Project Status Report

High End Computing Capability
Strategic Capabilities Assets Program

November 10, 2016

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HECC Facilities Team Completes Bringing Infrastructure Online and Testing of MSF

- Working with NASA Ames Code J and SGI/CommScope staff, the HECC Facilities team connected the Modular Supercomputing Facility (MSF) to site electrical utilities, a 2.5-megawatt transformer, water supply, drainage, and emergency services (such as fire and physical security).
- The MSF's first system, Electra, is now operational and consumes 440 kilowatts of power with a LINPACK benchmark load. The initial Power Usage Effectiveness (PUE) during the LINPACK run (slide 4) was between 1.02–1.03.
- The HECC team received training on and have taken over responsibility for operation of the Electra module. The MSF control systems are completely functional and we are in the process of conducting environmental testing.
- Electra is still on schedule to go into production in December 2016.

Mission Impact: By working closely with NASA Ames Center Operations and SGI/CommScope staff, the HECC Modular Supercomputing Facility (MSF) project team ensured the successful installation of the first MSF module.

Left: The Modular Supercomputing Facility's Programmable Logic Controller (PLC) user interface. Right: The MSF construction site, located across from the NASA Advanced Supercomputing facility at NASA's Ames Research Center.

POCs: William 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, CSRA LLC

Successful LINPACK and HPCG Benchmark Runs Completed on Pleiades

- During dedicated time, HECC and SGI engineers ran the LINPACK and High Performance Conjugate Gradient (HPCG) benchmarks on the Pleiades supercomputer.
- Pleiades achieved 5.95 petaflops (PF) on the LINPACK benchmark, with 83.7% efficiency, using the majority of the system. This number would have moved the system up to 9th place on the June 2016 TOP500 list. Pleiades has a theoretical peak performance of 7.25 PF.
- Pleiades achieved 175 teraflops on the HPCG benchmark. This result would have moved the system up to 7th place on the June 2016 HPCG list.
- The benchmarks provide a good stress test on the system and help to quickly identify marginal hardware on the system. Over 60 components were identified as sub-optimal and replaced during this test.

Mission Impact: Running the LINPACK and HPCG benchmarks across a large portion of Pleiades provides HECC with a good method to identify and address system issues, thereby improving overall reliability for users.

The LINPACK and HPCG benchmarks are widely used to evaluate the performance of different high-performance computers, and provide two complementary viewpoints on performance on different workloads.

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

Successful LINPACK and HPCG Benchmark Runs Completed on Electra

- SGI completed running the LINPACK and HPCG benchmarks on the Electra supercomputer as part of a stress test.
- Electra achieved 1.096 petaflops (PF) on the LINPACK benchmark, with 88.5% efficiency (95.7% efficiency based on the Advanced Vector Extensions, or AVS frequency.) This would have placed the system in 80th place on the June 2016 TOP500 list. Electra has a theoretical peak performance of 1.2 PF.
- Electra achieved 25.188 teraflops on the HPCG benchmark. This number would have placed the system in 38th place on the June 2016 HPCG list.
- The Power Utilization Efficiency (PUE) measurement, which is the total facility power divided by the IT equipment power, fluctuated between 1.02–1.03 during the LINPACK benchmark. A PUE of 1.0 would be indicative of a system that used no power for cooling.

Mission Impact: HECC's new Electra system demonstrates that a high-performance computer can be power-efficient while still providing the resources to meet NASA's growing computational requirements.

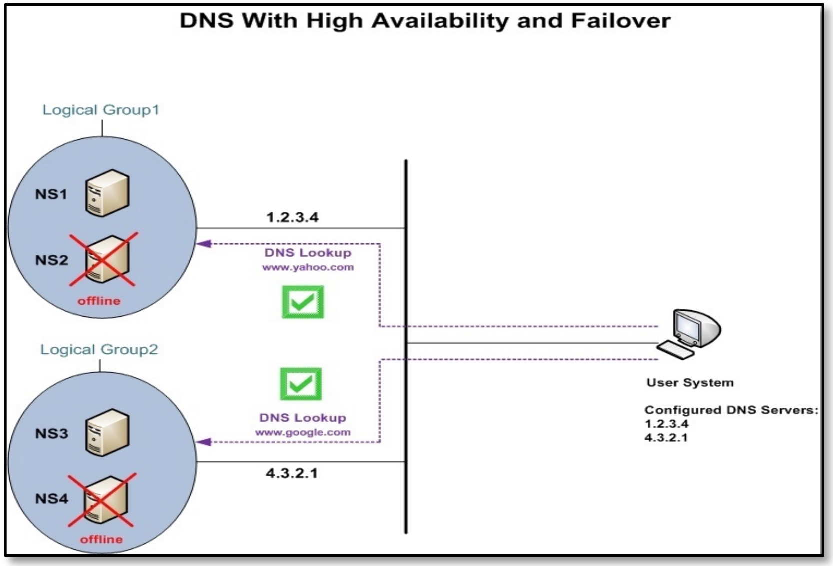
The Electra system, consisting of 1,152 Broadwell nodes, is able to run efficiently while running demanding benchmarks like LINPACK and HPCG.

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 Networks Team Leads Agency Design on DNS Service

- The agency's Domain Name System (DNS) service was centralized to run out of Marshall Space Flight Center by the NASA Integrated Communications Services (NICS) contract under the Discrete Data Input/Internet Protocol Address Management (DDI/IPAM) project. HECC provided key input requirements at the start of the project that were later adopted by the agency as a more reliable and standard model.
  - The HECC Networks team provided requirements for high availability across DNS servers in a virtual cluster pair. In the event that one DNS server goes down, another will take over its role, resulting in no downtime.
  - HECC's NASLAN network was the first to have this implemented and now the agency has 5 other sites set up with a similar architecture.
  - The HECC requirement of having redundant array of independent disk (RAID) hard drives mirrored in case of drive failure is now standard practice across all DNS servers to increase availability.
- NASLAN continues to be the only network site, throughout the agency, in compliance with IPv6 requirements to have its DNS servers supporting native IPv6. We will continue working with NICS as the IPv6 part of this effort moves forward.

Mission Impact: HECC network architecture designs are a model for the agency, and lead to reduced downtime and higher availability of DNS service to all of NASA.



This diagram shows the high-availability Domain Name System (DNS) architecture that HECC network engineers helped the NASA Integrated Communications Services team design.

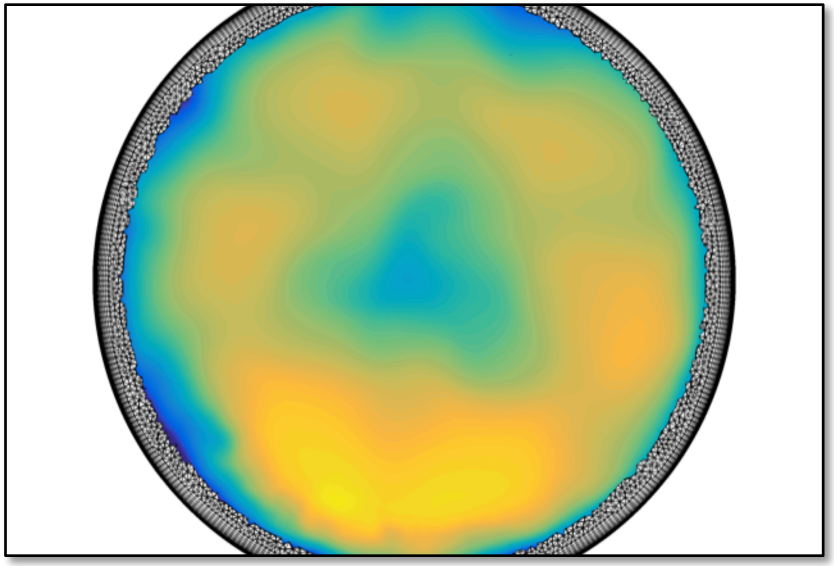
POC: Nichole Boscia, nichole.k.boscia@nasa.gov, (650)604-0891, NASA Advanced Supercomputing Division, CSRA LLC

Assessing Liquid Rocket Engine Feed Line Flow for the Space Launch System *

- Researchers at NASA Marshall Spaceflight Center ran simulations on Pleiades to help designers better understand how fuel will flow within the Space Launch System (SLS) liquid propulsion system.
  - The section of the SLS propulsion system that was modeled included a liquid hydrogen (LH) duct bend, a ball-strut tie rod joint, a gimbal joint, and the RS-25 engine's low pressure fuel pump (LPFP).
  - Three distinct cases were modeled: the LH feed line with no angulation and no inducer; the LH feed line with no angulation, coupled to the RS-25 LPFP; and the LH feed line with 4.5 degrees gimbal angle, coupled to the RS-25 LPFP.
  - The simulations assessed the flow environment in the LH feed line upstream of the LPFP, at normal RS-25 operating conditions during SLS ascent.
  - Flow uniformity, a key factor in LPFP performance and operation, was calculated for the three cases and compared. The various sources of flow variation were identified and their relative contributions to the flow field were determined.
- Results showed that the current configuration appears to have an acceptable flow environment.

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

Mission Impact: HECC supercomputing resources enabled modeling of the full-scale geometry with fine details, providing designers of the SLS liquid propulsion system with information that can help ensure its components can withstand the complex flow environments generated by the propulsion system.



A planar cut through the simulation model of the Space Launch System feed line, showing the average axial velocity of the liquid propellant near the pump inlet for the straight duct with the RS-25 low pressure fuel pump.

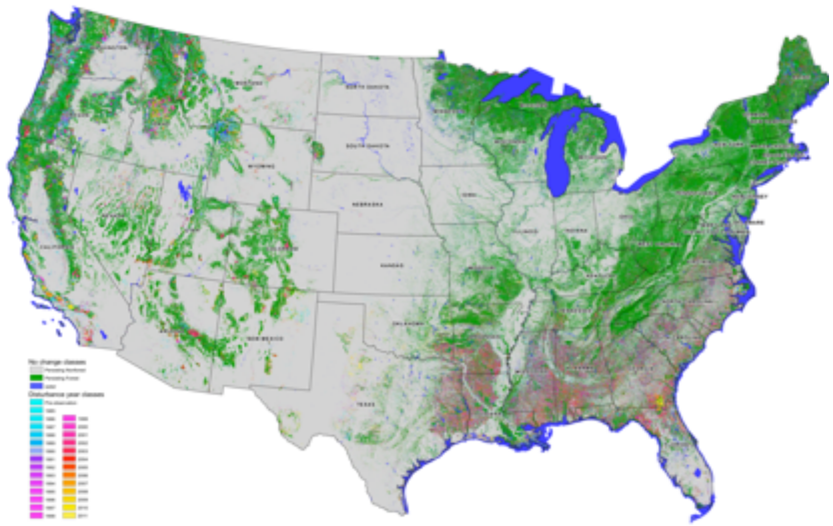
POC: Andrew Mulder, andrew.mulder@nasa.gov, (256) 544-6750, NASA Marshall Space Flight Center

Enabling NASA Earth Exchange (NEX) Petabyte Data Production Systems *

- To support a growing number of projects that are developing new, large-scale science data products, the NEX team developed a hybrid HPC-cloud data production system during the last year.
- The NEX system represents both the production rules and the execution of the rules as a directed graph, from which user can analyze and reproduce scientific results.
- The system makes it possible for small science teams to execute projects that would not have been possible previously. Examples include:
  - Production pipeline for Landsat and NASA Global Imagery and Browse Service – 37 steps, 7 petabytes of data, and 670,000 processor-hours.
  - NEX Downscaled Climate Projections (NEX-DCP30) and NEX Global Daily Downscaled Projections (NEX-GDDP) pipeline – 40 terabytes (TB) of data and 320,000 processor-hours.
  - Estimating biomass by counting trees across the United States by using machine learning and computer vision – 40 TB of data/100,000 processor-hours.
- Over the last year, NEX projects used more than 9 million processor-hours on Pleiades and processed more than 3 petabytes of data.

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

Mission Impact: The Pleiades supercomputer, combined with HECC's massive data storage and high-speed networks, enables the NASA Earth Exchange (NEX) team to engage large scientific communities and provide large-scale modeling and data analysis capabilities not previously available to most scientists.



NEX production pipeline example: Preliminary national forest disturbance map from the North American Forest Dynamics (NAFD) team, developed using a combination of 25 years of Landsat data (1985–2010) and over 200,000 compute hours. The product is a wall-to-wall forest disturbance map for the entire United States at 30-meter spatial resolution.

***POCs**:* Petr Votava, petr.votava@nasa.gov, (650) 604-4675, Andrew Michaelis, andrew.r.michaelis@nasa.gov, (650) 604-5413, NASA Ames Research Center

HECC Facility Hosts Several Visitors and Tours in October 2016

- HECC hosted 9 tour groups in October; guests learned about the agency-wide missions being supported by HECC assets, and some groups also viewed the D-Wave 2X quantum computer system. Visitors this month included:
  - Peter Hughes, Center Chief Technologist for NASA Goddard Spaceflight Center.
  - A group from the United Nations who is interested in the technological partnership opportunities with NASA Ames Research Center in planetary sustainability/Earth science and space exploration.
  - Technical staff from the Office of Naval Research.
  - A group from the California Council on Science and Technology.
  - A large group of students from Mt. Diablo High School in Oakland, part of an at-risk-youth program.
  - Members of the 2016 Haas School of Business, Berkeley Innovation Fair.
  - Students from the Ames Fall Internship program.

NAS Division Chief Piyush Mehrotra presents computational fluid dynamics results on the NAS facility hyperwall to members of the 2016 Haas School of Business, Berkeley Innovation Fair.

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

Papers

- "**Extension of the MURaM Radiative MHD Code for Coronal Simulations**, M. Rempel, arXiv:1609.09818 [astro-ph.SR], September 30, 2016. *
https://arxiv.org/abs/1609.09818
- "**Cosmological Hydrodynamic Simulations of Preferential Accretion in the SMDH of Milky Way Size Galaxies**," N. Sanchez, et al., arXiv:1610.01155 [astro-ph.GA], October 4, 2016. *
https://arxiv.org/abs/1610.01155
- "**The Influence of Daily Meteorology on Boreal Fire Emissions and Regional Trace Gas Variability**," E. Wiggins, et al., Journal of Geophysical Research: Biosciences, October 6, 2016. *
http://onlinelibrary.wiley.com/doi/10.1002/2016JG003434/full
- "**Properties of Dark Matter Halos as a Function of Local Environment Density**," C. Lee, et al. arXiv:1610.02108 [astro-ph.GA] October 7, 2016. *
https://arxiv.org/abs/1610.02108
- "**Colors, Star Formation Rates, and Environments of Star Forming and Quiescent Galaxies at the Cosmic Noon**," R. Feldmann, et al., arXiv:1610:02411 [astro-ph.GA] October 7, 2016. *
https://arxiv.org/abs/1610.02411

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

Papers (cont.)

- "**Optimization of Flexible Wings and Distributed Flaps at Off-Design Conditions**," D. Rodriguez, M. Aftosmis, M. Nemec, G. Anderson, Journal of Aircraft (AIAA), Published online October 7, 2016. *
  http://arc.aiaa.org/doi/abs/10.2514/1.C033535
- "**The Role of Baryons in Creating Statistically Significant Planes of Satellites Around Milky Way-Mass Galaxies**," S. Ahmed, A. Brooks, C. Christensen, arXiv:1610.03077 [astro-ph.GA], October 10, 2016. *
  https://arxiv.org/abs/1610.03077
- "**Why Do High-Redshift Galaxies Show Diverse Gas-Phase Metallicity Gradients?**," X. Ma, et al., arXiv:1610.03498 [astro-ph.GA], October 11, 2016. *
  https://arxiv.org/abs/1610.03498
- "**Effect of Thermal Nonequilibrium on Ignition in Scramjet Combustors**," R. Fievet, et al., Proceedings of the Combustion Institute, Published online October 13, 2016. *
  http://www.sciencedirect.com/science/article/pii/S1540748916304552
- "**Incompressible Modes Excited by Supersonic Shear in Boundary Layers: Acoustic CFS Instability**," M. Belyaev, arXiv:1610.04289 [astro-ph.HE], October 13, 2016. *
  https://arxiv.org/abs/1610.04289
- "**SatCNN: Satellite Image Dataset Classification Using Agile Convolutional Neural Networks**," Y. Zhong, et al., Remote Sensing Letters, Vol. 8, Issue 2, October 25, 2016.
  http://www.tandfonline.com/doi/full/10.1080/2150704X.2016.1235299

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

Papers (cont.)

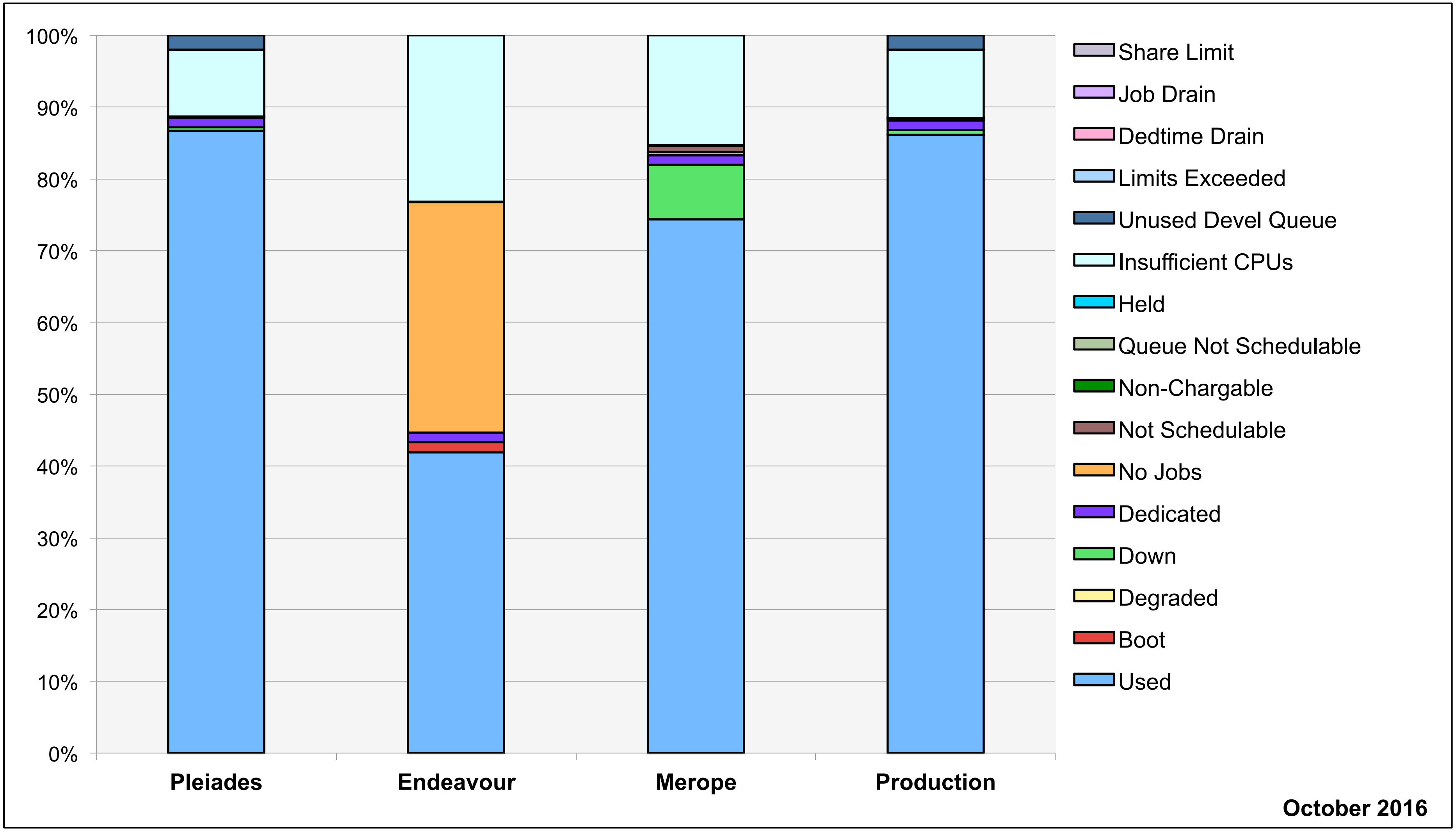
- "**Shocks and Angular Momentum Flips: A Different Path to Feeding the Nuclear Regions of Merging Galaxies**," P. Capelo, M. Dotti, arXiv:1610.08507 [astro-ph.GA], October 26, 2016. *
  https://arxiv.org/abs/1610.08507
- "**Conversion of Internal Gravity Waves into Magnetic Waves**," D. Lecoanet, et al., arXiv:1610.08506 [astro-ph.SR], October 26, 2016. *
  https://arxiv.org/abs/1610.08506
- "**Quantifying Supernovae-Driven Multiphase Outflows**," M. Li, et al., arXiv:1610.08971 [astro-ph.GA], October 27, 2016. *
  https://arxiv.org/abs/1610.08971
- "**A NASA Perspective on Quantum Computing: Opportunities and Challenges**," R. Biswas, et al., Parallel Computing Journal, accepted for publication, October 27, 2016.
  http://www.sciencedirect.com/science/article/pii/S0167819116301326

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

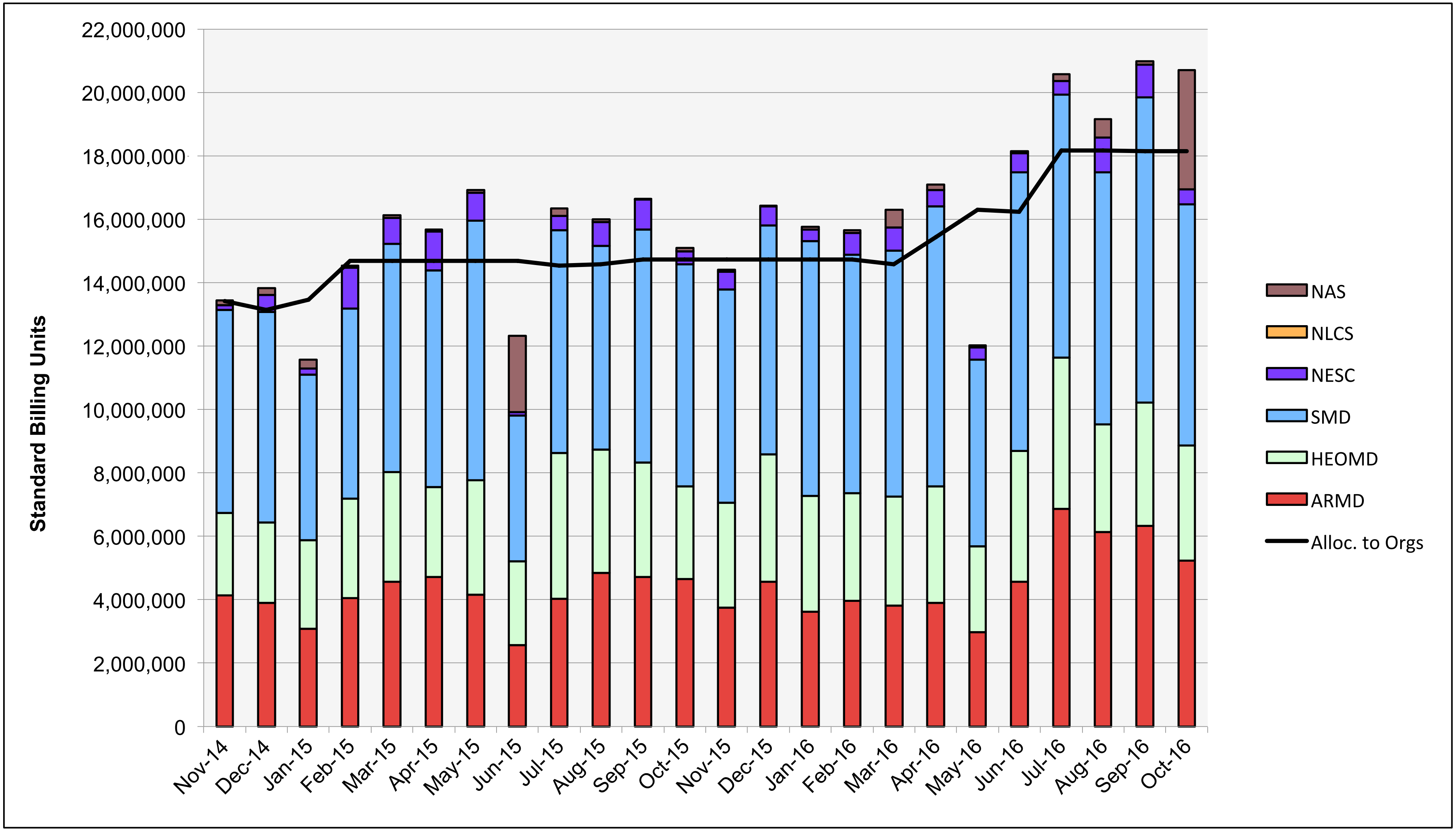
News and Events

- **Looking to the Stars**, *The La Grande Observer*, October 21, 2016—Adam Moreno, a forest ecologist, has been awarded a fellowship from NASA to do research at its Ames Research Center with assistance from the Pleiades supercomputer and data from the space agency's satellite system. He will use these tools to develop a model for forecasting when a forest is reaching the verge of catastrophic collapse. "I want to develop an early warning system," Moreno said. *http://www.lagrandeobserver.com/news/local/4777546-151/looking-to-the-stars*

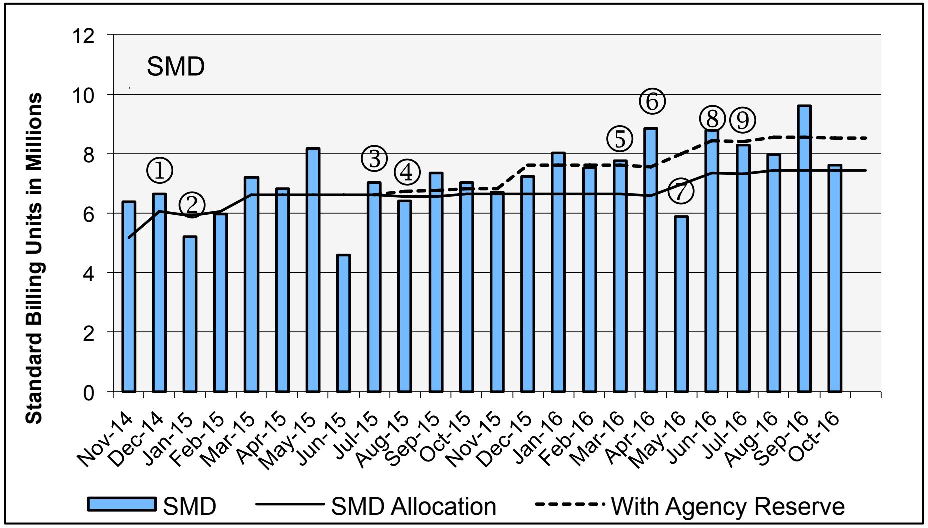
HECC Utilization

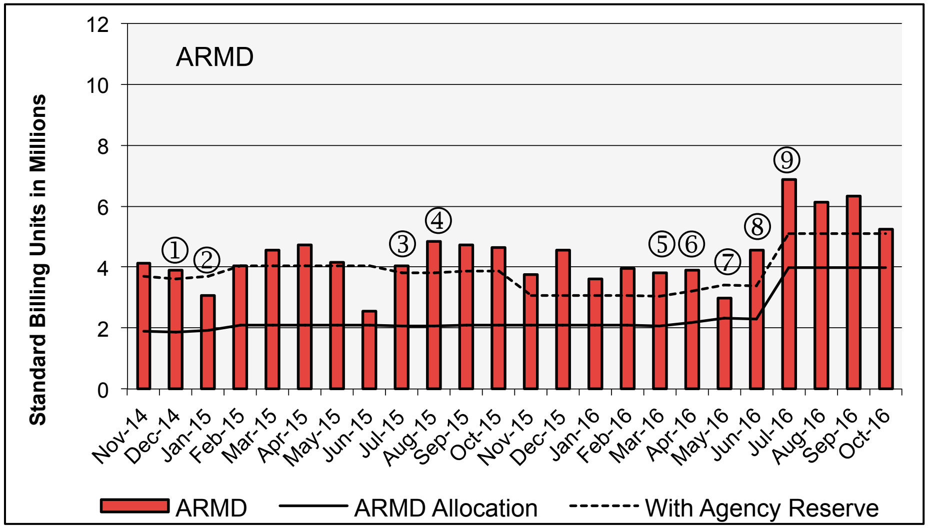


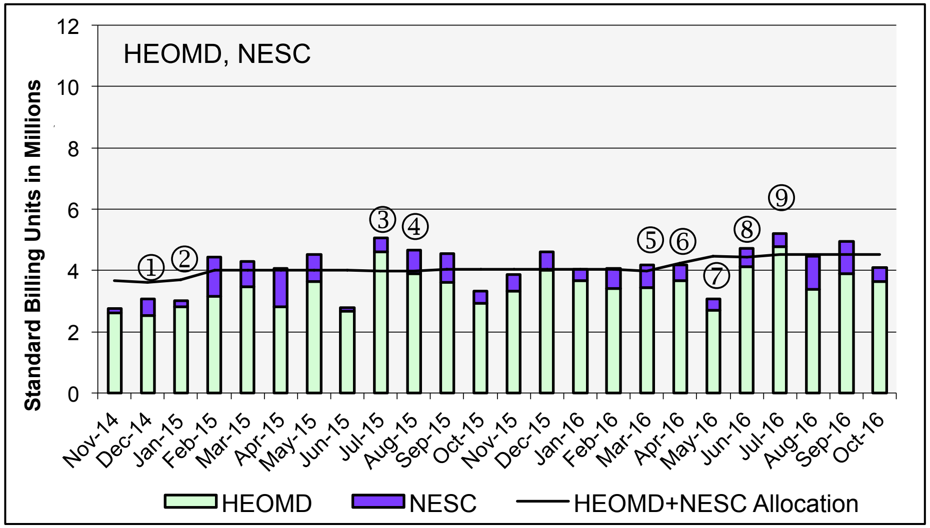
HECC Utilization Normalized to 30-Day Month



HECC Utilization Normalized to 30-Day Month

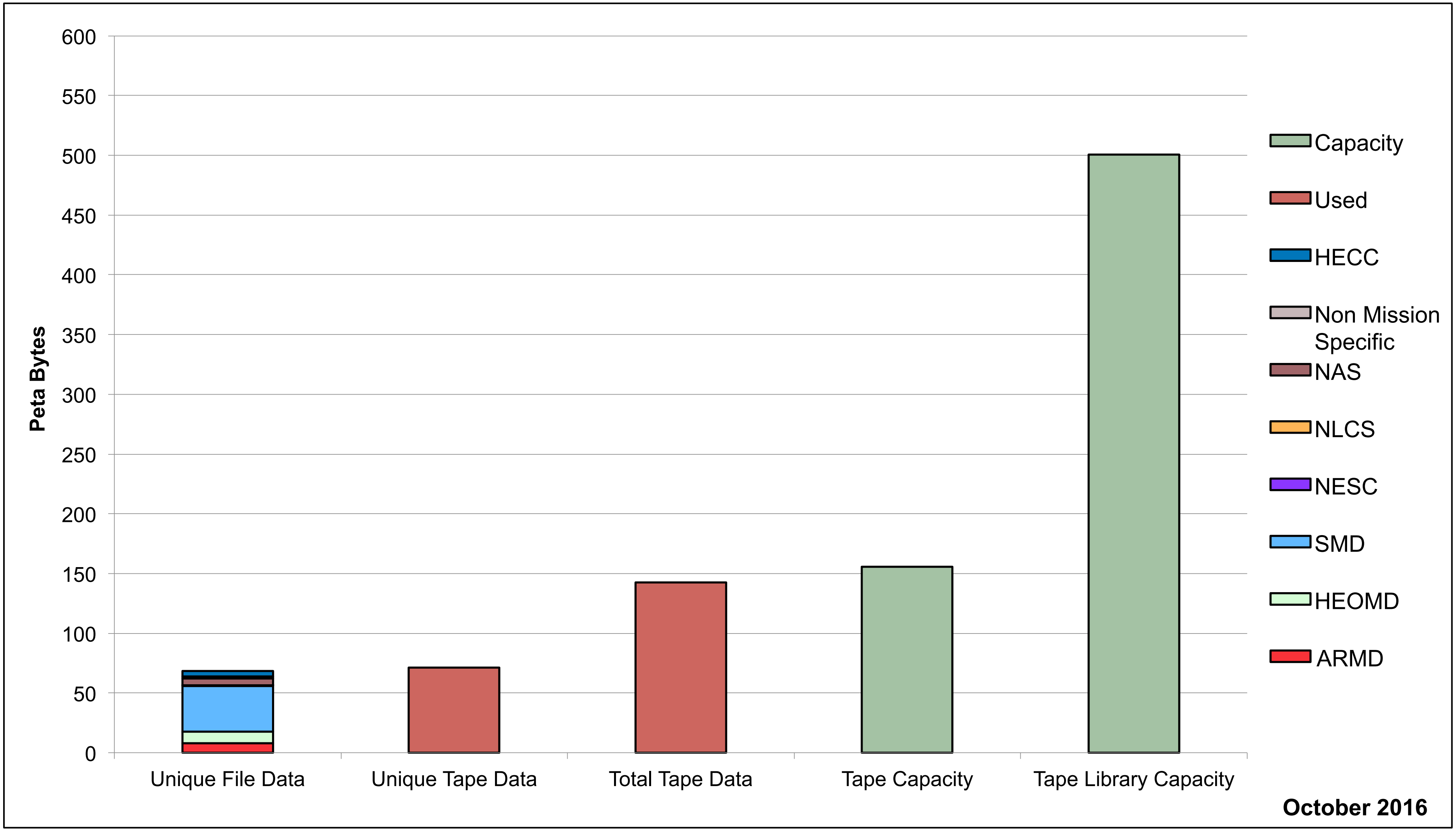






① 16 Westmere racks retired from Pleiades
② 14 Haswell racks added to Pleiades
③ 7 Nehalem ½ racks retired from Merope
④ 7 Westmere ½ racks added to Pleiades
⑤ 16 Westmere racks retired from Pleiades
⑥ 10 Broadwell racks added to Pleiades
⑦ 4 Broadwell racks added to Pleiades
⑧ 14 (all) Westmere racks retired from Pleiades
⑨ 14 Broadwell racks added to Pleiades (10.5 Dedicated to ARMD)

Tape Archive Status



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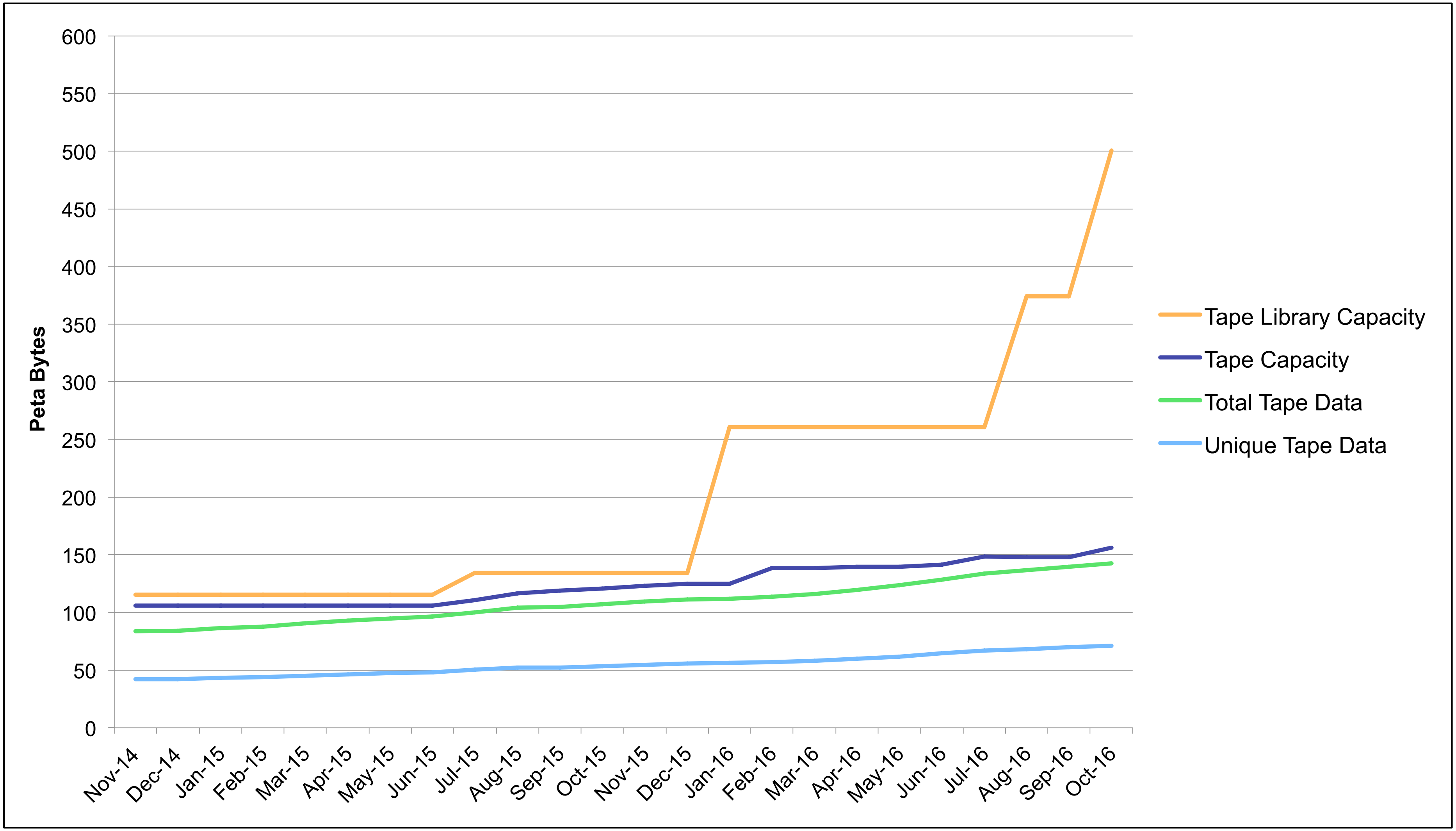
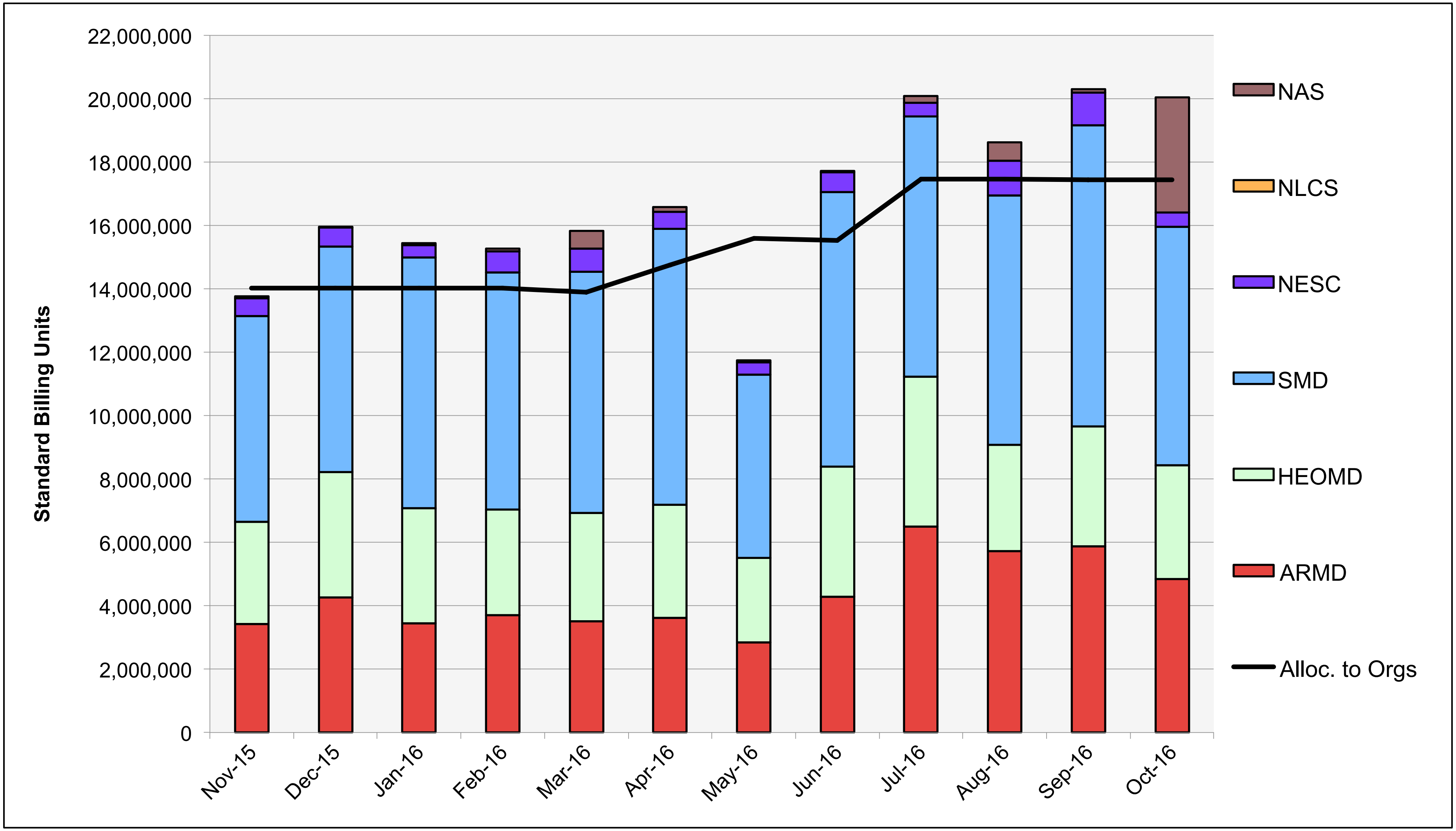
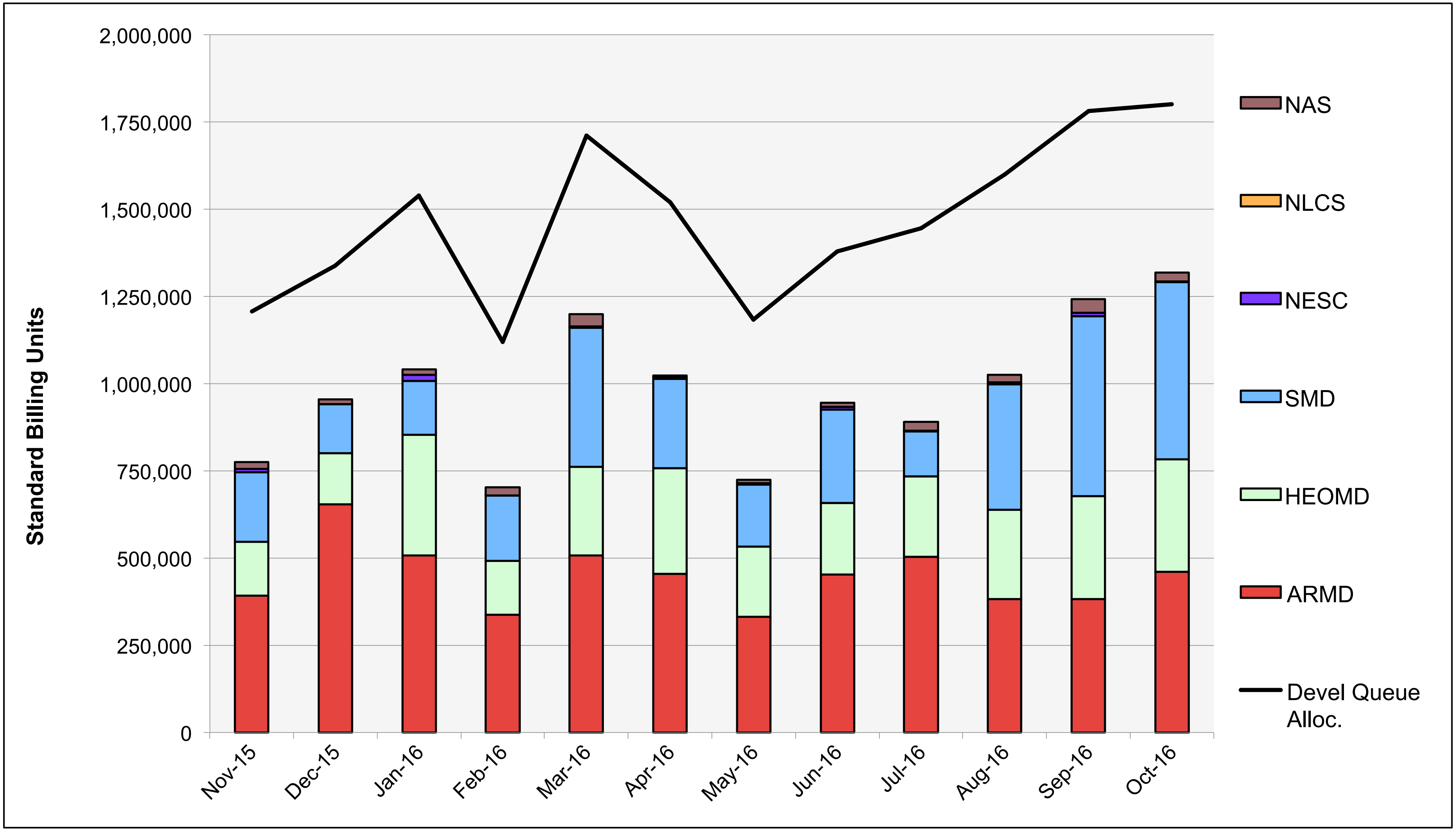


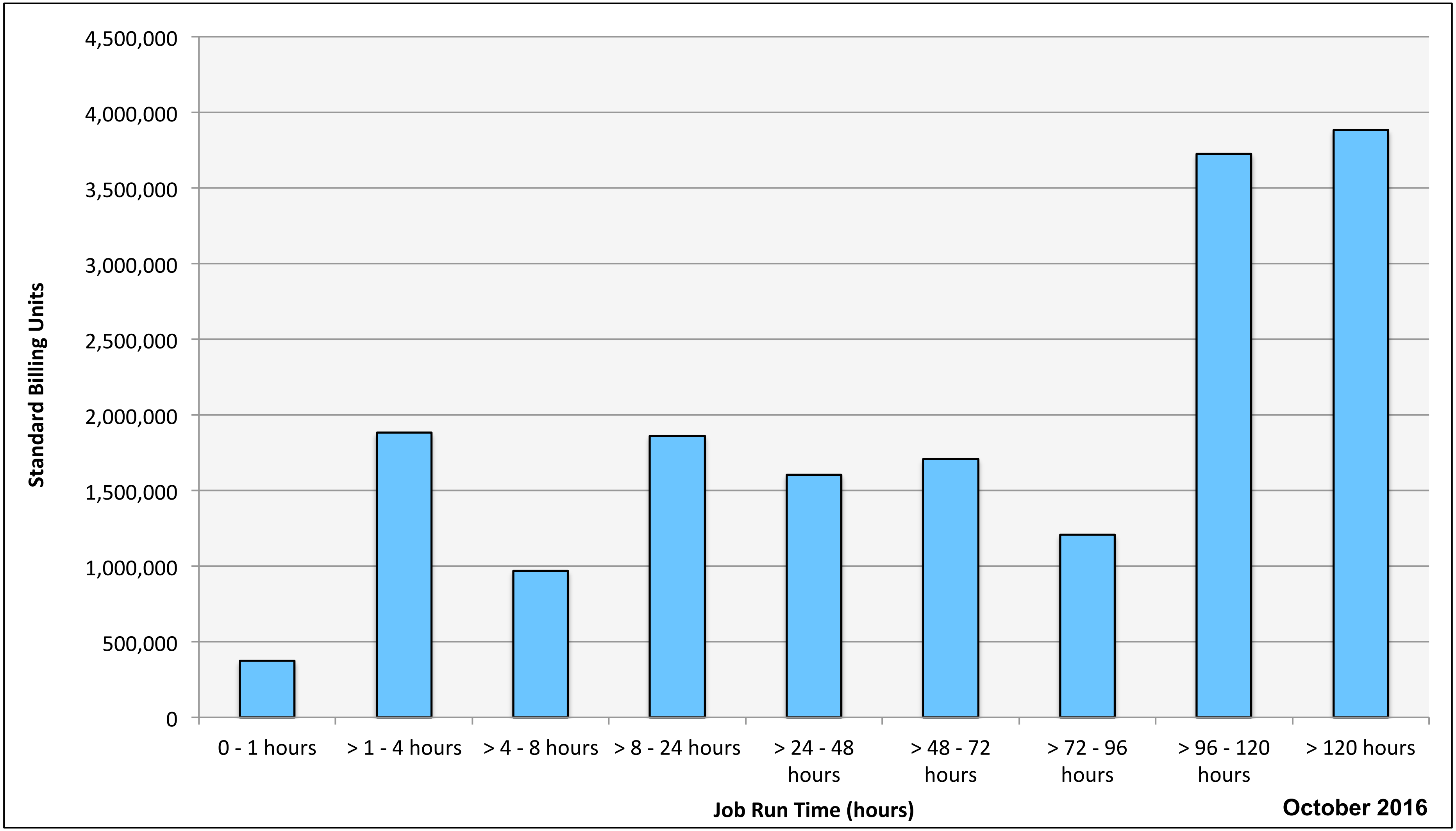
Pleiades: SBUs Reported, Normalized to 30-Day Month



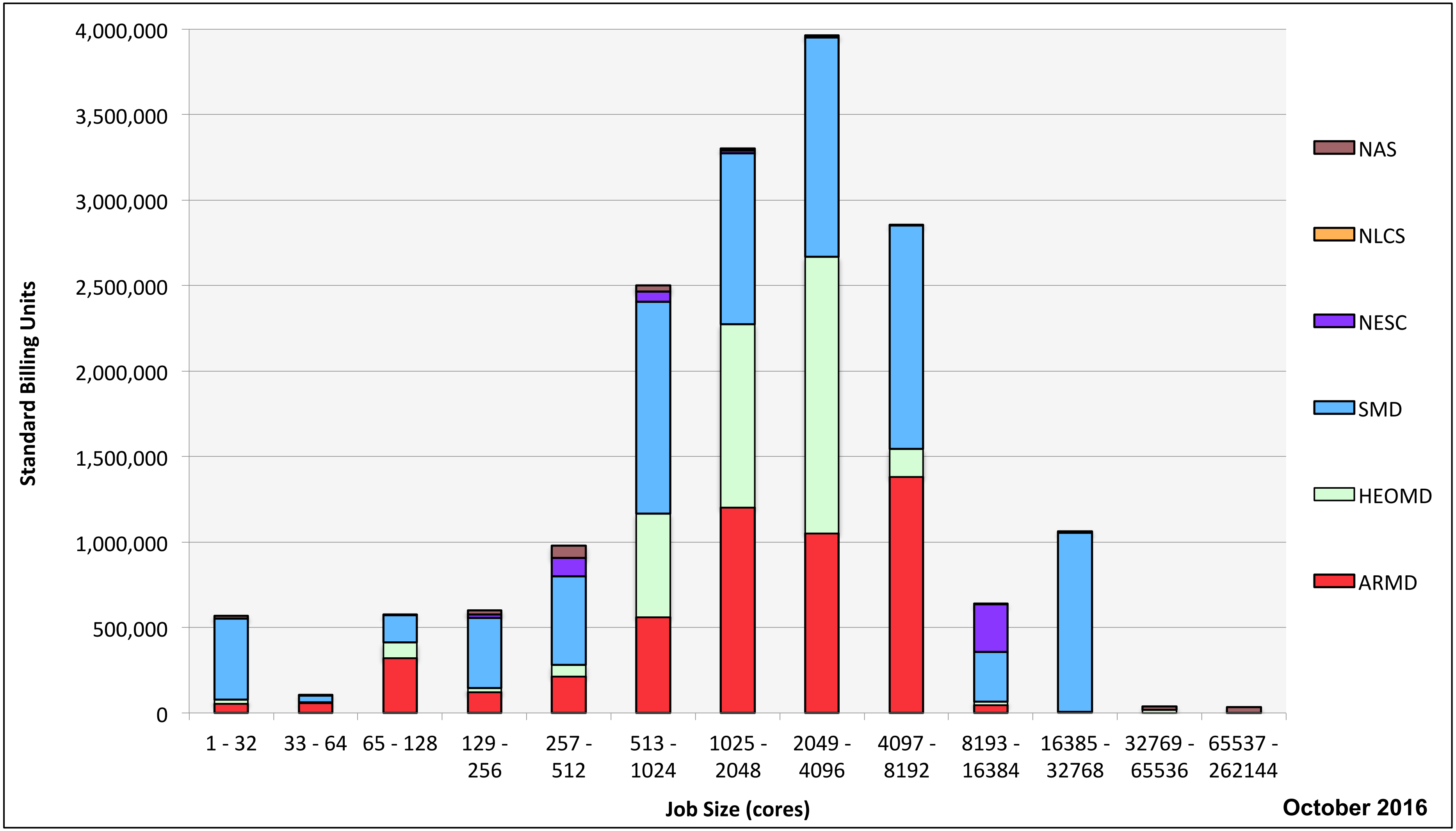
Pleiades:
Devel Queue Utilization



Pleiades:
Monthly Utilization by Job Length



Pleiades: Monthly Utilization by Size and Mission



Pleiades:
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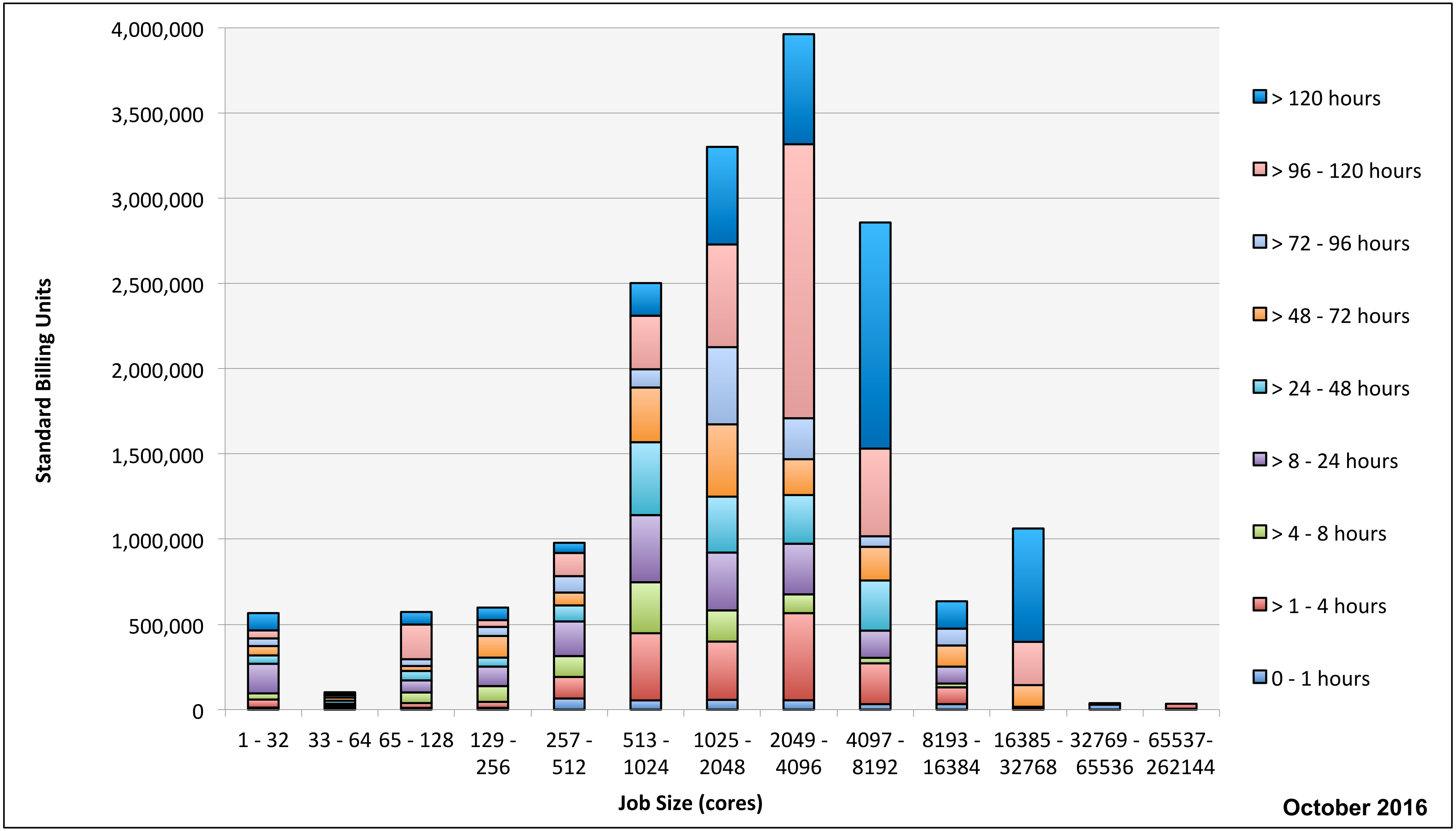
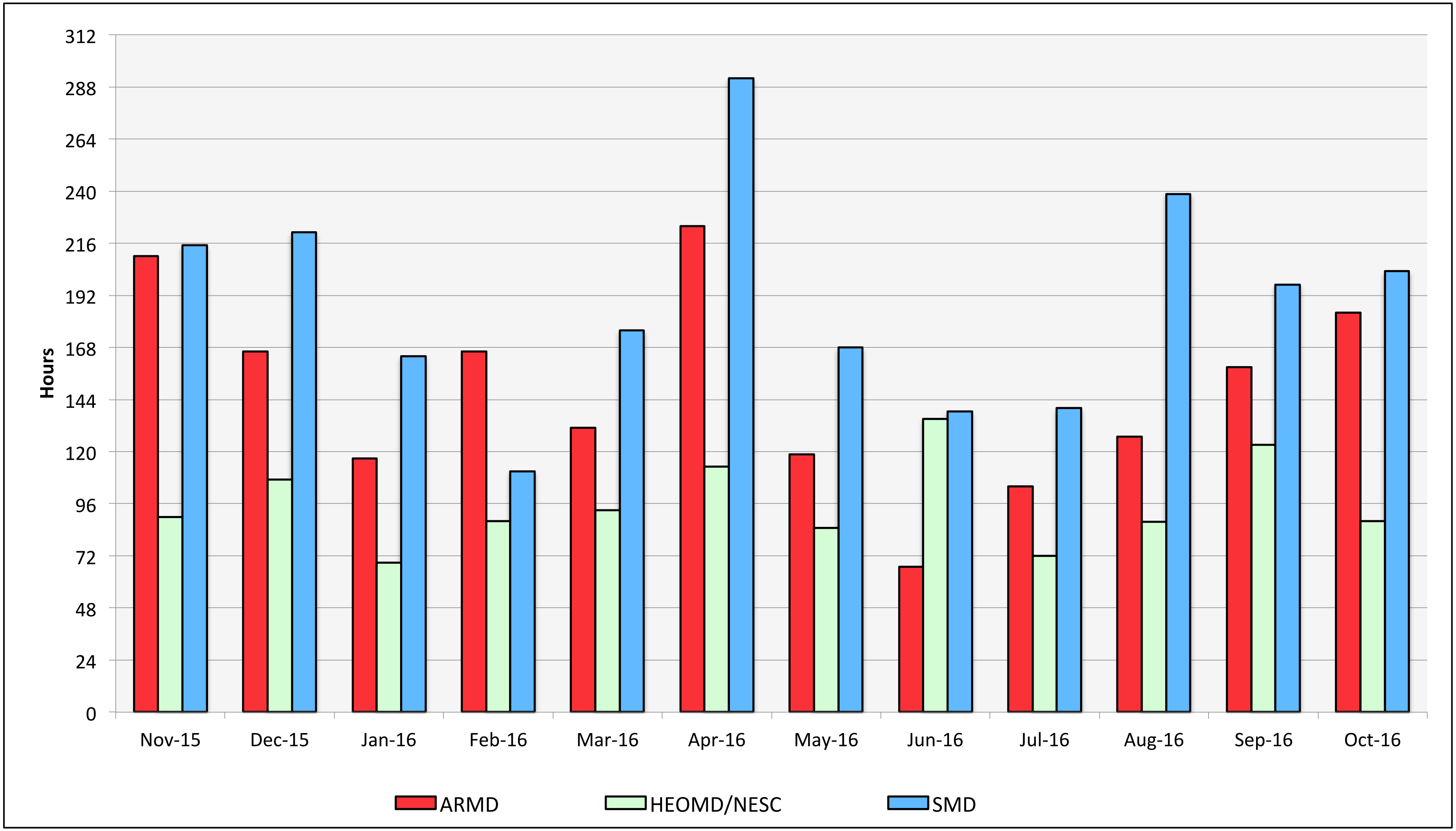
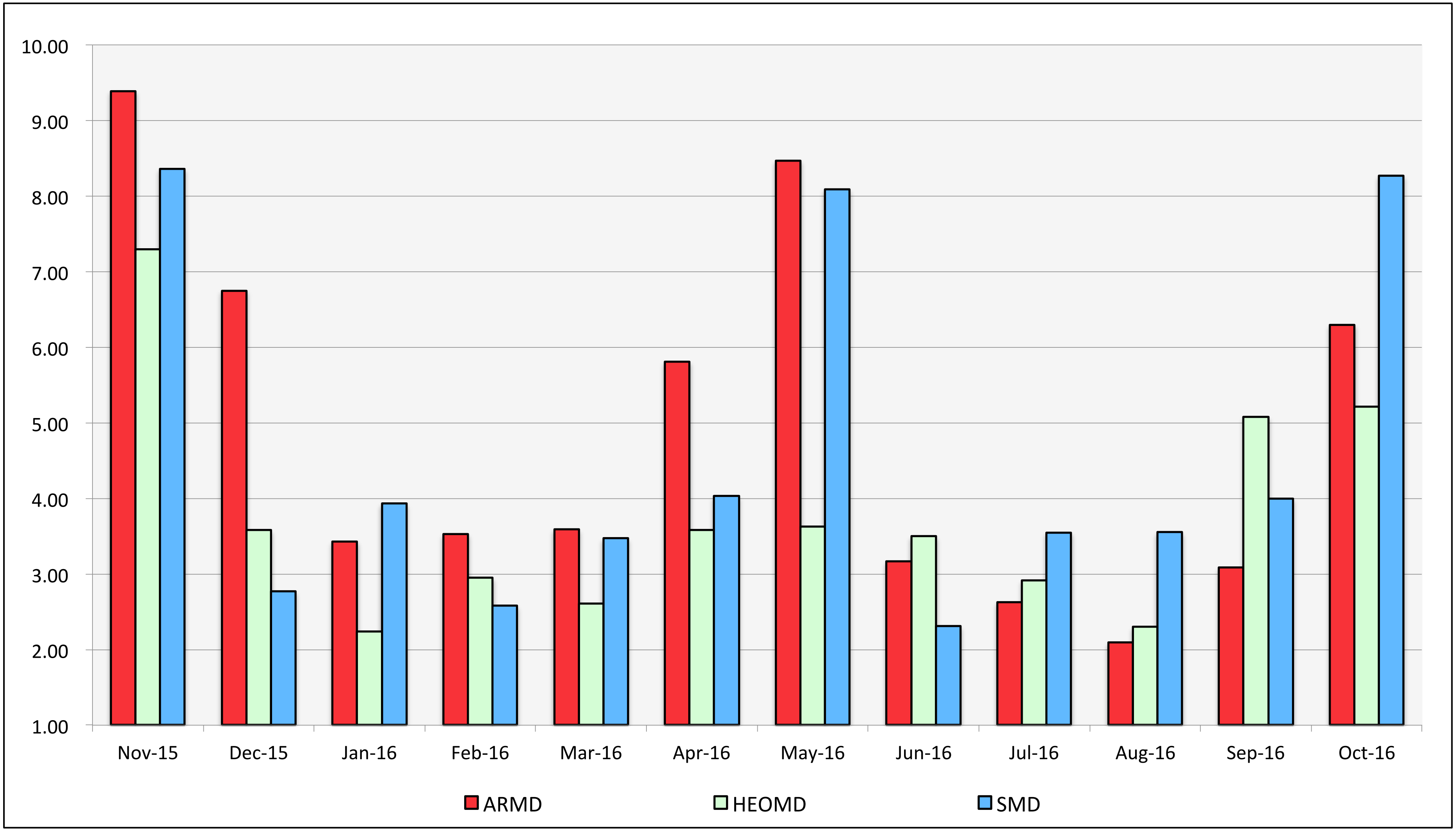


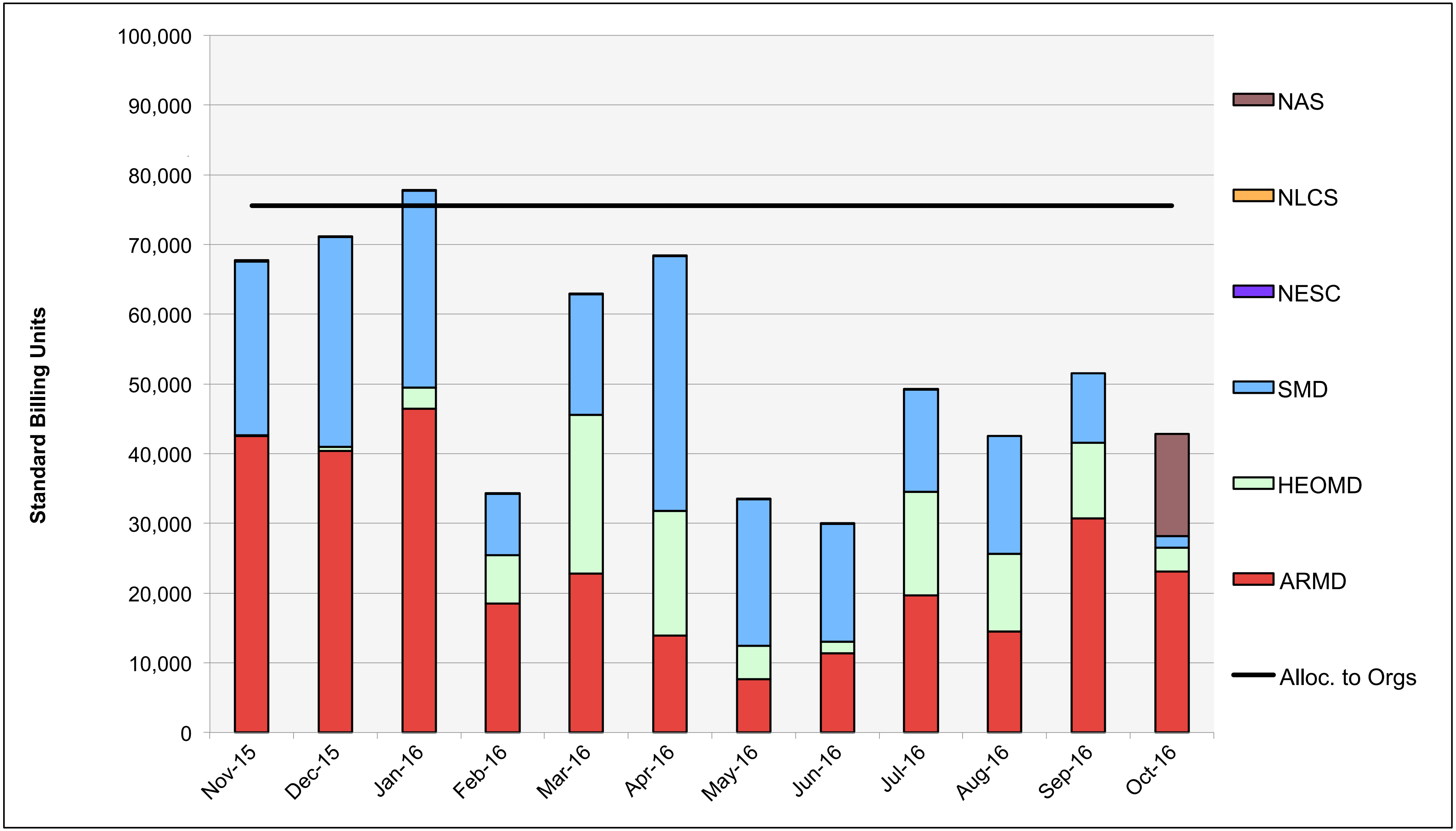
Pleiades: Average Time to Clear All Jobs



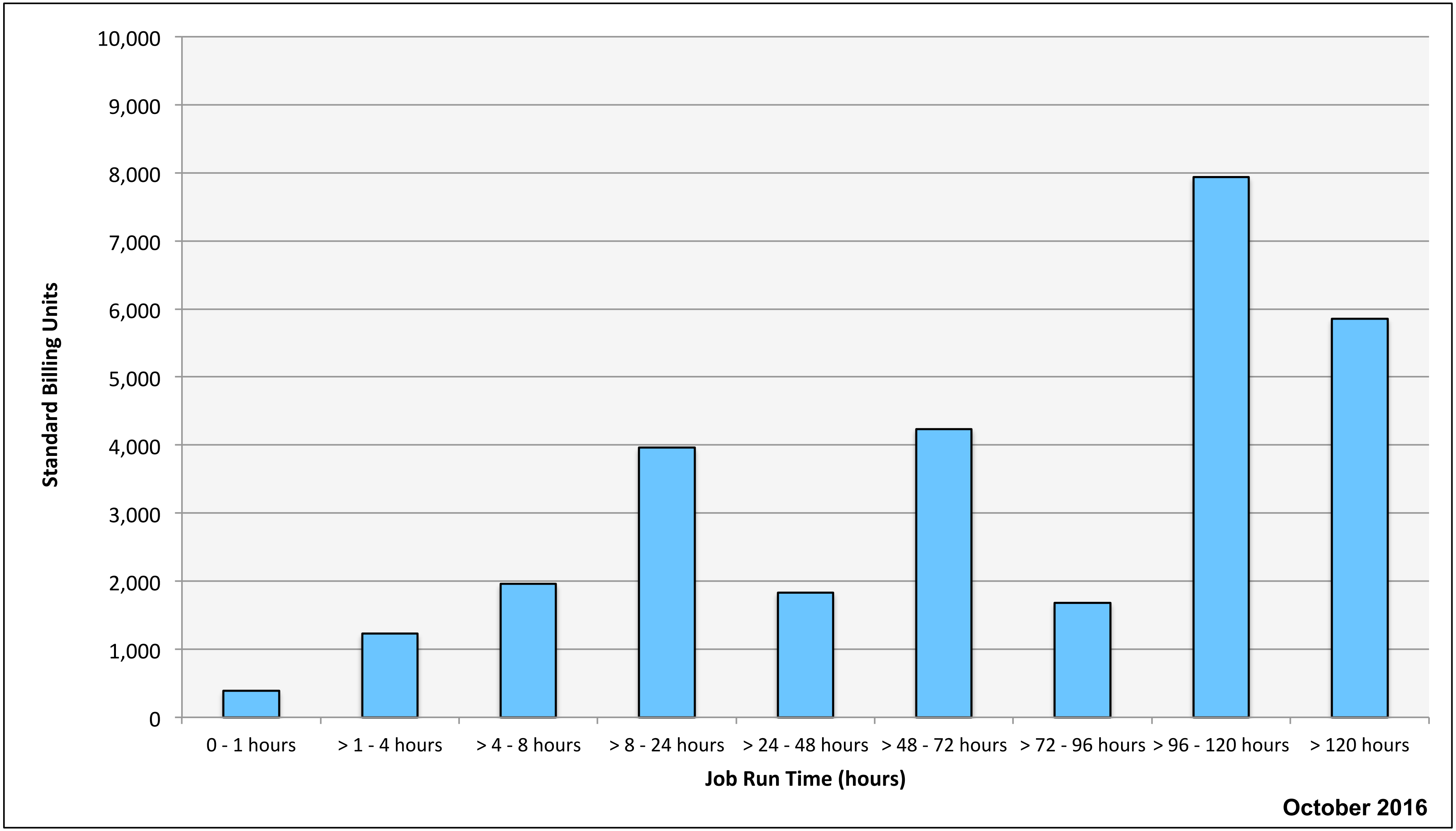
Pleiades: Average Expansion Factor



Endeavour: SBUs Reported, Normalized to 30-Day Month



Endeavour: Monthly Utilization by Job Length



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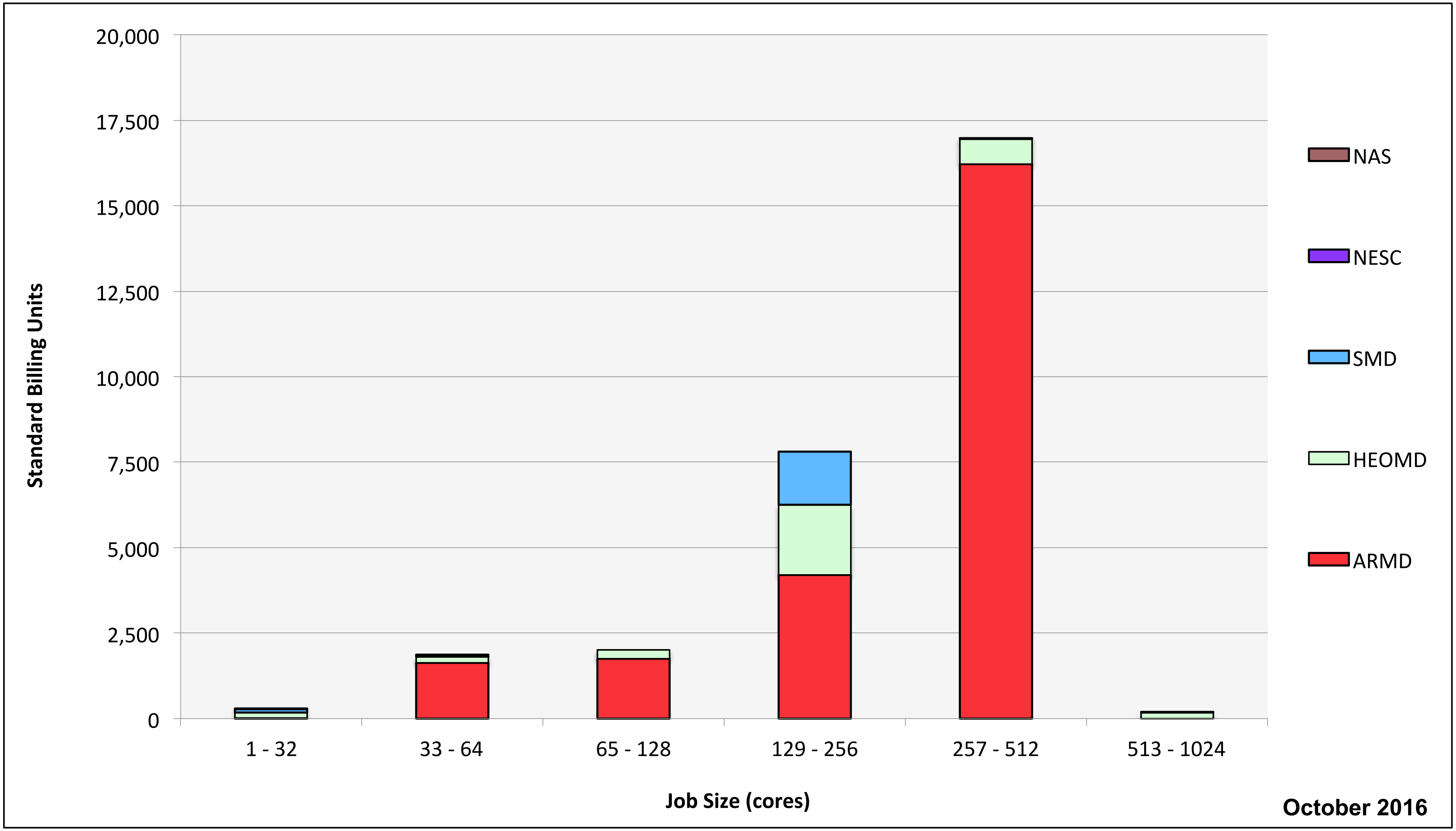
Monthly Utilization by Size and Mission



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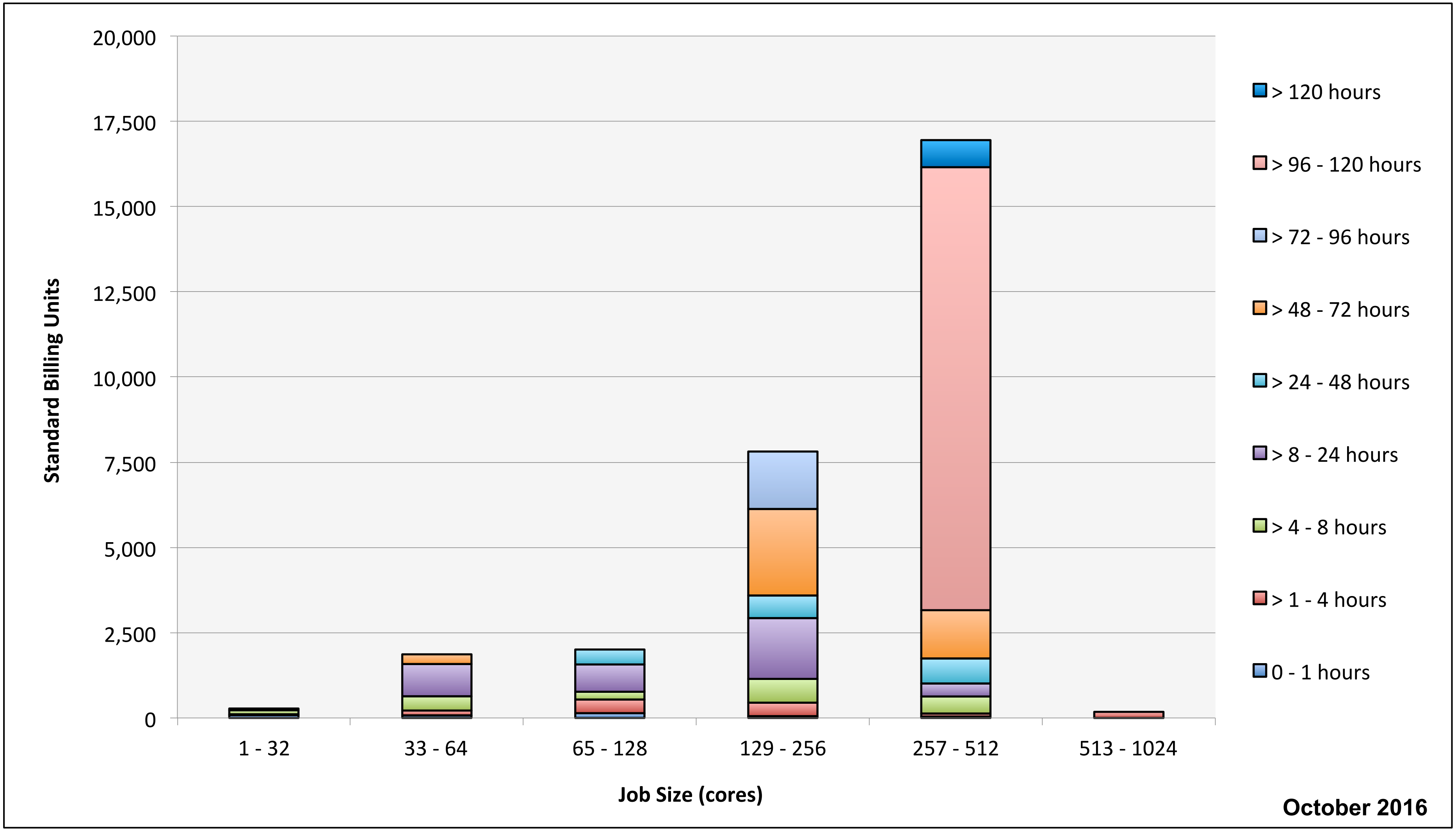
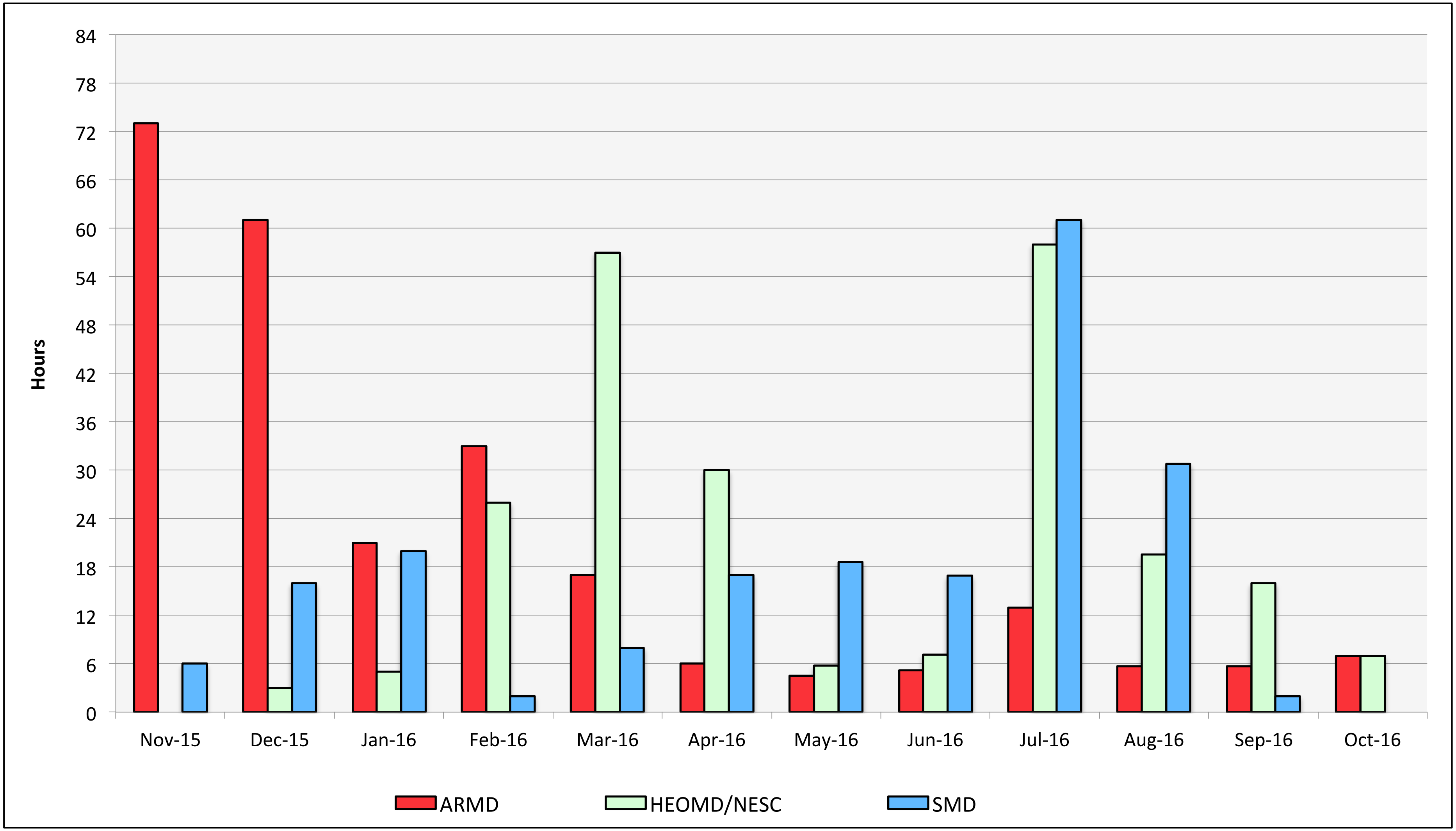
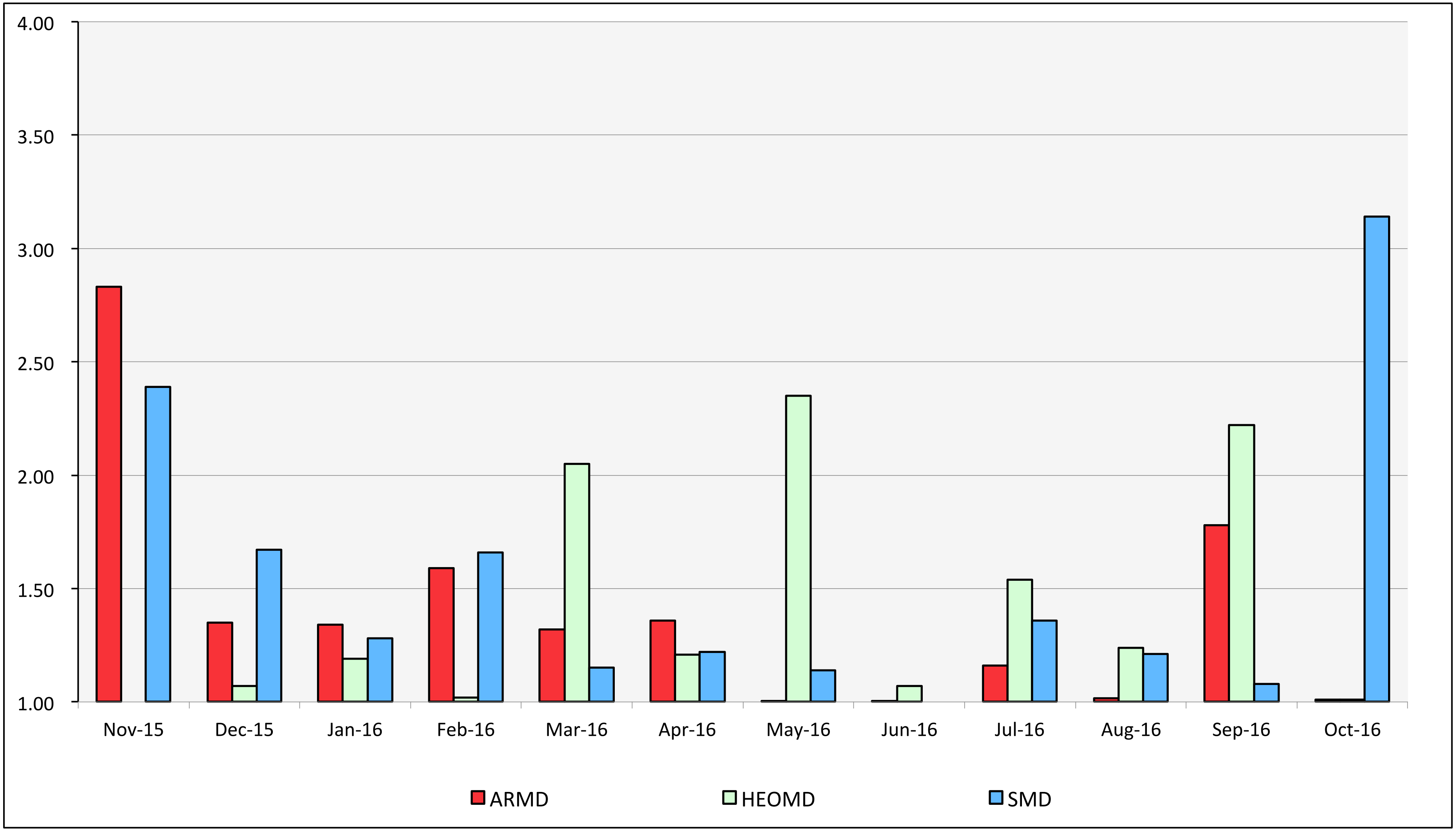


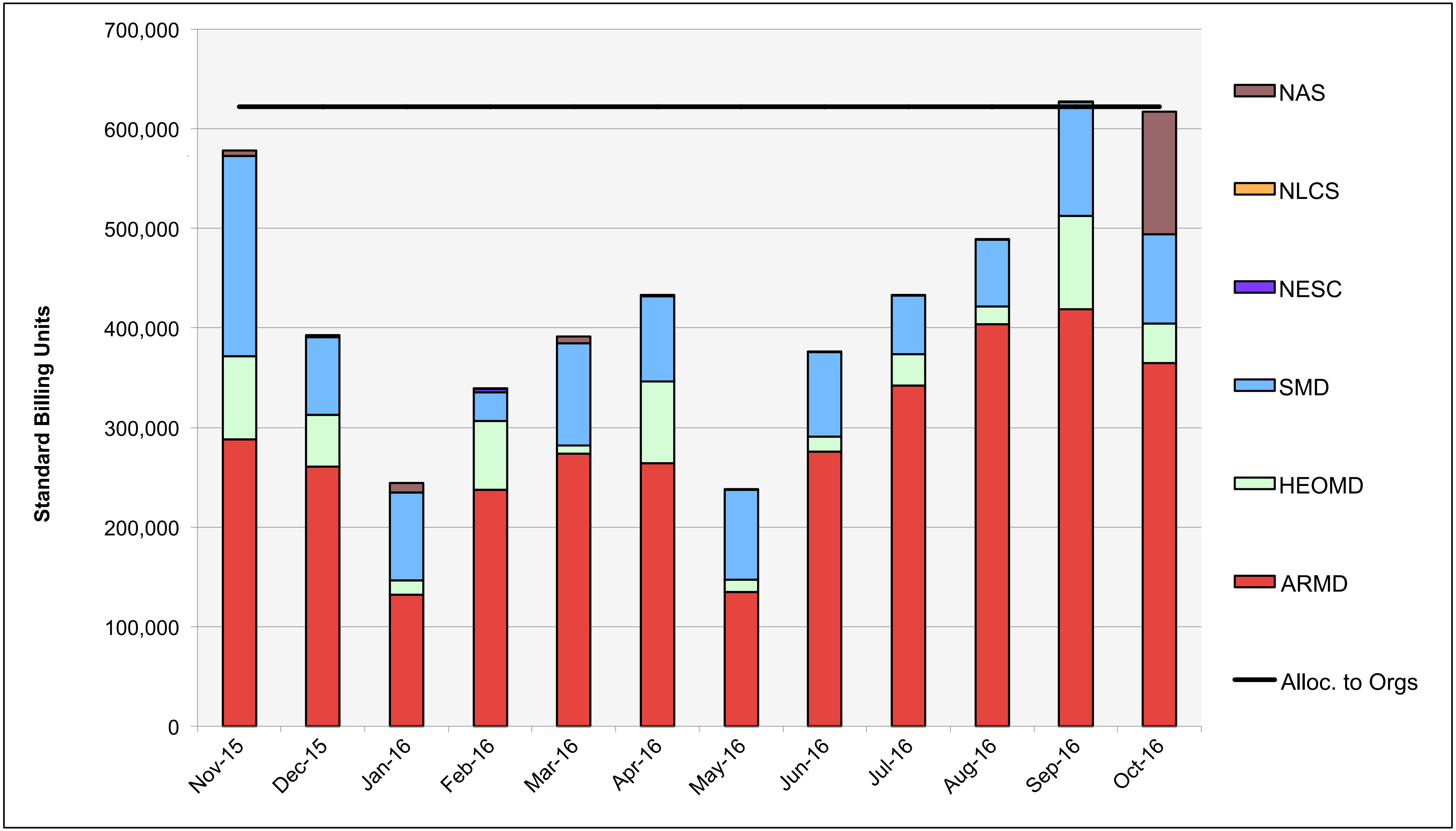
Endeavour:
Average Time to Clear All Jobs



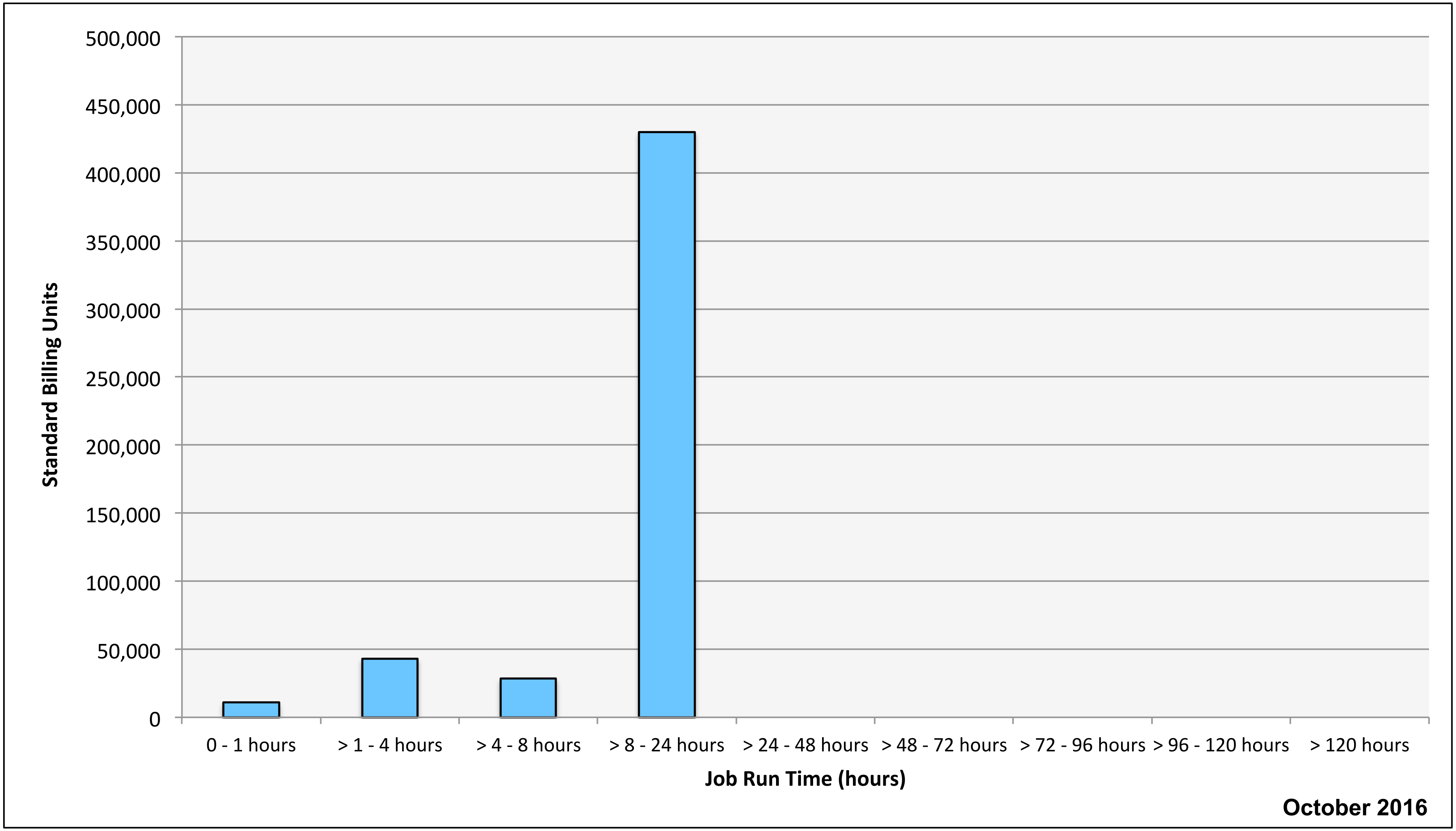
Endeavour: Average Expansion Factor



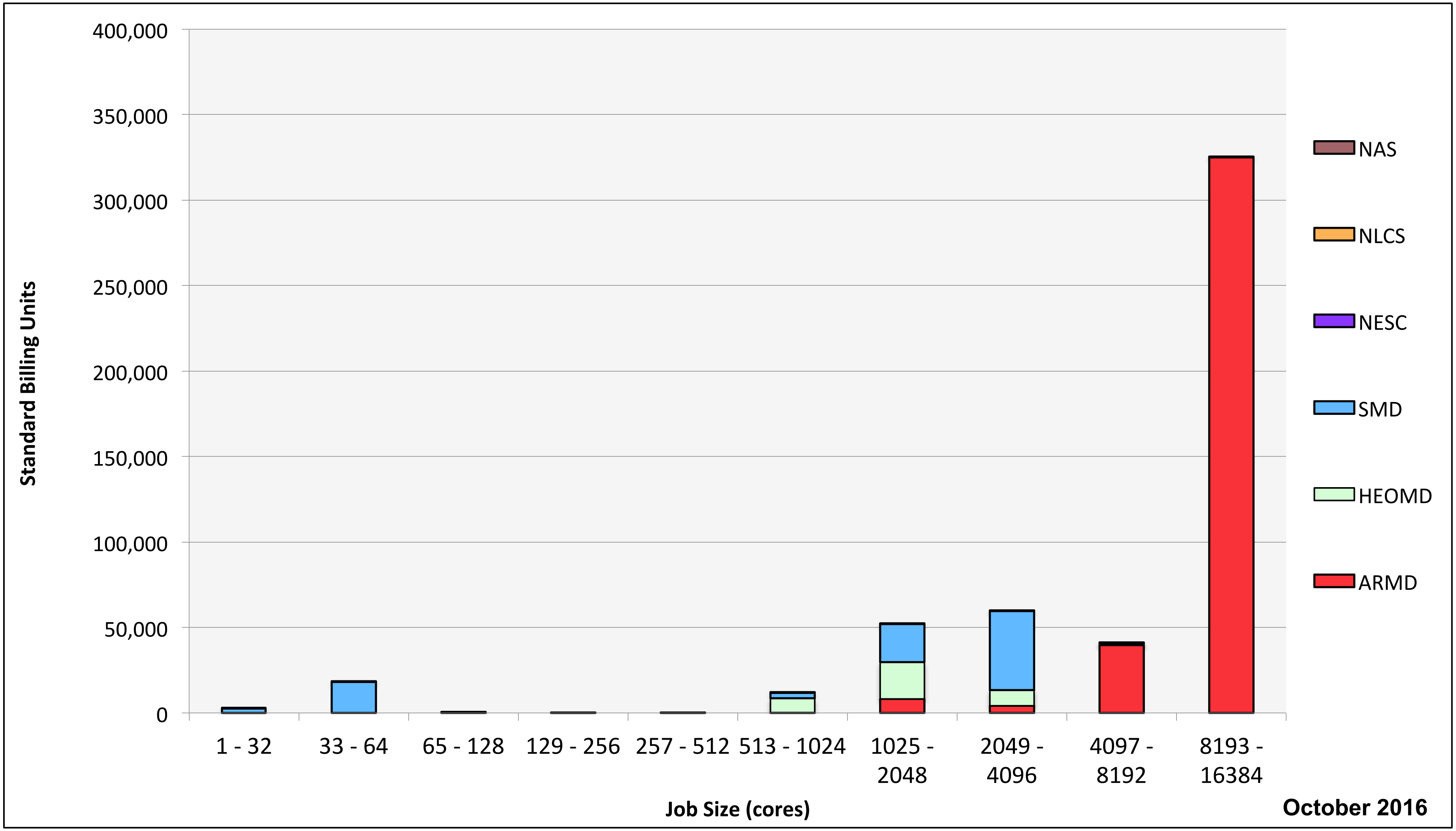
Merope:
SBUs Reported, Normalized to 30-Day Month



Merope:
Monthly Utilization by Job Length



Merope:
Monthly Utilization by Size and Mission



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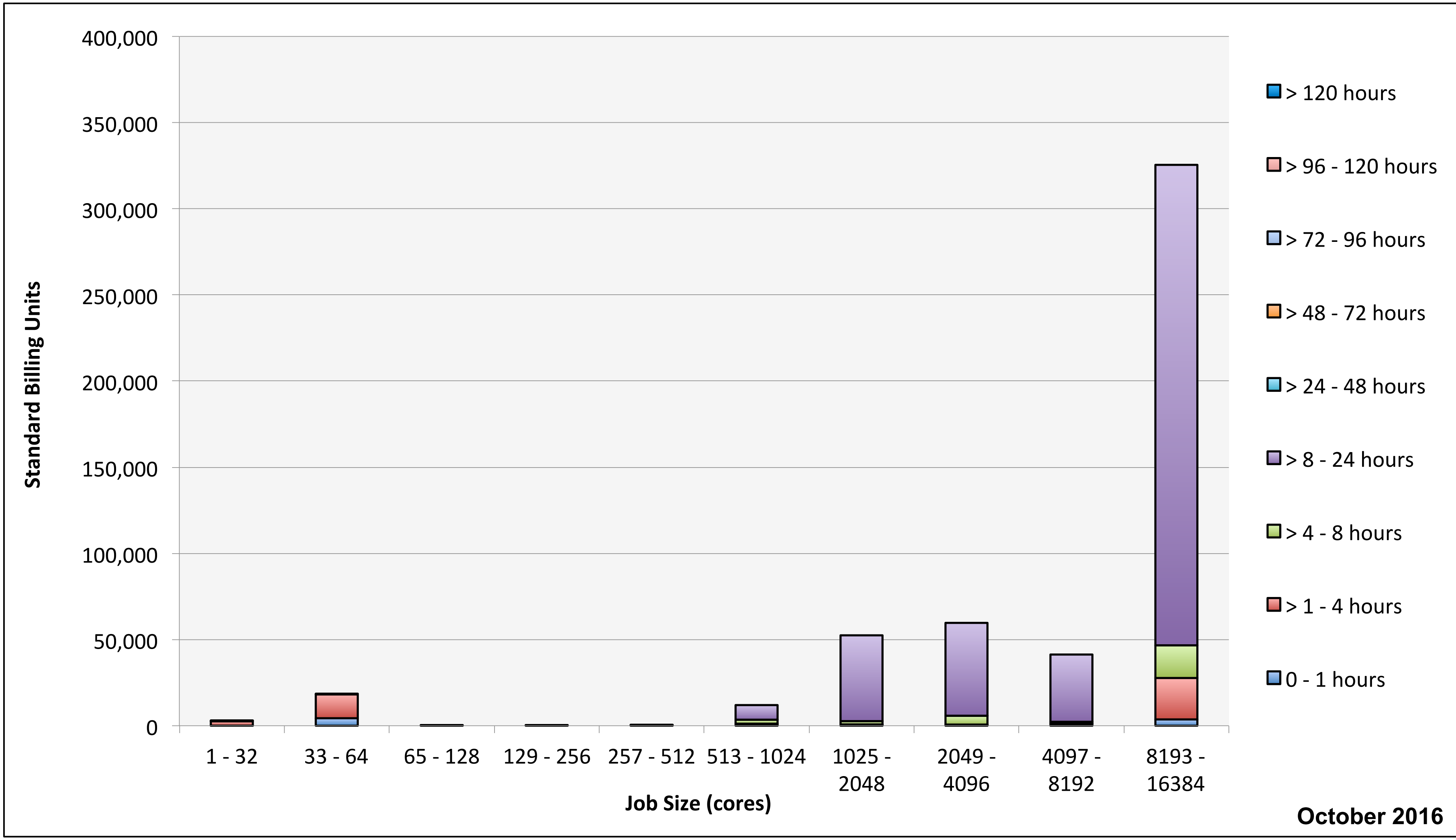

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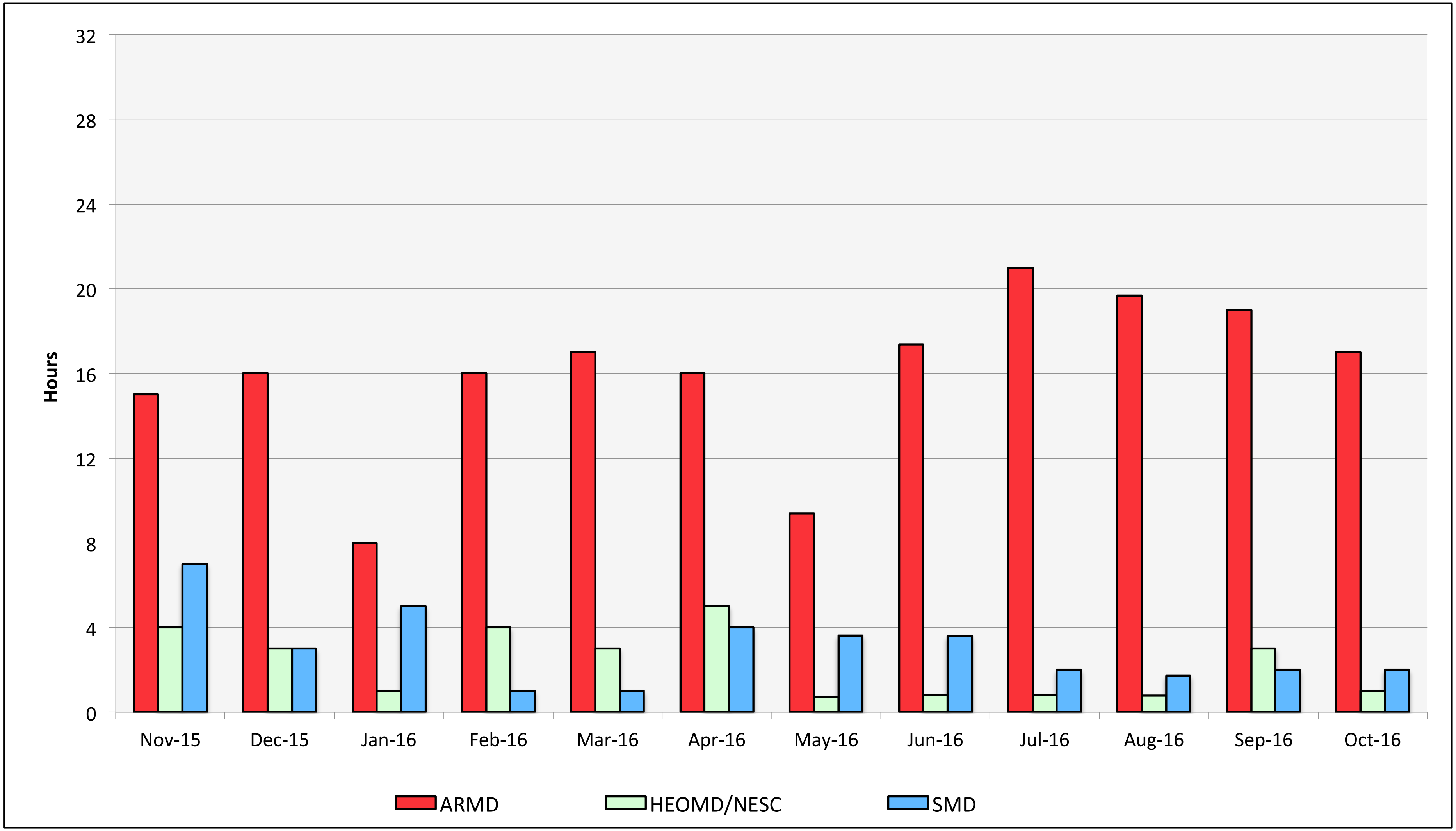

Merope:
Average Expansion Factor