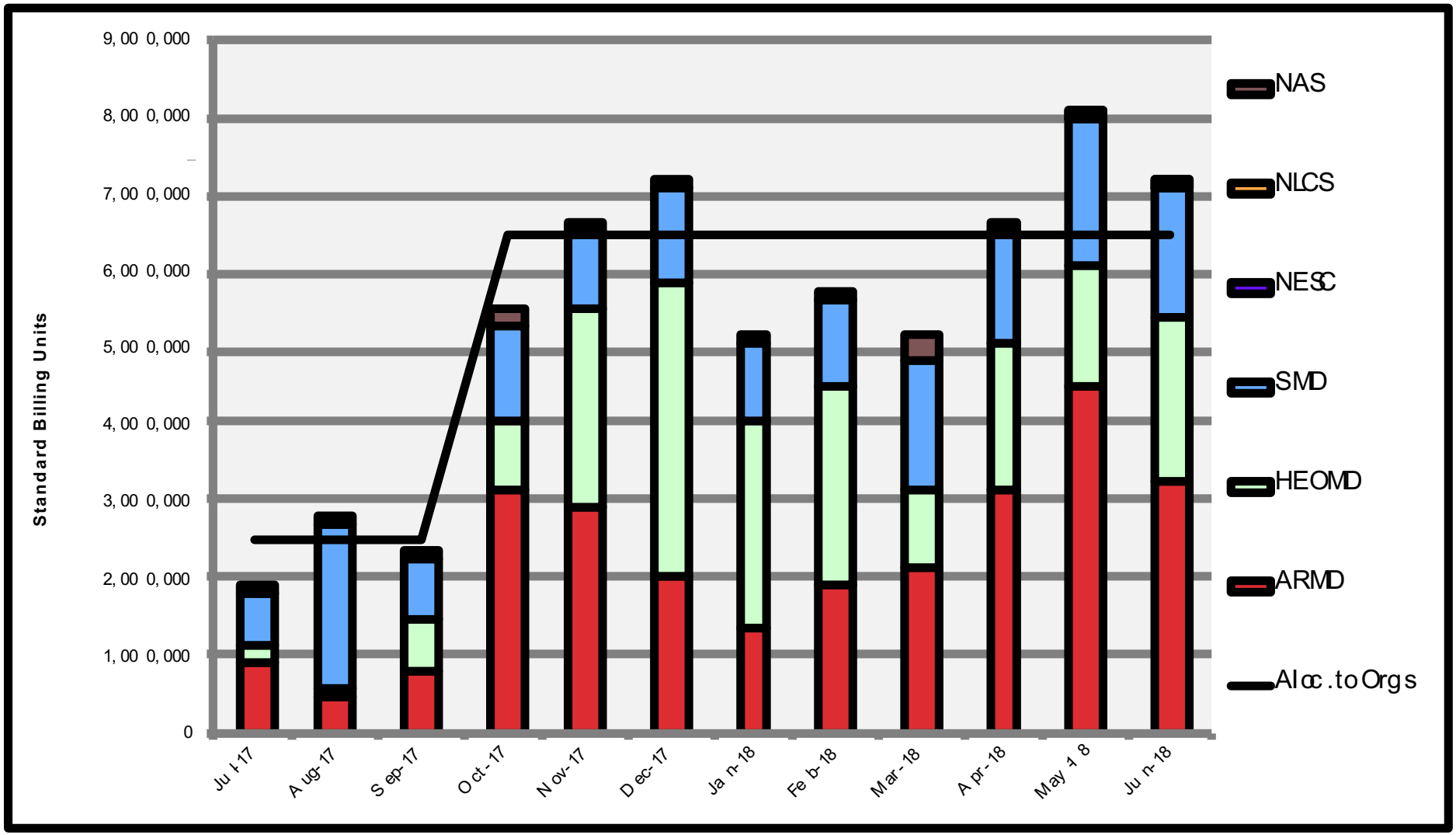
Pleiades:
Average Time to Clear All Jobs



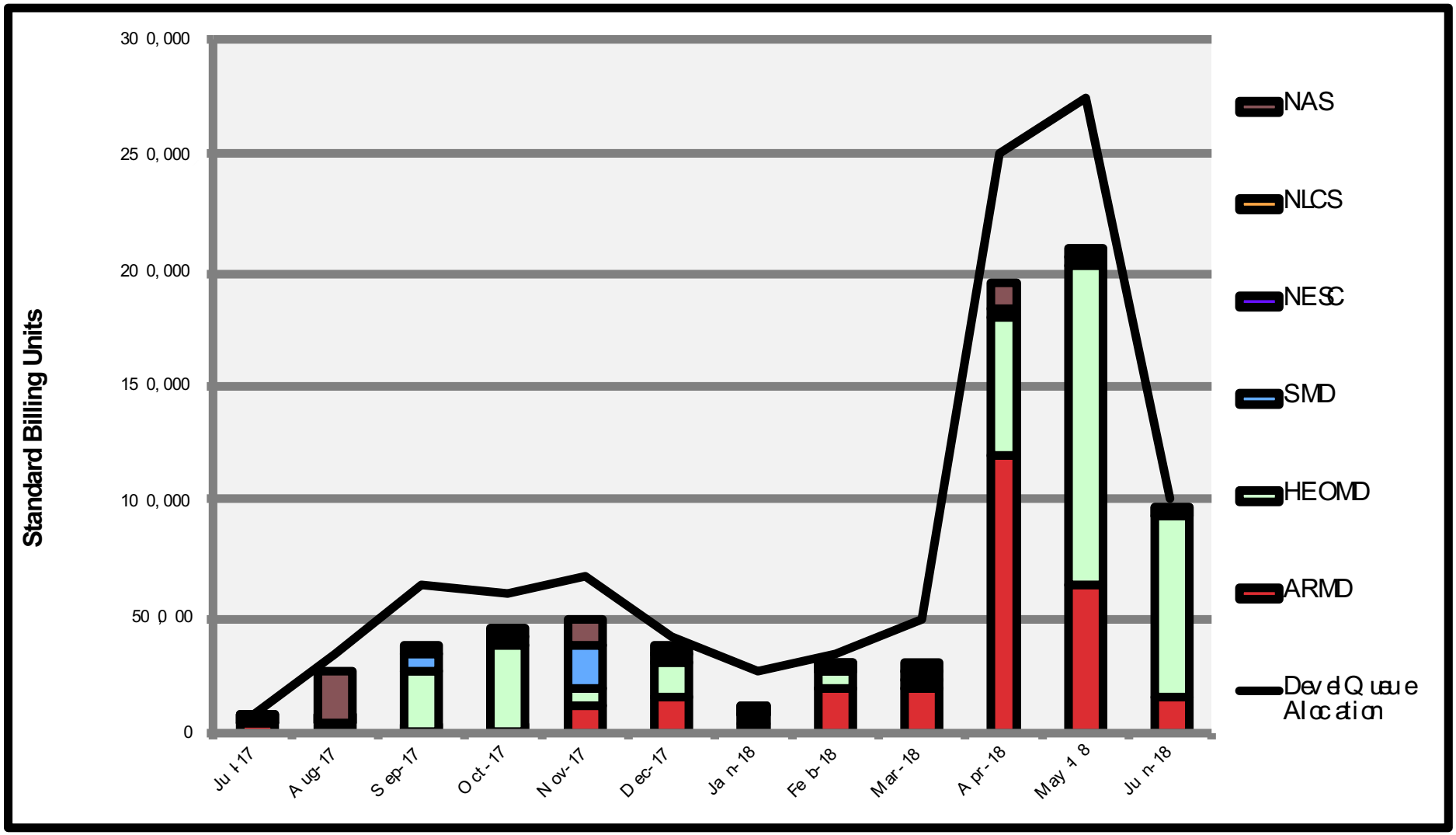
Pleiades:
Average Expansion Factor



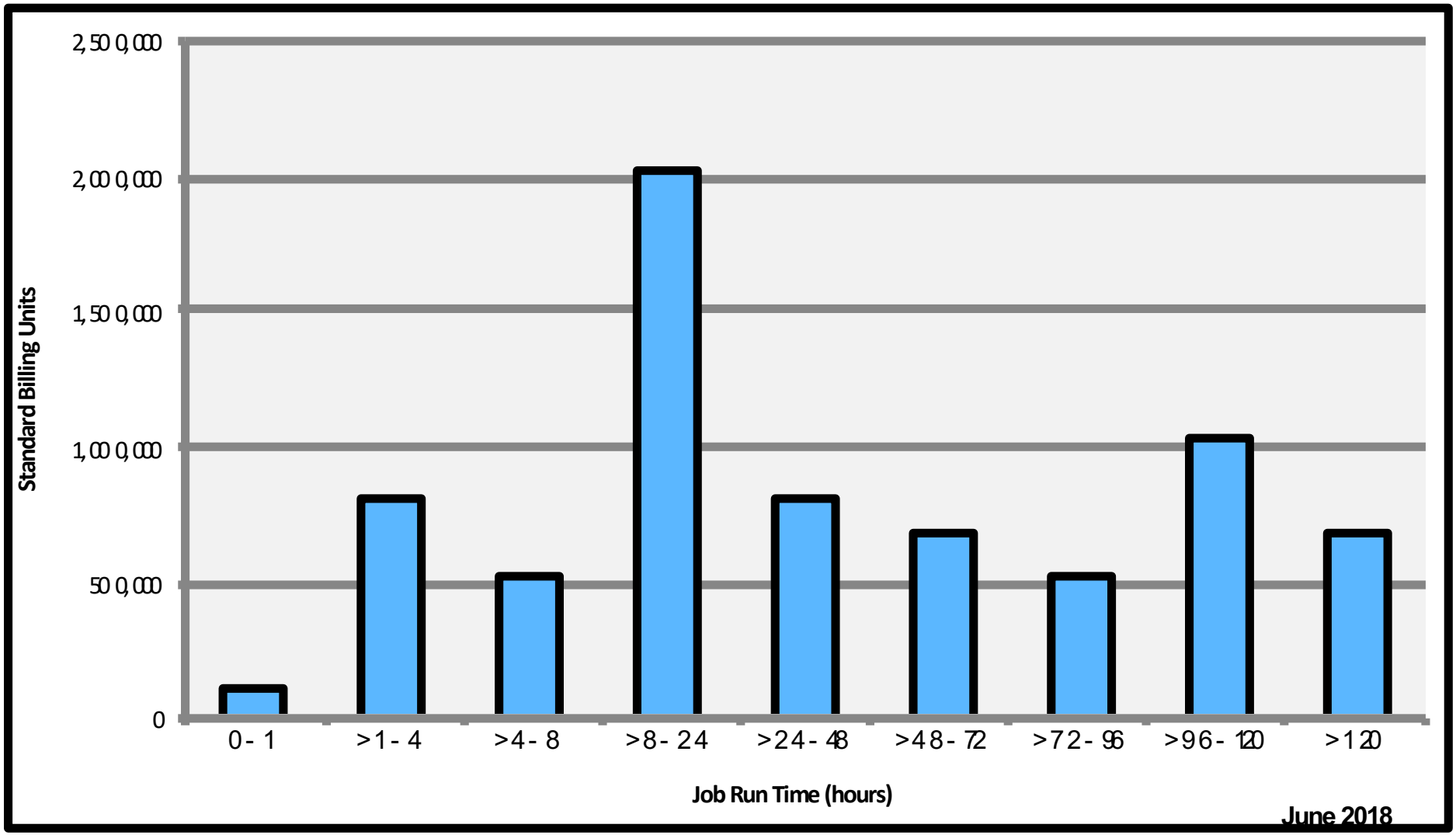
Electra:
SBUs Reported, Normalized to 30-Day Month



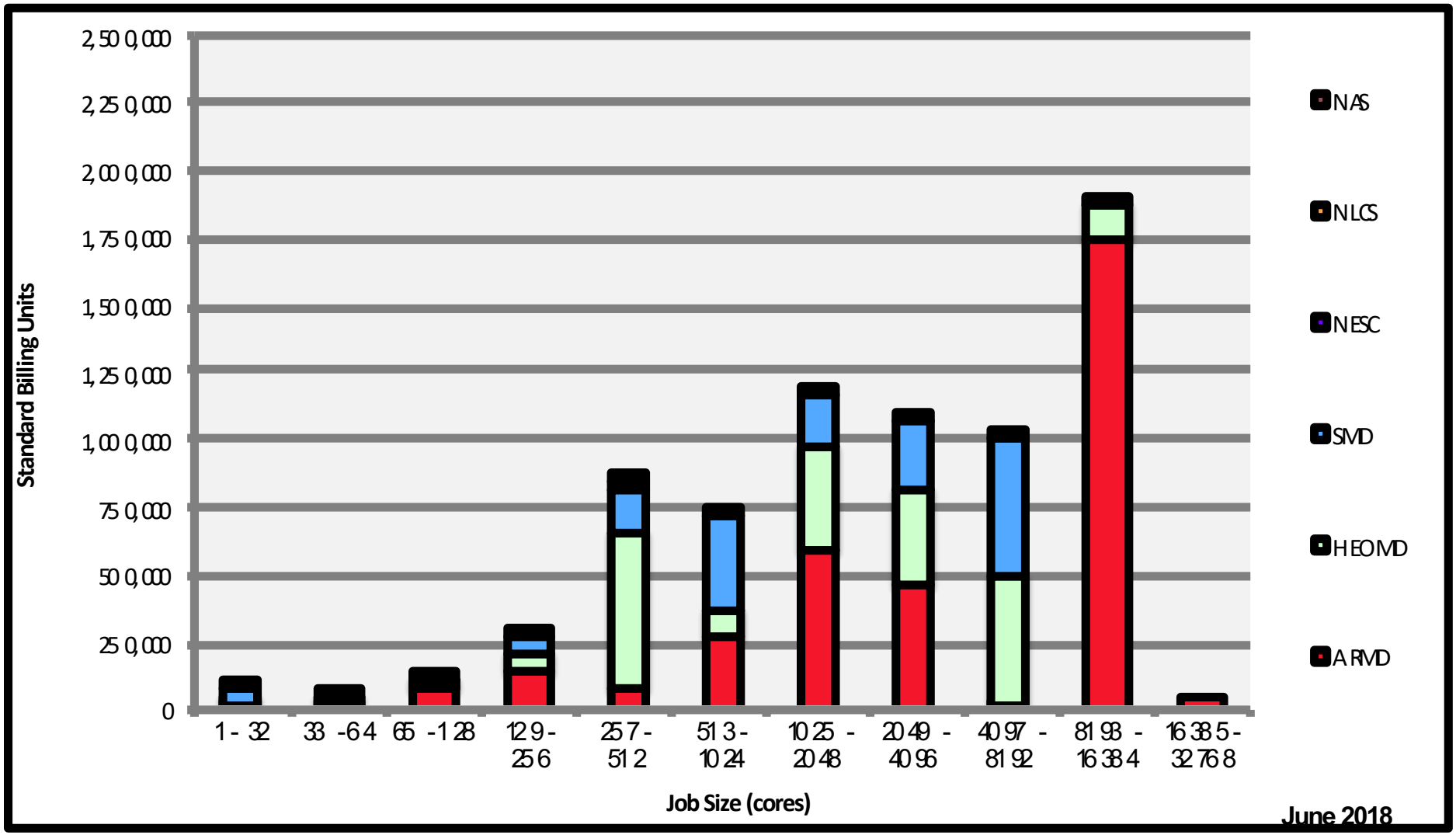
Electra:
Devel Queue Utilization



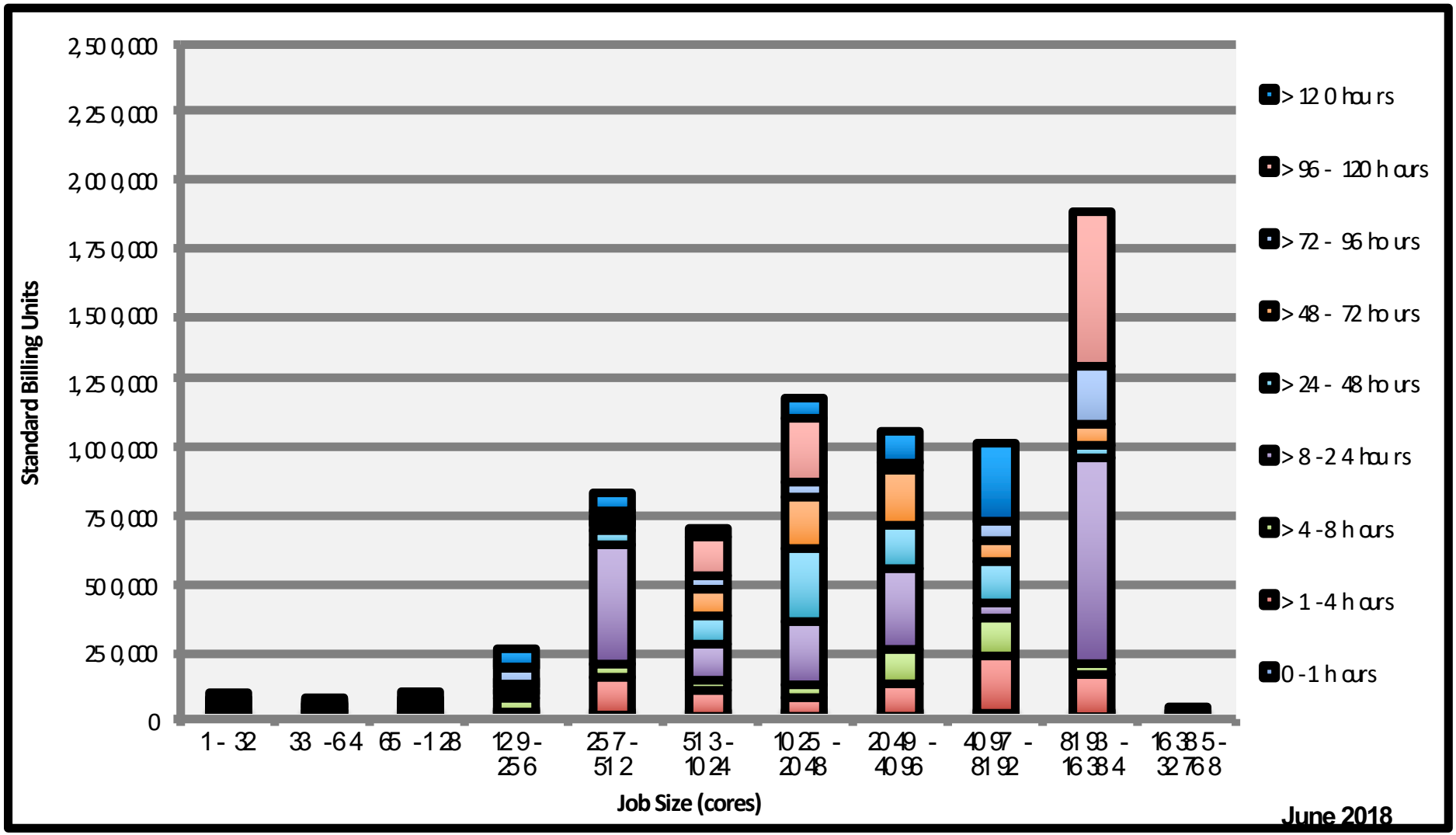
Electra:
Monthly Utilization by Job Length



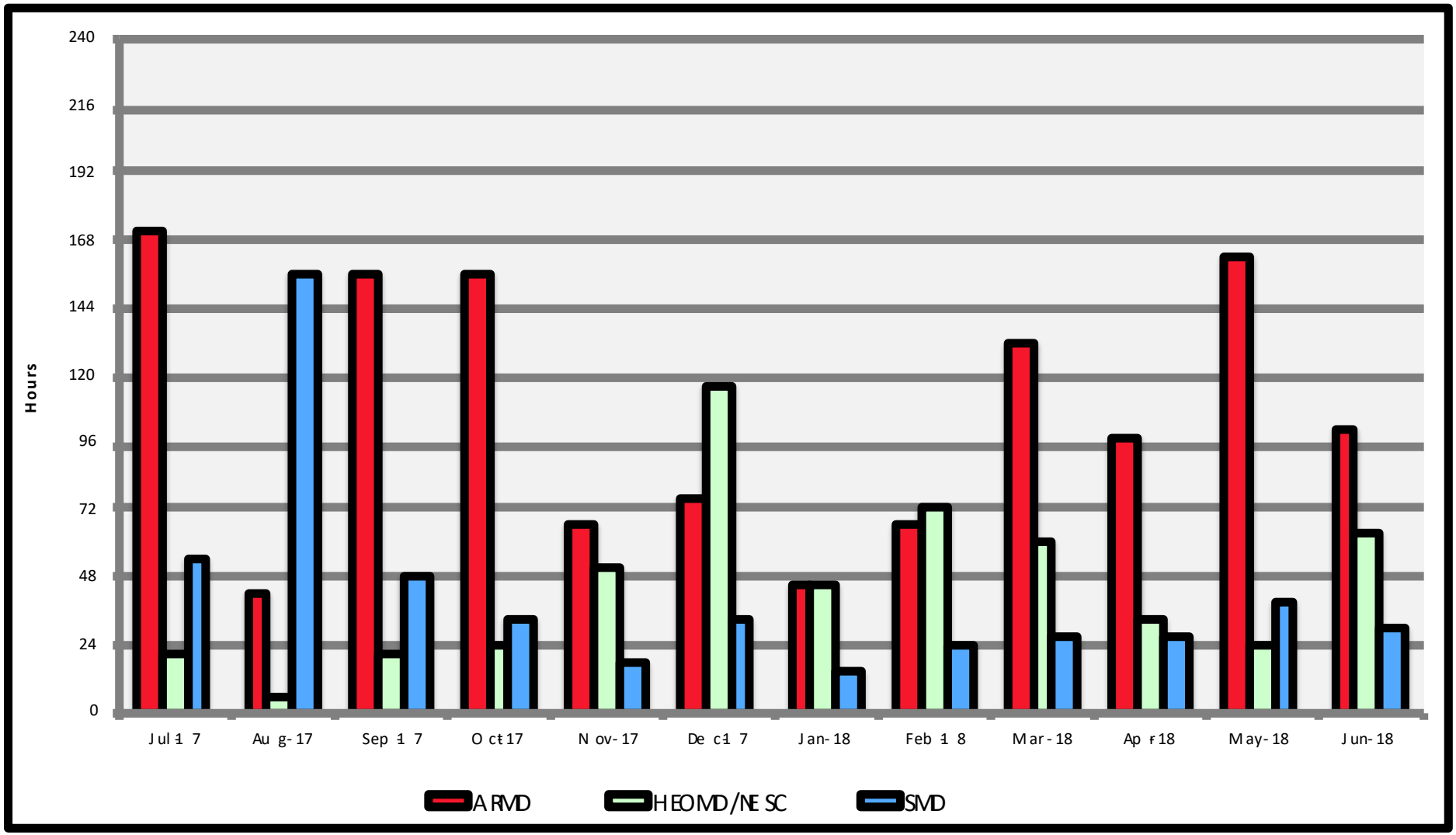
Electra:
Monthly Utilization by Size and Mission



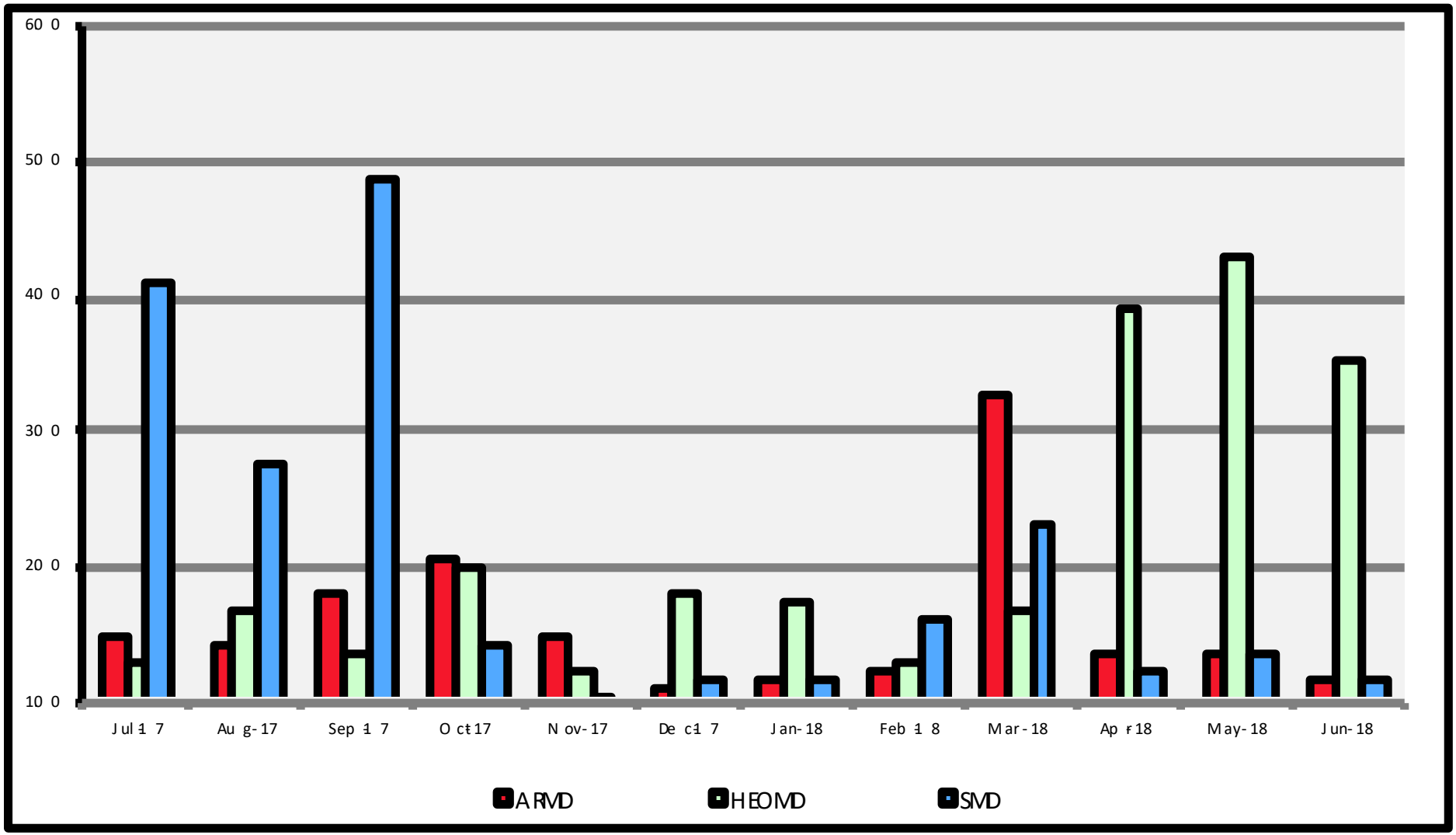
Electra:
Monthly Utilization by Size and Length



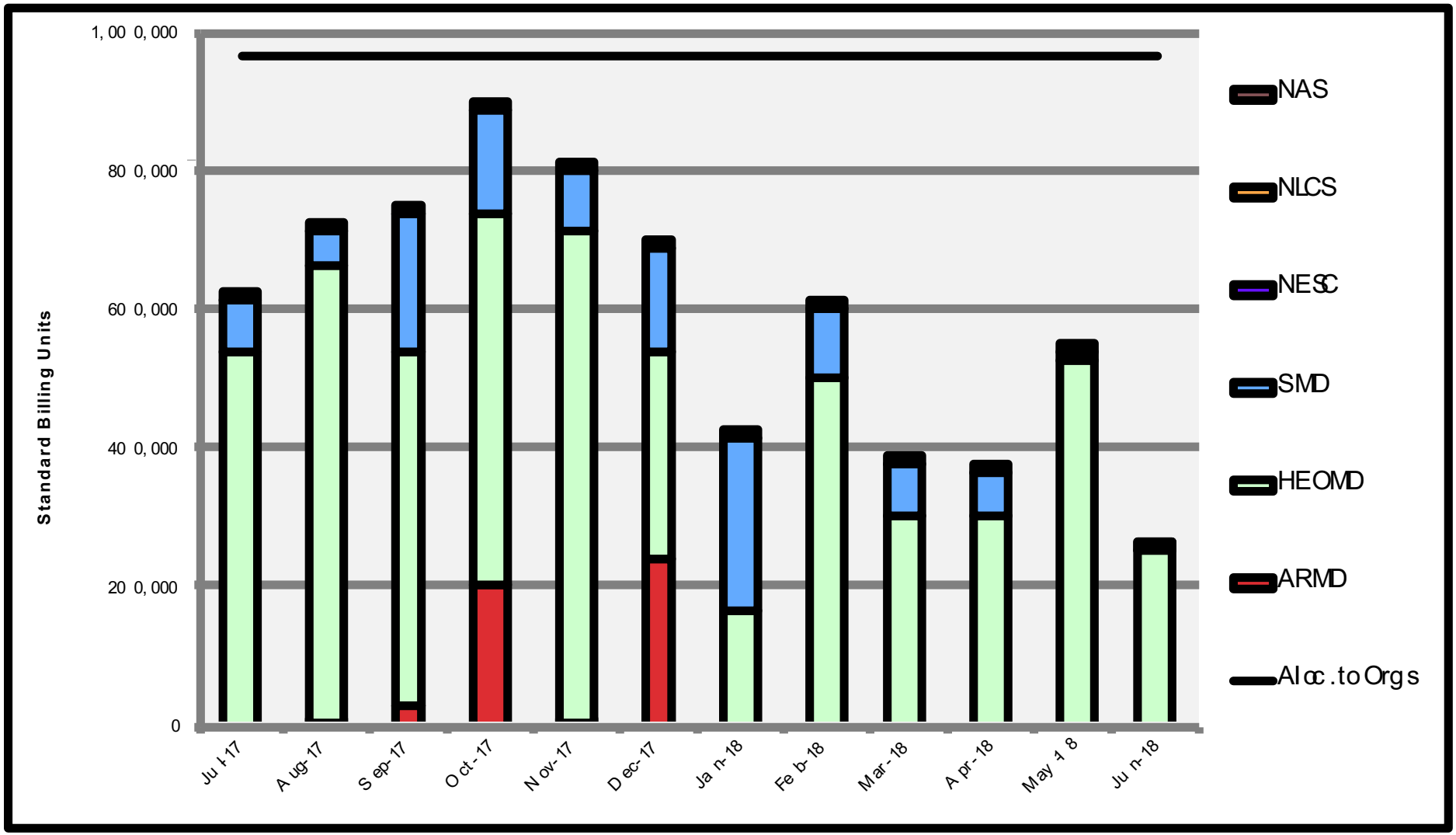
Electra:
Average Time to Clear All Jobs



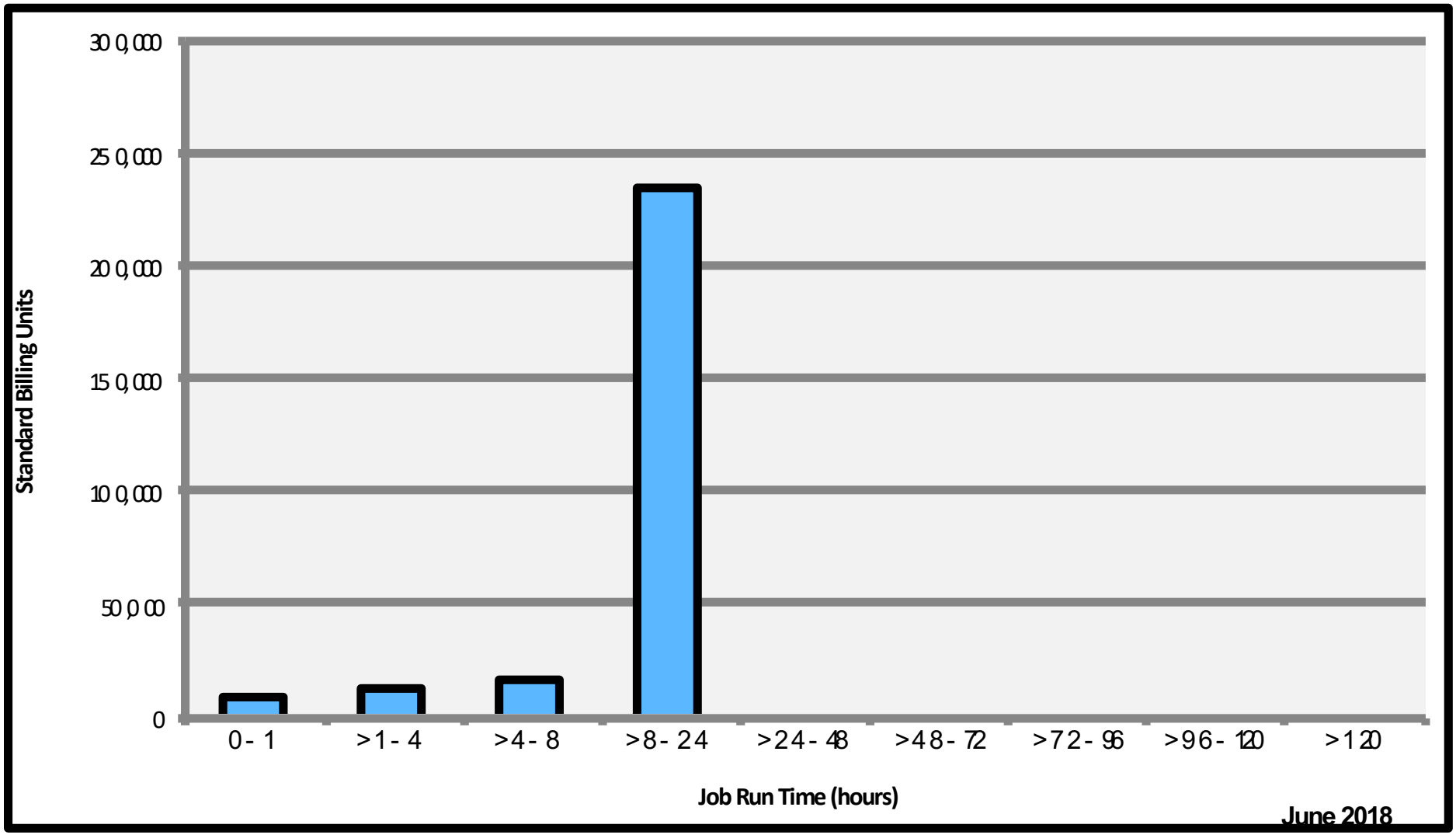
Electra:
Average Expansion Factor



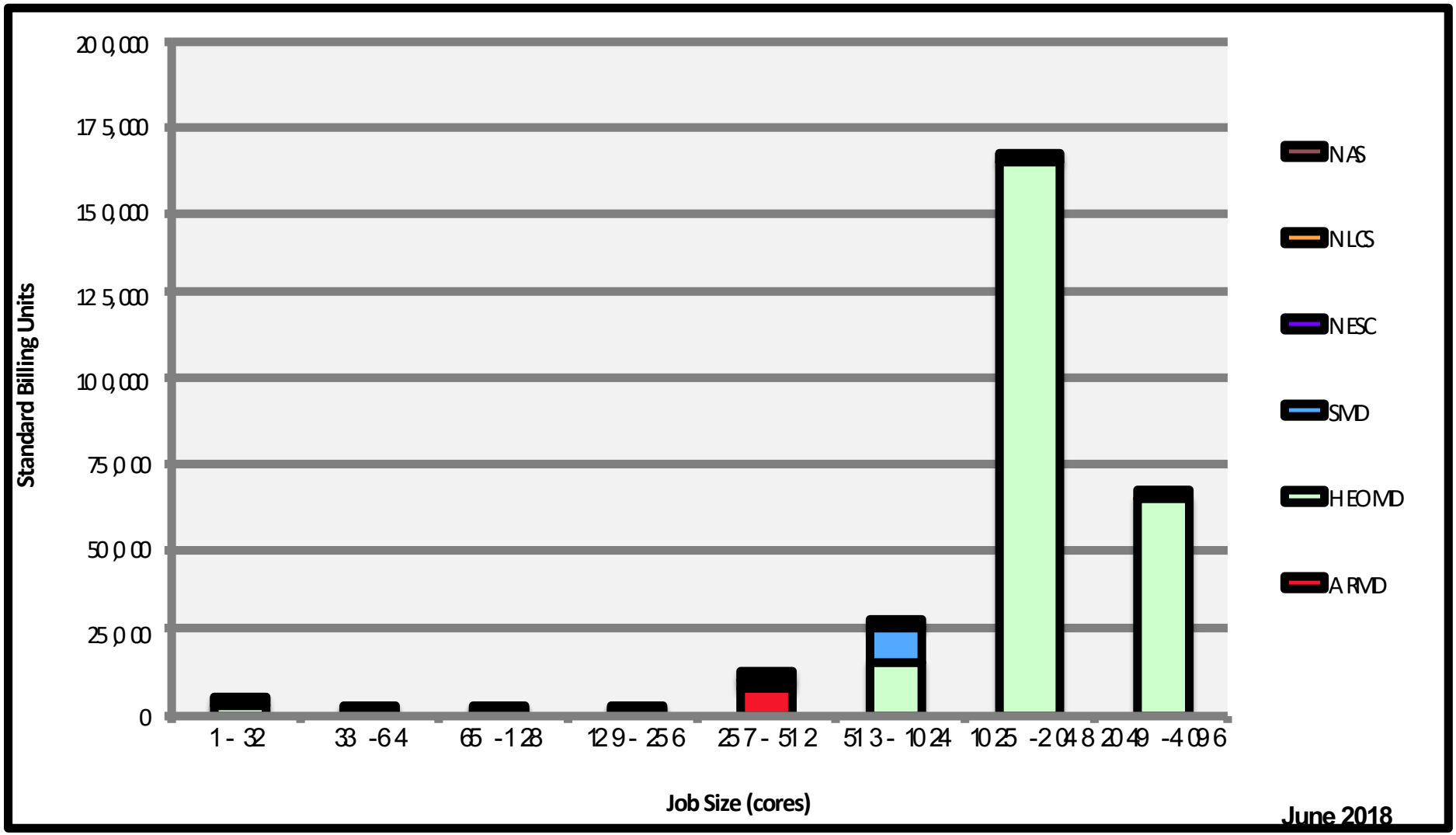
Merope:
SBUs Reported, Normalized to 30-Day Month



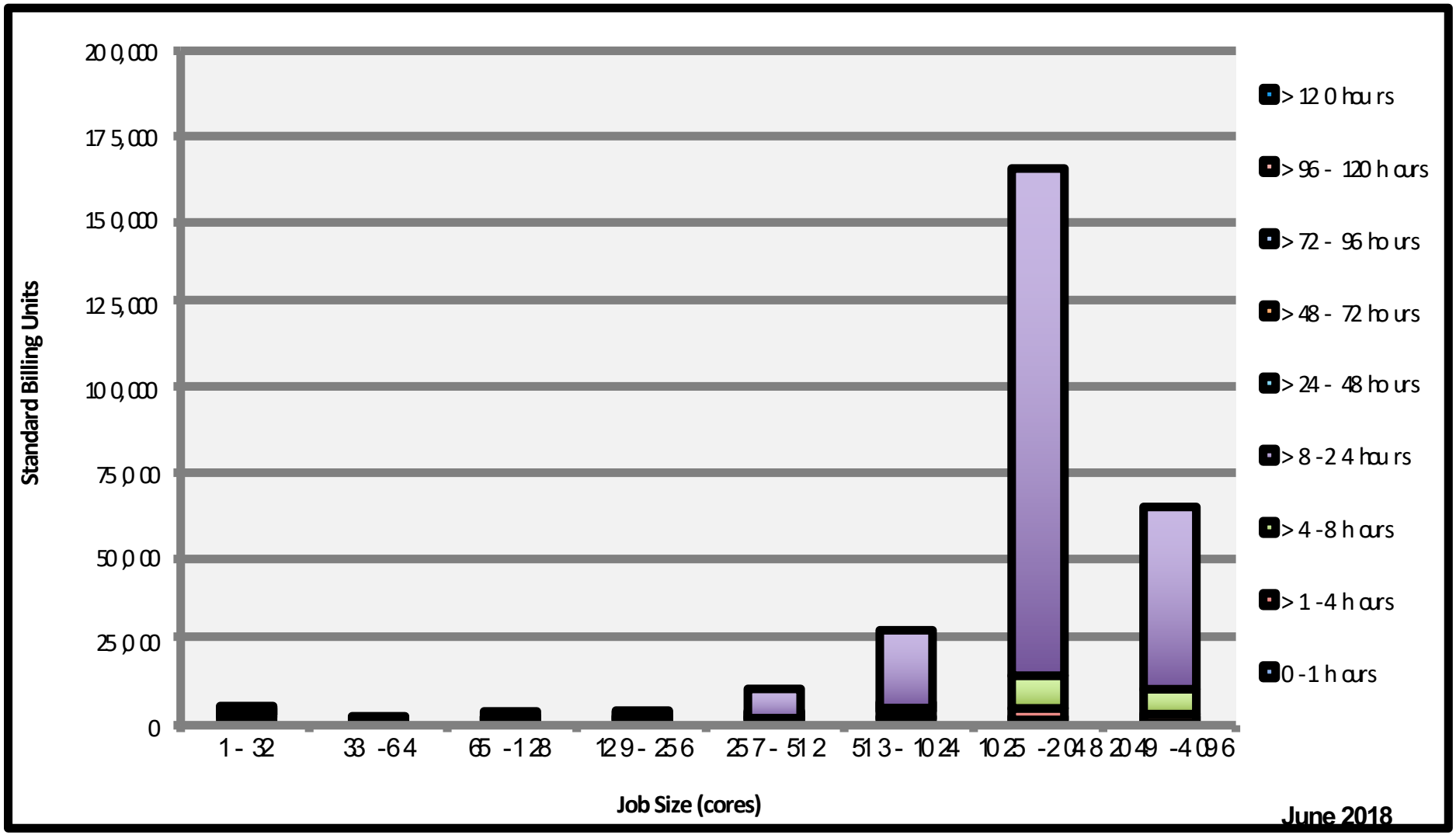
Merope:
Monthly Utilization by Job Length



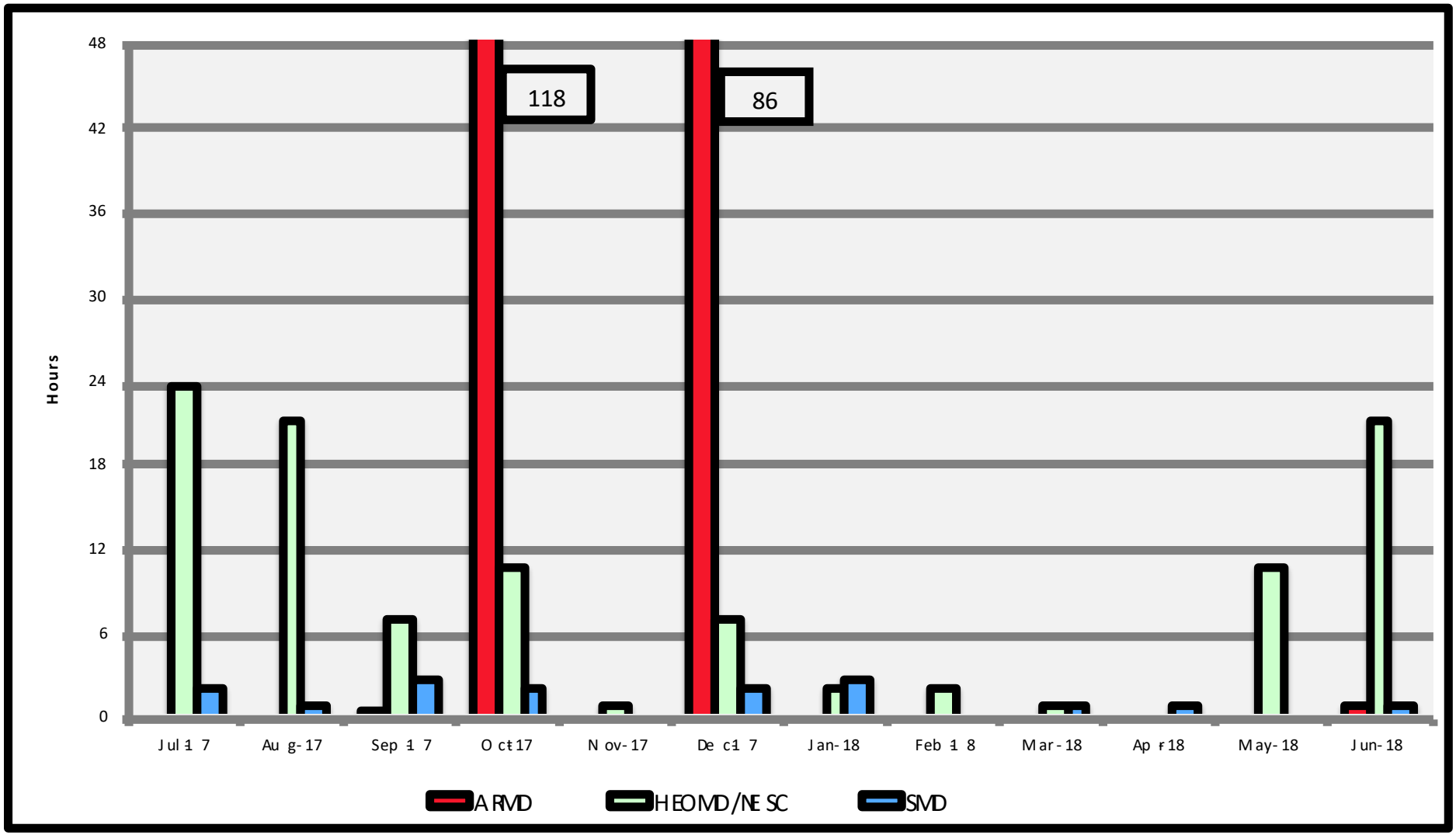
Merope:
Monthly Utilization by Size and Mission



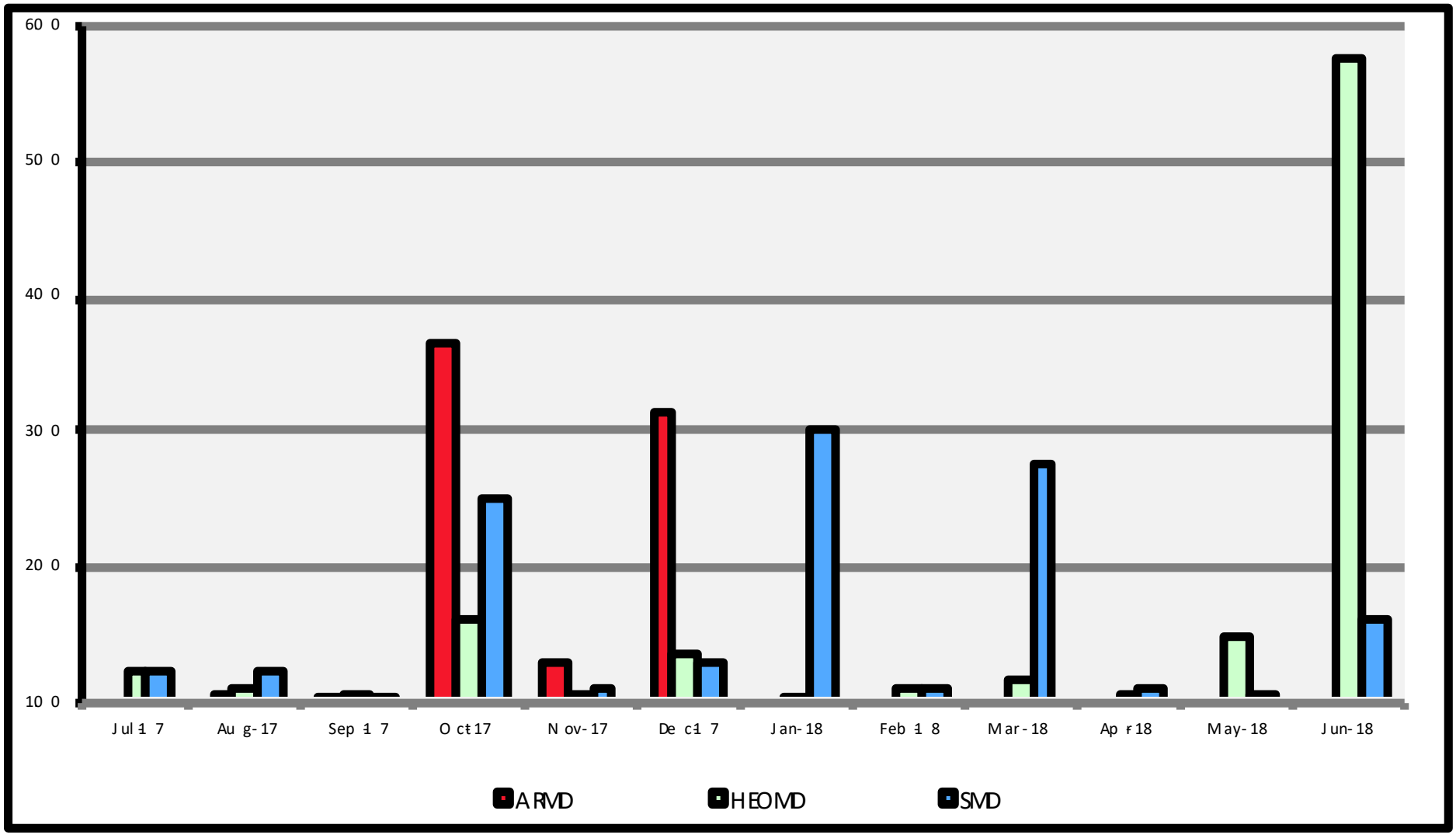
Merope:
Monthly Utilization by Size and Length



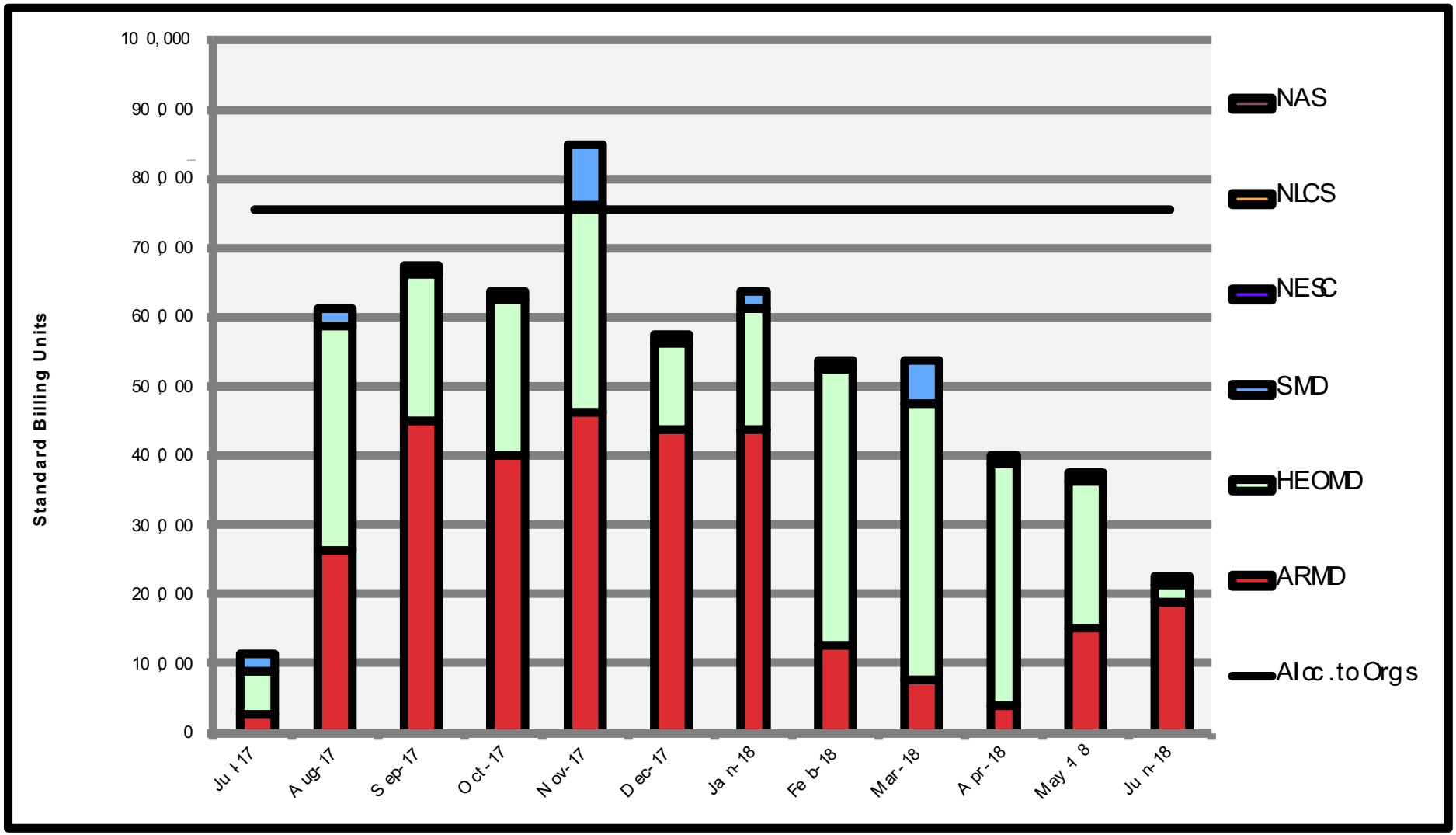
Merope:
Average Time to Clear All Jobs



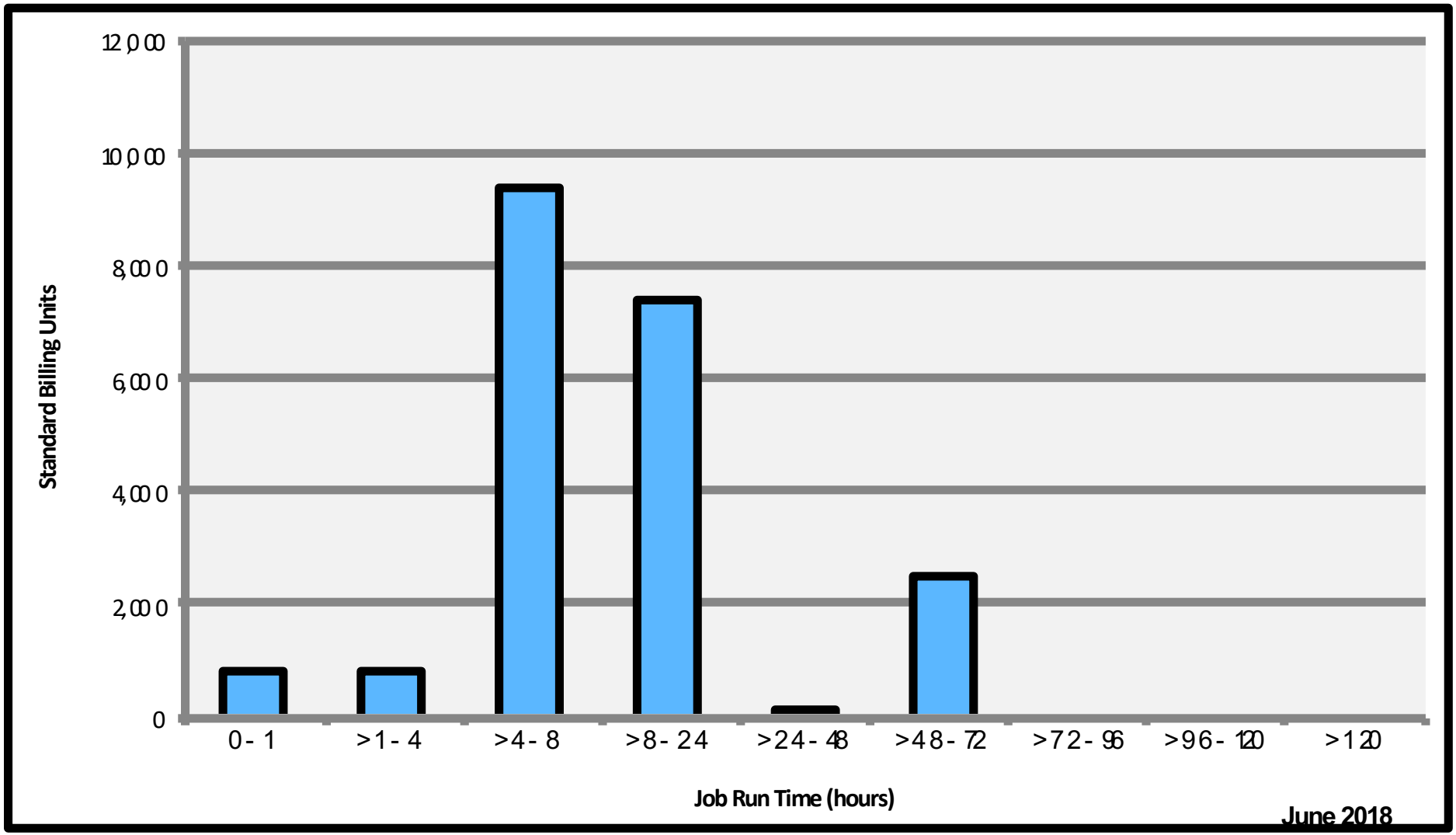
Merope:
Average Expansion Factor



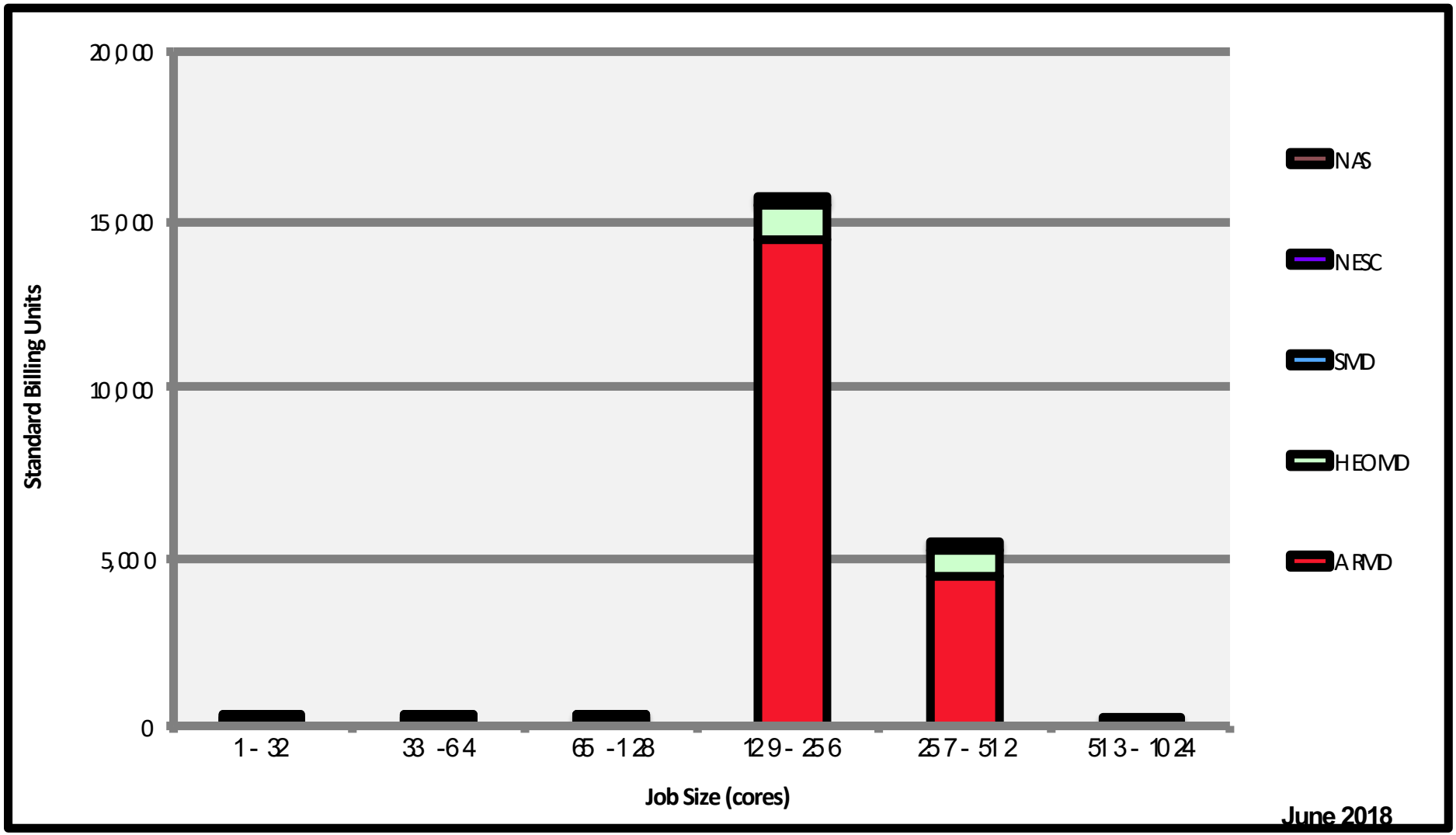
Endeavour:
SBUs Reported, Normalized to 30-Day Month



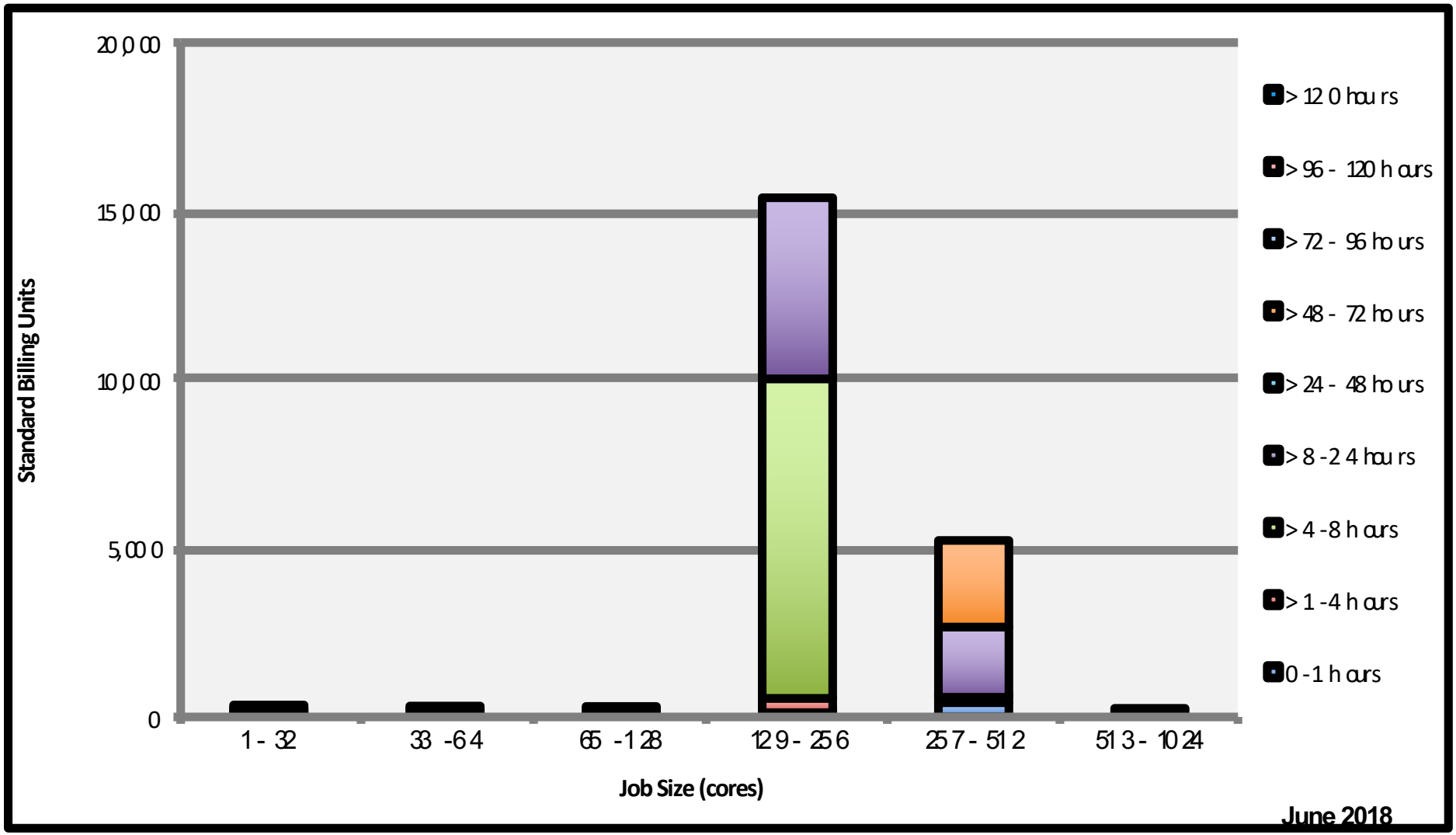
Endeavour:
Monthly Utilization by Job Length



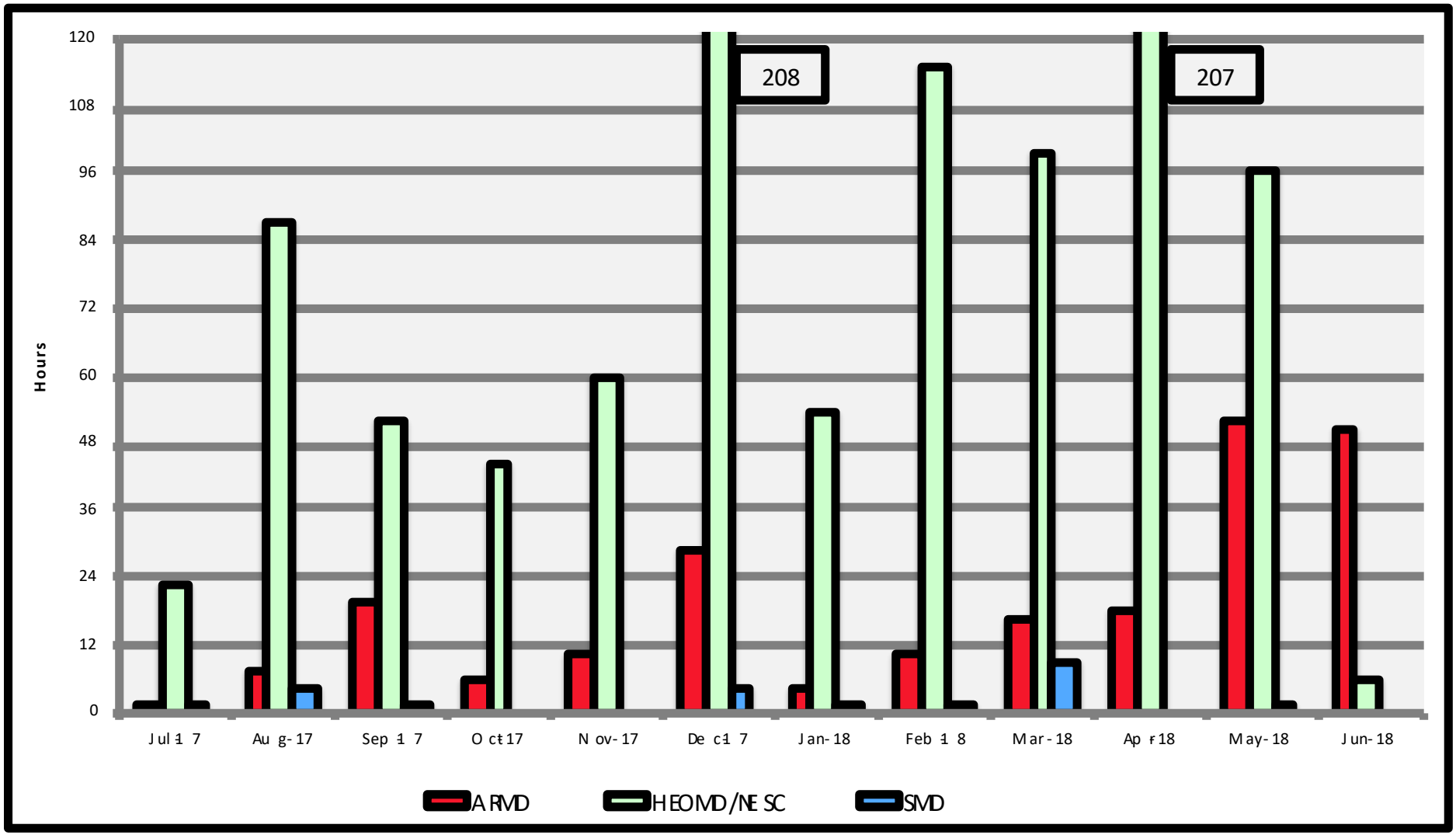
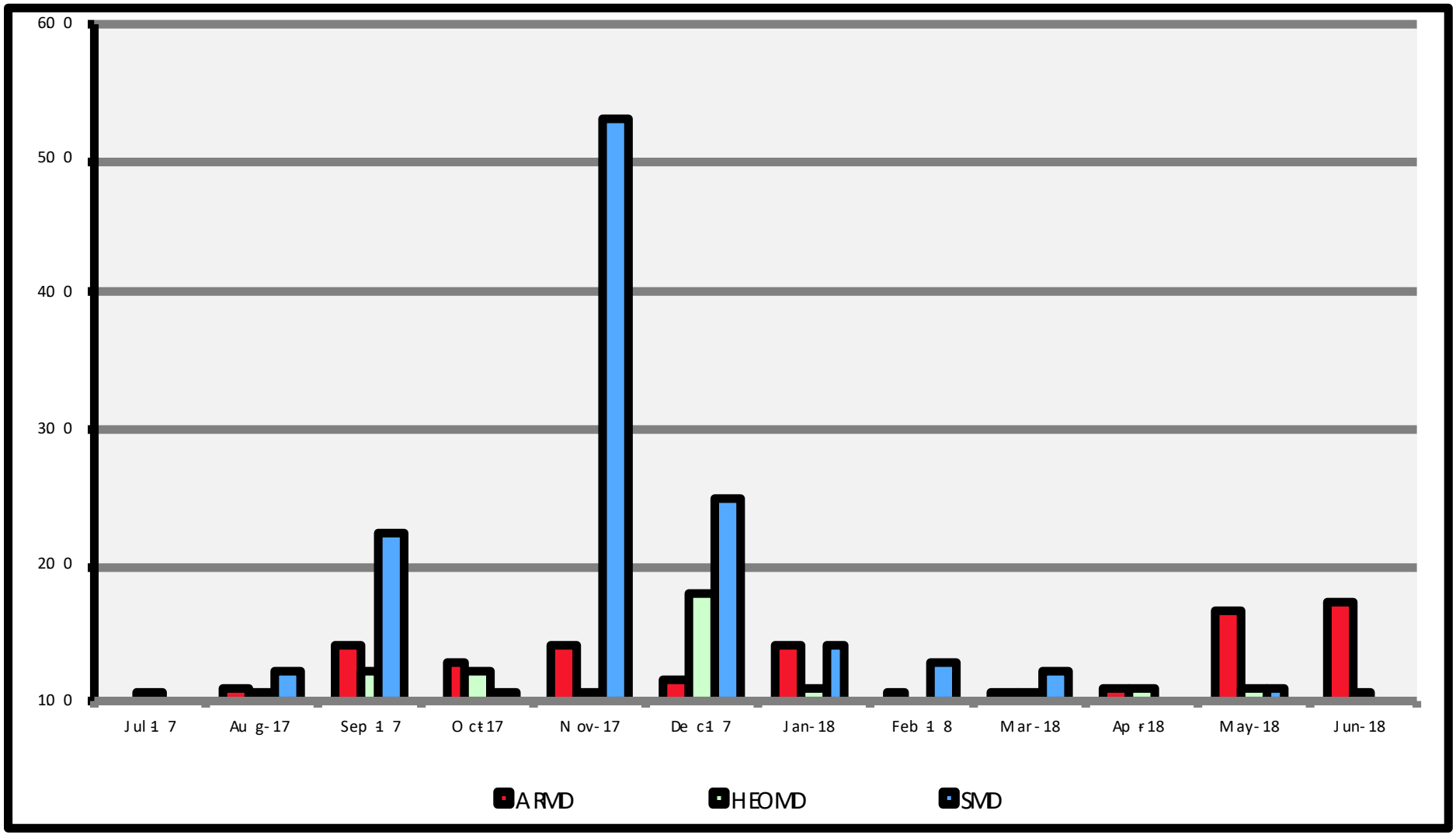
Endeavour:
Monthly Utilization by Size and Mission



Endeavour:
Monthly Utilization by Size and Length



Endeavour:
Average Time to Clear All Jobs



Endeavour:
Average Expansion Factor