Project Status Report

High End Computing Capability
Strategic Capabilities Assets Program

January 10, 2017

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Users Get New Year's Present—Electra is Ready for Production January 1, 2017

- On December 31, Electra passed early-access user testing and was declared ready to go into production on January 1, 2017.
- The 1.2-petaflop Electra system (#96 on the TOP500 list of the world's most powerful supercomputers) provides NASA scientists and engineers a 15% increase in HECC resources.
- Earlier in the month, HECC supercomputer systems analysts and facilities engineers completed their testing of both Electra and the Modular Supercomputing Facility that houses the system.
- Then, other HECC staff ran benchmarks and performed extensive input/output testing to assure the system was ready for about 30 volunteer users to "kick the tires."
- Early-access testing by users was successful, and HECC staff pronounced Electra ready for general use at the beginning of the new year.

Mission Impact: More computer power provides mission directorates with more resources for the accomplishment of their goals and objectives.

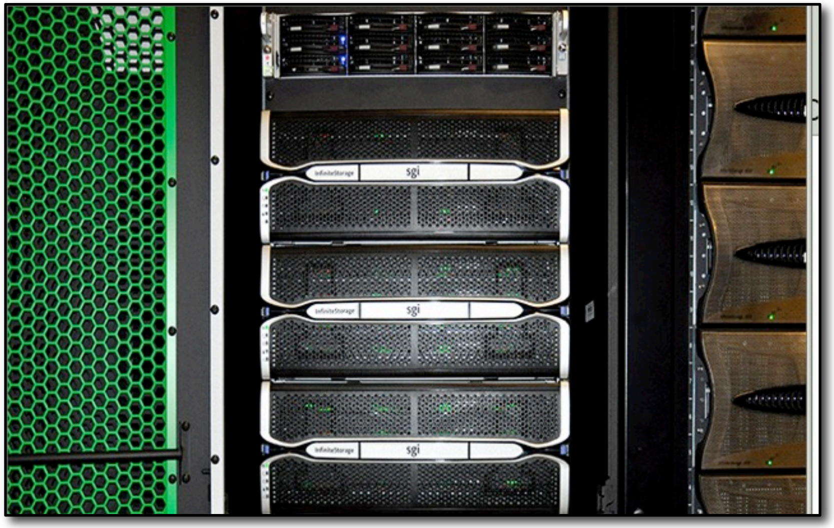
Interior of the Modular Supercomputer Facility (located adjacent to the main NAS facility) with racks of Electra on the left and fans and the monitoring station on the right. Electra has 16 Broadwell racks, each containing 72 nodes of two, 14-core E5-2680v4 (2.4 GHz) processor chips and 128 GB of memory. Electra will provide an additional 30 million Standard Billing Units (SBUs) per year, where one SBU is equivalent to an hour of a 12-core Westmere node.

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

Systems Team Augments and Deploys NASA Earth Exchange NFS Server Capacity

- HECC systems engineers recently installed and configured a new 1.2-petabyte (PB) NASA Earth Exchange (NEX) server that increased storage capacity by 900 terabytes (TB). This represents a nearly 50% increase in capacity for NEX.
- The increased capacity enables NEX researchers to store larger Earth science datasets that are accessible for processing on NEX and HECC supercomputing resources. The datasets include:
  - Moderate Resolution Imaging Spectrometer (MODIS) Collection 6
  - LandSat Collection 1
  - Visible Infrared Imaging Radiometer Suite
- Using the HECC-developed tool, Shift, the NEX team is migrating data from a soon-to-be-retired 350-TB filesystem, which will save money spent on support. The transition will be completed within a month.

Mission Impact: Increasing storage for the NASA Earth Exchange enables researchers to conduct larger and more complex data analysis projects.



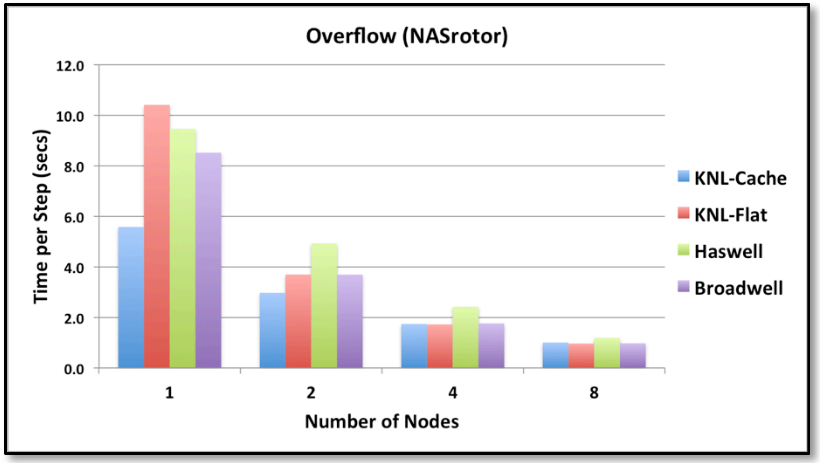
The new NEX filesystem built from an SGI Infinite Storage server comprises a half-rack of equipment.

POCs: Bob Ciotti, bob.ciotti@nasa.gov, (650) 604-4408, NASA Advanced Supercomputing (NAS) Division;
Jeff Becker, jeffrey.c.becker@nasa.gov, (650) 604-4645, NAS Division, CSRA LLC

HECC Conducts Knights Landing Cluster Testing with Micro-Benchmarks and Applications

- HECC staff conducted an initial evaluation of our 20-node SGI cluster based on Intel Knights Landing (KNL) processors connected with the Intel Omni-Path fabric. They evaluated system usability and multi-node performance under different memory configurations using selected micro-benchmarks and NASA applications.
- Highlights from the initial tests include:
  - System usability and the application porting process improved significantly over KNL's predecessor.
  - With minimal changes, the hybrid OVERFLOW code performed 40% better on a KNL node than on a Haswell node, and scaled reasonably well up to 16 nodes.
  - The unstructured FUN3D code still performed 20–50% better on Xeon nodes than on KNL nodes.
  - The multi-zone NAS Parallel Benchmarks performed 10–20% better on Xeons compared to KNLs.
  - From the Ohio Statue University benchmarks, the MPI collective performance on KNL/Omni-Path is about 50% worse than on Haswell/InfiniBand.
- The cluster is now open to ~35 interested users for more application tests. HECC will get feedback on their experience in mid-January 2017 and plans to have deep-dive optimization training for staff and users in February in coordination with Intel.

Mission Impact: Early valuation of new technologies is critically important for NASA's acquisition of high-end computing systems with next-generation processors.



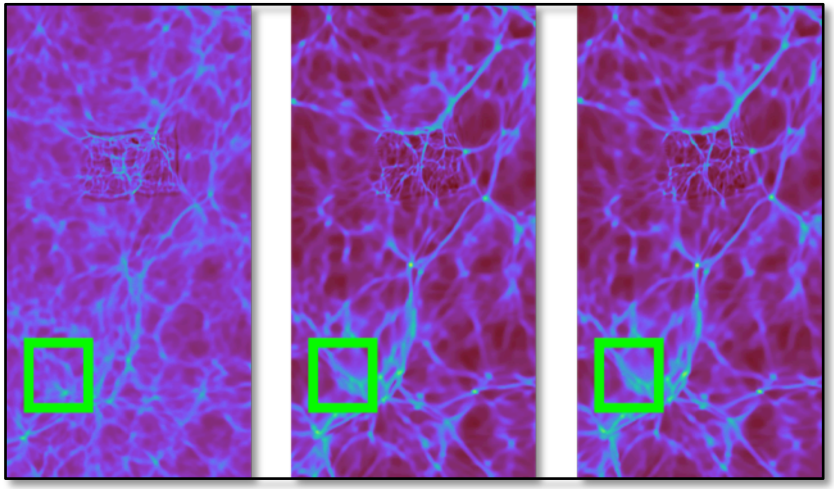
Performance of NASA's OVERFLOW code on the Intel Knights Landing (KNL) cluster in two memory configurations, compared to performance on Intel Xeon Haswell and Broadwell nodes for the NAS rotor (91 million grid points) test case that represents a realistic workload. A single KNL node in Cache mode outperformed a Haswell node by 40%; however, the code showed better scaling on the Haswell and Broadwell nodes.

POCs: Henry Jin, haoqiang.jin@nasa.gov, (650) 604-0165, NASA Advanced Supercomputing (NAS) Division; Bob Hood, robert.hood@nasa.gov, (650) 604-0740, NAS Division, CSRA LLC

APP Team Updates Enzo Application in Benchmark Suite

- As part of an effort to improve the benchmarks used to establish the System Billing Unit (SBU), HECC's Application Performance and Productivity (APP) team recently updated the Enzo application.
- Major updates to the Enzo benchmark include:
  - Used an up-to-date version of the Enzo code and a user-provided input dataset based on production run.
  - Employed the Enzo restart mechanism to capture the steady-state of the execution.
  - Added a validation step based on image-processing techniques. At the suggestion of the HECC Visualization team, this step calculates the Peak Signal-to-Noise Ratio (PNSR) of two images to quantify the distortion between them. A low PSNR value indicates a high distortion. If the PNSR calculated for an image from a test run and a reference image meets the minimum threshold, then the test run is deemed to be valid.
- The APP team plans to collaborate with HECC users of Enzo to optimize the code and refine the validation process.
- In addition to Enzo, the team updated 4 of the other 5 benchmarks in the SBU suite and is working with NCCS to update the GEOS-5 benchmark. When complete, the new suite will be used to establish new SBU rates for HECC compute resources.

Mission Impact: The last update of the HECC SBU benchmark occurred in 2011, based on Westmere processors. Updating the benchmark suite makes it more representative of the production workloads and state-of-art hardware.



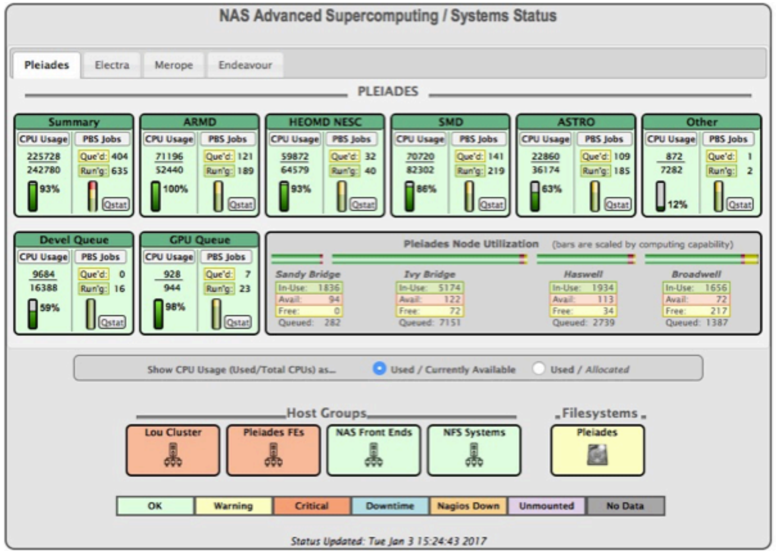
Left to right: z-slices of gas density at cycles, 200, 600, and 900, of an Enzo execution. Differences between cycle 200 (left) and 900 (right) are clearly visible. Differences between cycle 600 (middle) and cycle 900 are barely detectable to the human eye; an example area is marked by the green squares. The Peak Signal-to-Noise Ratio (PNSR) value will still detect these subtle differences and report values less than 30 decibels, which does not meet our validation threshold.

POCs: Gabriele Jost. gabriele.jost@nasa.gov, (650) 604-0468, NASA Advanced Supercomputing (NAS) Division, Supersmith; Robert Hood, robert.hood@nasa.gov, (650) 604-0740, NAS Division, CSRA LLC

Upgraded MiniHUD Enables Mission Directorate View of Real-Time Systems Status

- The web-based HECC system monitoring tool, “MiniHUD,” which provides a near-real-time view of compute resources by mission directorate, was re-implemented to provide a more intuitive interface.
- This new version enables the easy addition of new compute systems, such as Electra.
- Major features include metrics for HECC’s major compute systems:
  - Per-mission CPU usage and PBS data.
  - Extensive use of status colors and rollovers to drill down for more information.
  - Expanded display option for more system and mission status data at-a-glance.
  - Node usage data by model class.
  - Various server and front-end system suites and filesystems.
- The codebase was completely rewritten with modern web libraries and technologies, drastically improving maintenance, scalability, and feature addition.

Mission Impact: The upgraded web-based tool for near-real-time monitoring of HECC compute resources enables an at-a-glance view of system and job performance from a mission directorate perspective.



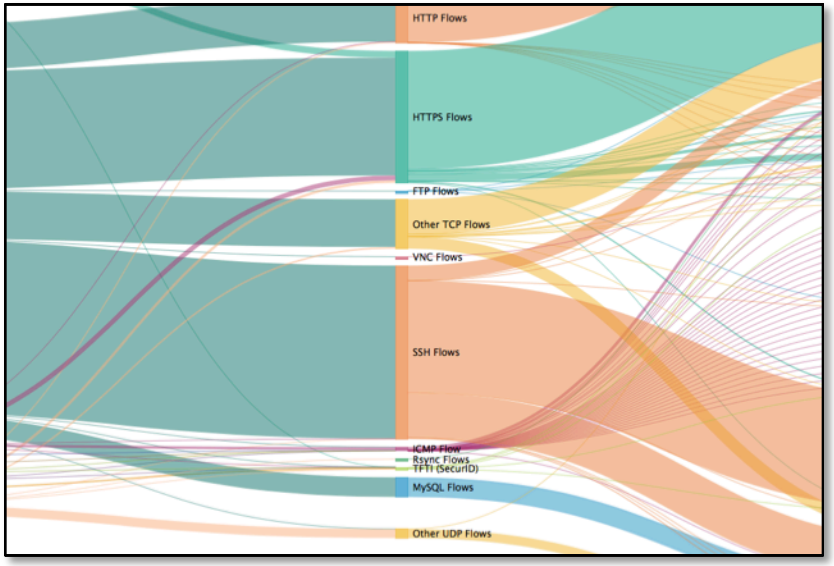
The new version of the HECC systems status page (called the MiniHUD) features a tabbed interface to access the major HECC compute systems, and shows a variety of color-coded system status data, mission directorate CPU usage, and PBS jobs data at-a-glance. Rollovers are used to show more detail. An expanded information display can be optionally launched.

POC: Glenn Deardorff, glenn.deardorff@nasa.gov, (650) 604-3169, NASA Advanced Supercomputing Division, SGT, Inc.

New Network Flow Visualization Tool Helps Analyze Potential Security Issues

- Millions of network flows cross the NAS network every day. To help rapidly analyze these flows, the HECC Security team created a network flow visualization tool to see potentially significant security issues.
- Network flows can be visualized by categories:
  - Internet protocols (ICMP, TCP, UDP, etc.)
  - Application protocols (HTTP, SSH, DNS, etc.)
  - Activity such as network flows to organizational email servers or unauthorized DNS traffic.
- Network flows can also be visualized by different source and destination types: country, organization, network, class or type of systems, and single IP addresses.
- Visualizing network flows allows for rapid analysis of network traffic and helps to detect:
  - Unauthorized network traffic
  - Unusual network activity
  - Better insights into network usage
- Future work on the network flow visualization tool includes extending the categories, drilldowns, and additional filtering.

Mission Impact: The HECC-developed Network Flow Visualization tool allows security analysts to quickly visualize network activity that may identify anomalous, malicious, and/or suspicious behavior.



The HECC-developed Network Flow Visualization tool visualizes network flows based on flow type, such as application protocols (shown here), as well as internet protocols and other network activities.

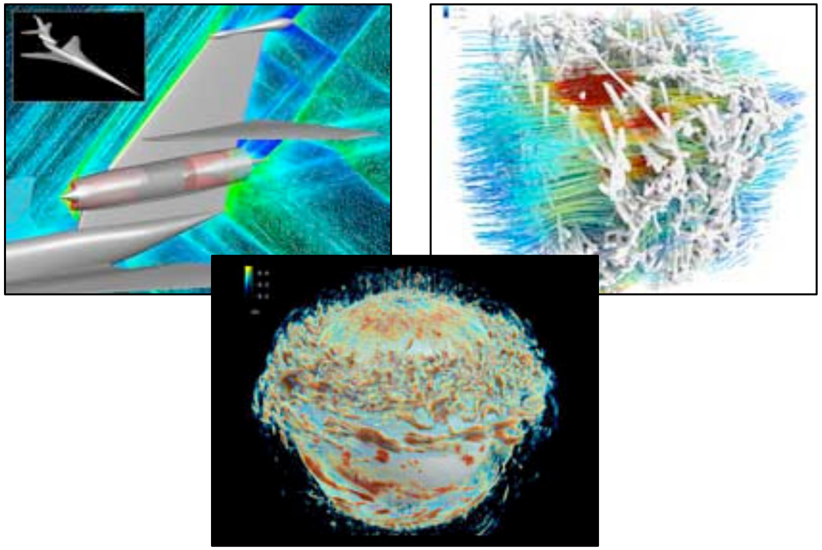
POC: Derek G. Shaw, derek.g.shaw@nasa.gov, (650) 604-4229, NASA Advanced Supercomputing Division, CSRA LLC

December 2016 Computer Usage on Pleiades Sets New Record of 21.7 Million SBUs

- December usage on the Pleiades supercomputer set a new record. Over 21.7 million Standard Billing Units (SBUs*) were used by NASA's science and engineering organizations, exceeding by about a million SBUs the previous records of 20.67 million SBUs set in November (normalized 30-day month) and 20.75 set in July 2016 (31-day month).
- This increase was enabled by high demand, system stability, and efficient operations that delivered system utilization of almost 90% (where 75% utilization is the target).
- Over 320 projects from all across NASA used time on Pleiades during December.
- The top 10 projects used from 458,852 to 1,839,723 SBUs each and together accounted for over 41% of total usage.
- The HECC Project continues to plan and evaluate ways to address the future requirements of NASA's users.

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

Mission Impact: Increasing Pleiades' capacity and improving its stability and operations provide mission directorates with more resources for the accomplishment of their goals and objectives.



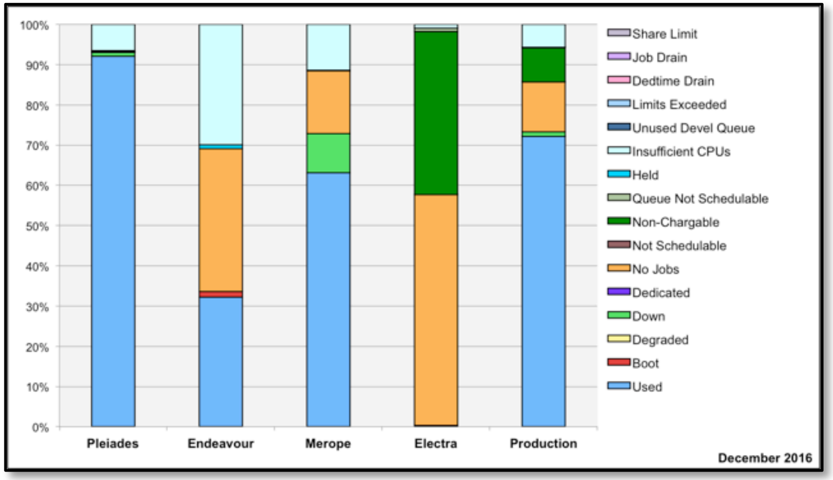
Images representing projects on Pleiades from different Mission Directorates. Clockwise from top left: Adjoint-based adaptation for a supersonic internal/external flow over a low-boom demonstrator aircraft configuration, *C. Heath, NASA/Glenn.* Velocity streamlines for the flow of argon through a sample rendering of virgin FiberForm, *A. Borner, NASA/ Ames.* The magnitude of the magnetic field being stored in the solar interior and its emergence onto the sun's surface, A. Stejko and A.Kosovichev, *New Jersey Institute of Technology.*

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

Electra System Accounting Added to HECC Monthly Status Reports

- The HECC Tools team updated the monthly status reports to add the new Electra system (see slide 2).
- With new improvements in the reporting programs and processes, adding Electra to the reports took only three weeks, down from 2.5 months for Merope. The programming work includes:
  - Added processor type and capacity to reports-api, which is used by other reporting scripts.
  - Added Electra Broadwell nodes and SBU information into the accounting database fields and views.
  - Added Electra Broadwell information to PBS utilization scripts and parsing programs that upload the data to the database.
  - Updated 3 MicroStrategy tables, 30 metrics, and 20 reports to reflect Electra data.
  - Updated 25 filters, 8 grids, and numerous scripts used for reporting queries.
- The team continues to automate accounting scripts and programs to the extent possible.

Mission Impact: HECC accounting reports and scripts are used to illustrate the usage, backlog, and allocation of resources and help to identify where changes and efficiencies might be needed.



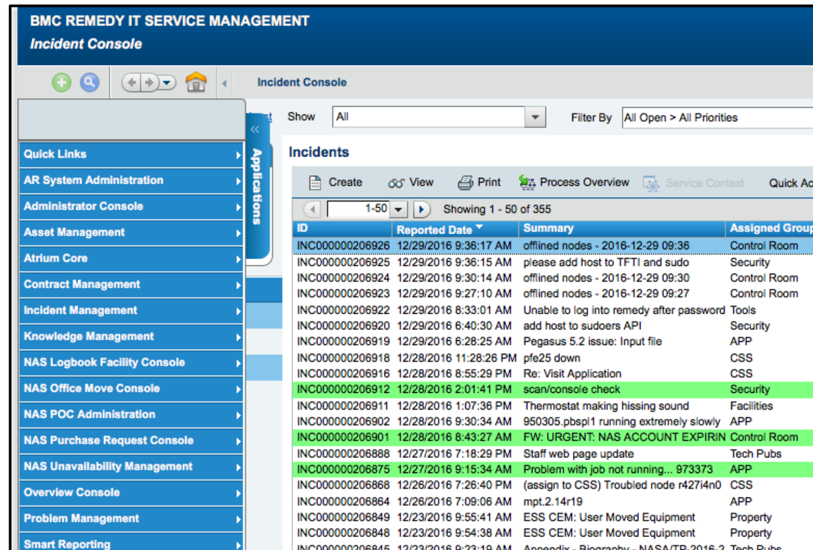
HECC monthly accounting reports use Standard Billing Unit (SBU) conversion rates for each processor type to SBUs in the reports.

POC: Blaise Hartman, blaise.hartman@nasa.gov, (650) 604-2539, NASA Advanced Supercomputing Division, CSRA LLC

Tools Team Develops and Supports HECC Applications and Websites

- HECC's Tools team continues development and support of applications, web tools, and databases to improve processes for our users. Major support includes:
  - HECC and HEC bi-weekly, monthly, and quarterly accounting reports using MicroStrategy.
  - Remedy application for HECC Incident Response and Asset Management, and Remedy workflows for downtime processing, purchase requests and travel requests.
  - myNAS iOS and Android apps and website.
  - Oracle and mysql databases development and administration.
  - NASA's Supercomputing Conference website.
  - HECC Account Request website.
  - Matlab Usage Statistics website for managing Matlab license requirements.
- New developments include myNAS website features for principal investigators, Special Access website for requesting elevated privileges, and RSA fob renewal feature on the Account Request website.

Mission Impact: HECC applications, web tools, and reports provide our users with enhanced accounting and request processes, and visibility into the performance of their jobs.



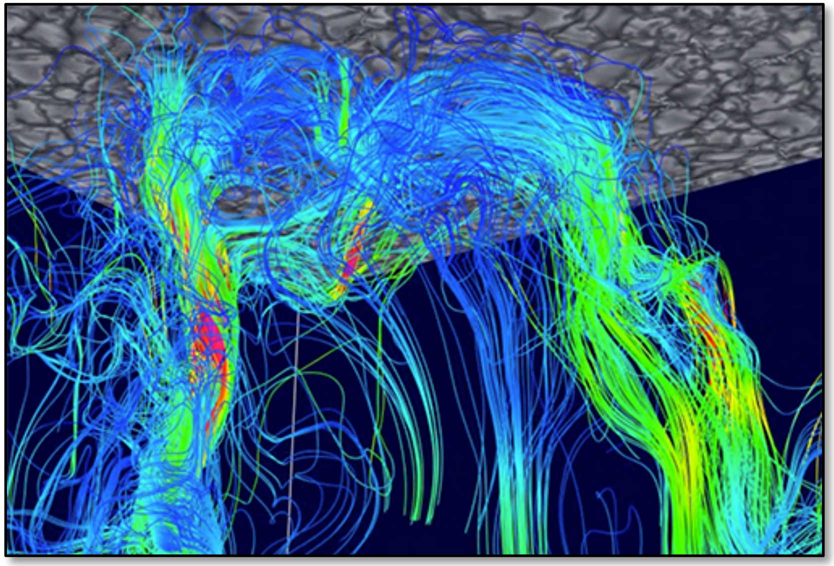
The HECC Tools team has integrated numerous utilities and workflows into the Remedy application, including the NAS logbook, incident and problem management, asset management, POC administration, maintenance contract management, purchase request console and smart reporting on these workflows.

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

Solar Activity Simulations Help Predict Impact on Earth's Space Weather *

- Researchers at Michigan State University (MSU), in collaboration with colleagues at Niels Bohr Institute, ran simulations from MSU's 3D, finite difference, magnetohydrodynamics code on Pleiades to help understand how sunspots form and evolve.
- Earth's space weather is driven by the evolution of the sun's magnetic field, especially the emergence of new magnetic flux and active regions. The MSU simulations reveal that:
  - Convective motions distort the magnetic field into serpentine loops.
  - The loops rise through the surface, producing sunspots.
  - The interaction of newly emerging fields with those already in the solar atmosphere leads to reconnection, intense energy release, flares, and coronal mass ejections of energetic particles and radiation.
- The simulation data provide a testbed for developing tools to detect emerging magnetic features before they reach the surface in order to predict eruptions that will affect Earth.
- In the next phase, researchers will use results from separate solar global dynamo calculations to provide more realistic bottom boundary conditions.

Mission Impact: HECC resources are essential to model complex solar phenomena that will enable scientists to attain their goal to predict when the dynamic solar weather will produce harmful space weather on Earth.



Snapshot of a magnetic loop emerging through the solar surface. Individual magnetic field lines are color-coded by the magnitude of the magnetic field. As the loop emerges through the solar surface, its vertical legs remain and produce the dark sunspot. *Patrick Moran, NASA/Ames*

POC: Robert Stein, stein@pa.msu.edu, (517) 884-5613, Michigan Statue University;
Aake Nordlund, aake@nbi.ku.dk, Niels Borh Institute

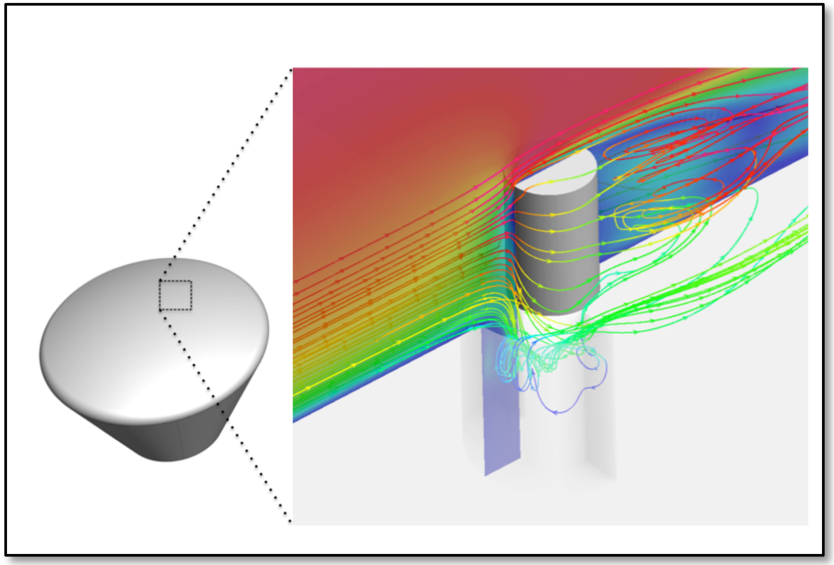
** HECC provided supercomputing resources and services in support of this work*

Orion Spacecraft's Thermal Protection System Designed with Help from Pleiades *

- Computational fluid dynamics (CFD) experts at NASA Ames are running simulations on Pleiades to help design engineers select materials for the Orion spacecraft's thermal protection system (TPS).
  - The TPS is being designed largely through computational analysis, including an aerothermal database that is used to define the convective and radiative heating environment.
  - The database includes simulations run using freestream conditions (velocity, altitude, and angle of attack) that span the possible flight space of re-entry trajectories.
  - Simulations of ground tests of complex flow phenomena were also run to provide difficult-to-measure data, such as boundary layer thickness and surface shear.
  - Comparisons of the ground test simulations and the measured data validated the accuracy of the CFD tools.
- The aerothermal database was used in the design of the TPS for Orion's Exploration Flight Test-1 (EFT-1) mission, which flew December 5, 2014.
- The database was updated using EFT-1 results, and is now being used to help design the TPS for the uncrewed Exploration Mission-1 (EM-1). It will be updated again to verify the TPS design of EM-2, the first Orion flight that will carry a crew.

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

Mission Impact: HECC resources provide Orion spacecraft designers with the aerothermal data they need to develop a thermal protection system that will shield NASA astronauts during re-entry into Earth's atmosphere.



Snapshot from a simulation of aluminum oxide radiometer sheath protruding through the recessed Orion heat shield during Earth re-entry. Increased heating just upstream of the exposed radiometer creates a cavity as the heat shield recesses further. Colored contours show local Mach numbers (ratio of velocity to speed of sound) and streamlines are colored according to temperature.

POC: Ryan McDaniel, ryan.d.mcdaniel@nasa.gov, (650) 604-5741, NASA Ames Research Center

HECC Facility Hosts Several Visitors and Tours in December 2016

- HECC hosted 3 tour groups in December; guests learned about the agency-wide missions being supported by HECC assets, and some groups also viewed the D-Wave 2X quantum computer system. Visitors this month included:
  - Aerospace engineering students from San Jose State University Chapter of The American Institute of Aeronautics and Astronautics society received a demo on the mini-hyperwall and a tour of the main computer room.
  - A group of 20 NASA FIRST (early career leadership program) graduates and their families received an overview of supercomputing work at Ames and a demo on the hyperwall.
  - Representatives from the Lawrence Berkeley Laboratory (LBNL) Public Affair Office filmed an interview at the hyperwall with Ames engineers for future media pieces on our joint collaboration on the use of X-ray tomography for heatshield material science. LBNL staff also shot footage during a tour of the computer room.

Aerospace engineer Francesco Panerai shows a visualization on the hyperwall depicting streaklines of scattered argon particles in a sample of virgin FiberForm that was acquired using X-ray microtomography produced by the Advanced Light Source synchrotron at LBNL. Visualization by *Arnaud Borner and Tim Sandstrom, NASA/Ames*

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

Papers

- "**Atmospheric Retrieval for Direct Imaging Spectroscopy of Gas Giants in Reflected Light II: Orbital Phase and Planetary Radius**, M. Nayak, R. Lupu, M. Marley, J. Fortney, T. Robertson, N. Lewiz, arXiv:1612.00342 [astro-ph.EP], December 1, 2016. *
https://arxiv.org/abs/1612.00342
- "**Three-phase Interstellar Medium in Galaxies Resolving Evolution with Star Formation and Supernova Feedback (TIGRESS): Algorithms, Fiducial Model, and Convergence**," C.-G. Kim, E. Ostriker, arXiv:1612.03918 [astro-ph.GA], December 12, 2016. *
https://arxiv.org/abs/1612.03918
- "**Nonthermal Particle Acceleration in Collisionless Relativistic Electron-Proton Reconnection**,G. Werner, D. Uzdensky, M. Begelman, B. Cerutti, K. Nalewajko, arXiv: 1612.04493 [astro-ph.HE], December 14, 2016. *
https://arxiv.org/abs/1612.04493
- "**Hybrid Reynolds-Averaged/Large-Eddy Simulation of a Cavity Flameholder: Modeling Sensitivities**," R. Baurle, AIAA Journal, Published Online December 16, 2016. *
http://arc.aiaa.org/doi/abs/10.2514/1.J055257
- "**Modeling the Historical Flux of Planetary Impactors**," D. Nesvorny, F. Roig, W. Bottke, arXiv:1612.08771 [astro-ph.EP], December 27, 2016. *
https://arxiv.org/abs/1612.08771

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

Presentations

- “**Combined Uncertainty and A-Posteriori Error Bound Estimates**,” T. Barth, presented at the JANNAF Standards Committee Meeting, Phoenix, AZ, December 7, 2016. *
- **2016 American Geophysical Union (AGU) Meeting**, December 12–16, 2016, San Francisco, CA.
  - “**Asteroid-Generated Tsunami and Impact Risk**,” M. Aftosmis, D. Mathias, D. Robertson, L. Wheeler, et al. *
  - “**Asteroid Threat Assessment: Land Versus Water Impact Risk**,” D. Mathias, L Wheeler, M. Aftosmis, D. Robertson, et al. *
  - “**Magnetoacoustic Waves Excitation in Self Organized Solar Magnetic Structures**,” I. Kitiashvili, N. Mansour, A. Wray, et al. *
  - “**Deploying the ODISEES Ontology-Guided Search in the NASA Earth Exchange (NEX)**,” G. Deardorff, R. Spaulding, M. Coitnoir, et al. *
  - “**Density of Near Earth Asteroids**,” J. Dotson, D. Mathias, et al. *
  - “**Asteroid Airburst Altitude vs. Strength**,” D. Robertson, L. Wheeler, D. Matthias. *
  - “**Atmospheric Breakup and Energy Deposition Modeling for Asteroid Impact Risk Assessment**,” L. Wheeler, D. Mathias. *
  - “**Improved Hazard and Risk Consequence Metrics for Assessing Asteroid Impact Threats**,” A. Tarano, D. Mathias, L. Wheeler. *
  - “**Uncertainty Assessment of the NASA Earth Exchange Global Daily Downscaled Climate Projections (NEX-GDDP) Dataset**,” R. Nemani, J. Dungan, et al. *

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

Presentations (cont.)

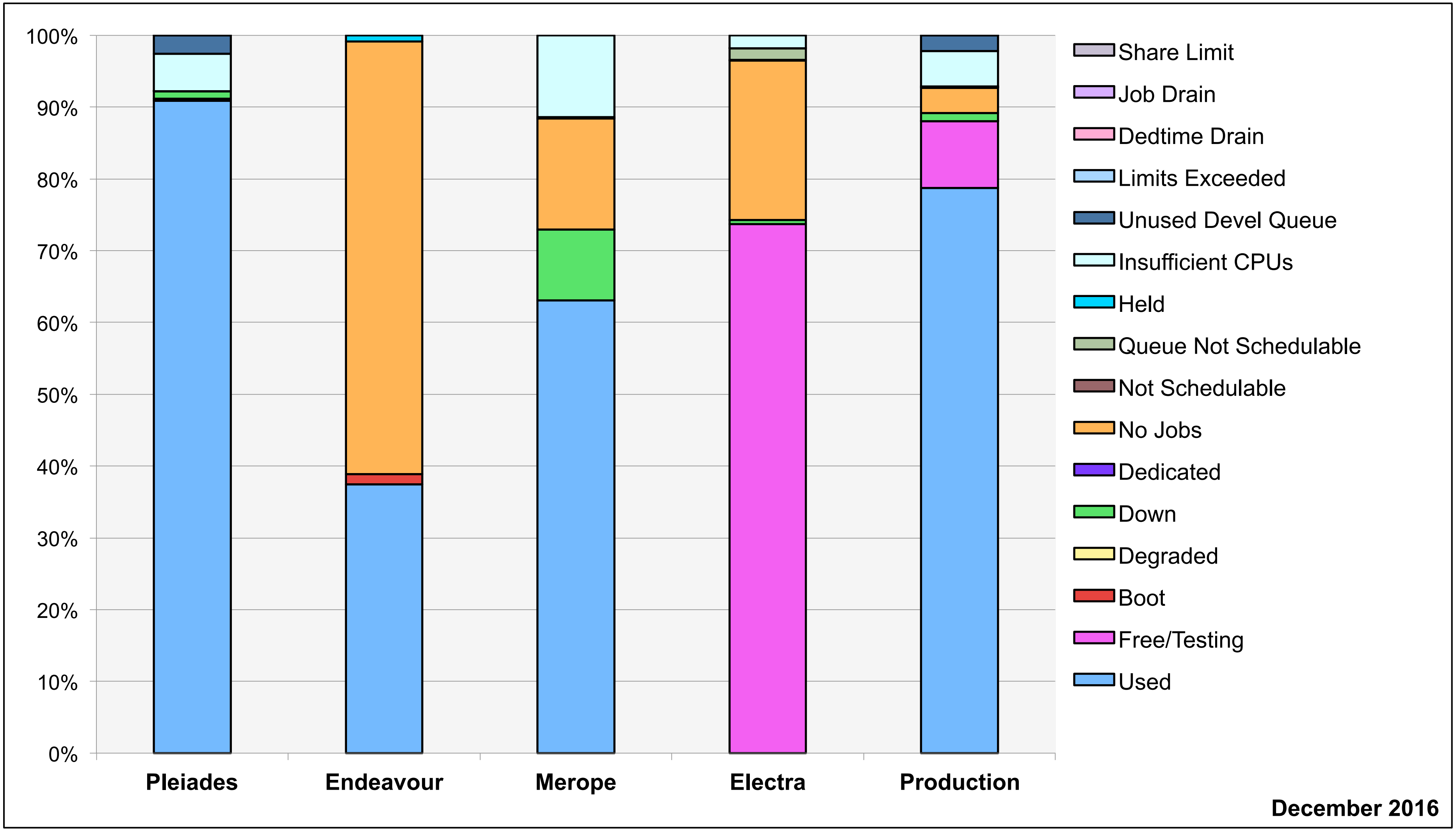
- **2016 American Geophysical Union (AGU) Meeting (cont.)**
  - "**Observed Trend in Surface Wind Speed Over the Conterminous USA and CMIP5 Simulations**," H. Hashimoto, R. Nemani. *
  - "**OpenNEX, a Private-Public Partnership in Support of the National Climate Assessment**," R. Nemani, S. Ganguly, et al. *
  - "**Analytics and Visualization Pipelines for Big Data on the NASA Earth Exchange (NEX) and OpenNEX**," R. Nemani, et al. *
  - "**DeepSAT: A Deep Learning Approach to Tree-Cover Delineation in 1-m NAIP Imagery for the Continental United States**," S. Ganguly, R. Nemani, et al. *

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

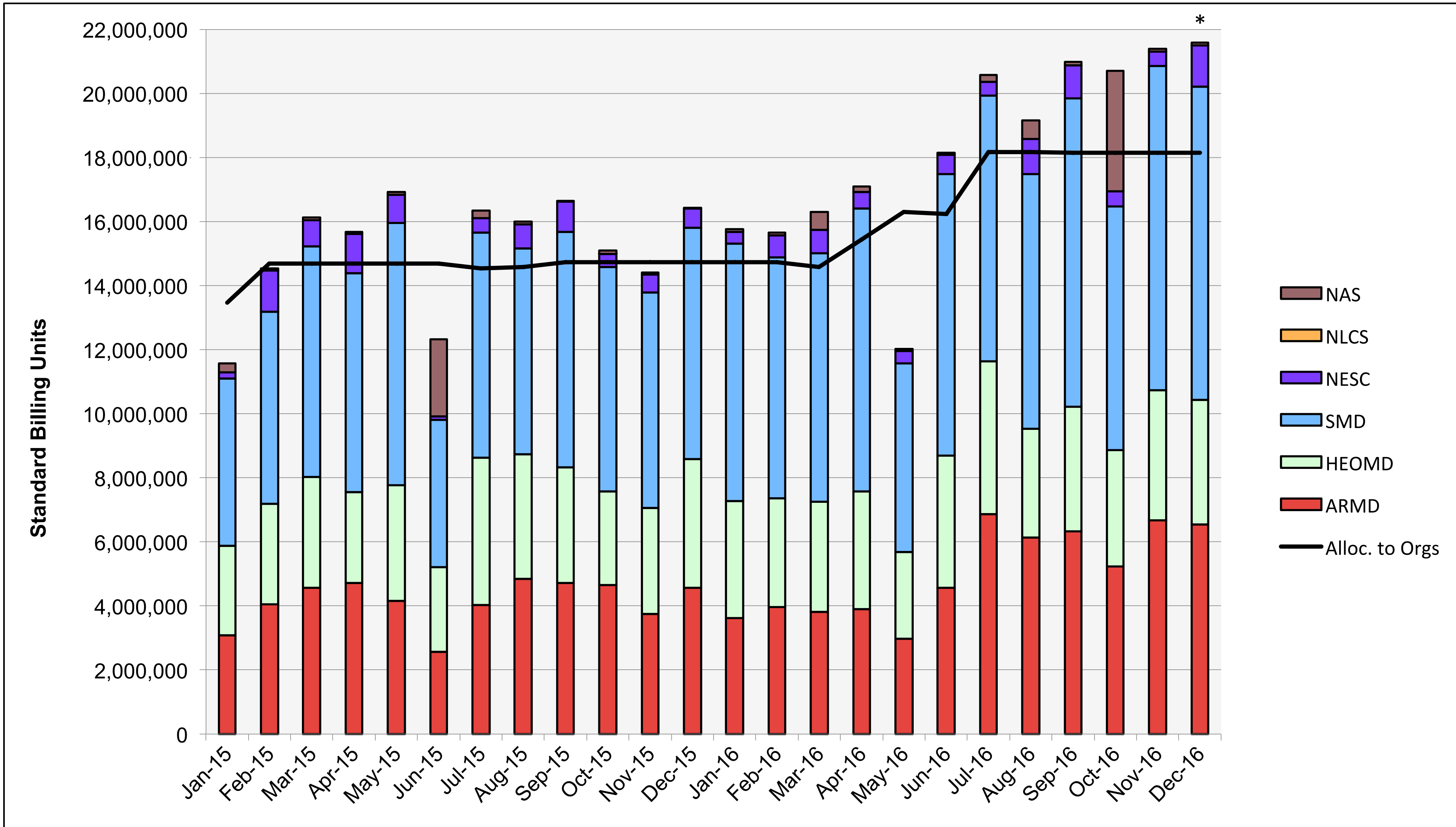
News & Events

- **NASA's hyperwall Wonderwall Uses Virtual Flash SAN**, *The Register*, December 6, 2016—The Register takes a deep look into what makes the 128-screen hyperwall at the NASA Advanced Supercomputing Division a premier science resource for the agency.
  http://www.theregister.co.uk/2016/12/06/nasas_hyperwall_wonderwall_uses_virtual_flash_san

HECC Utilization

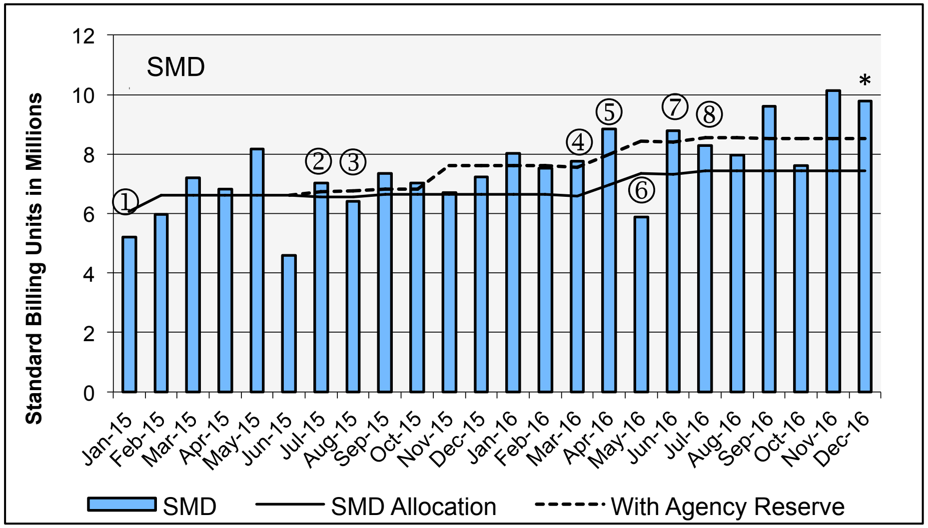


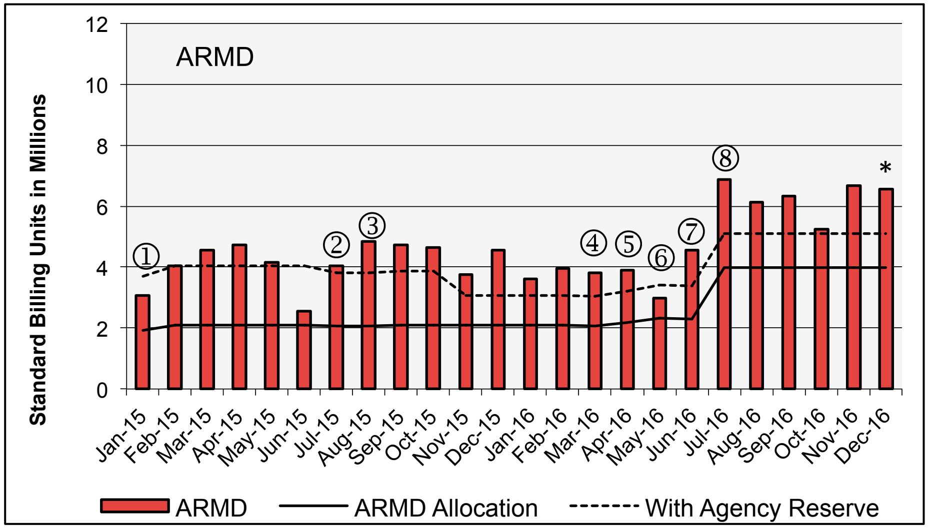
HECC Utilization Normalized to 30-Day Month

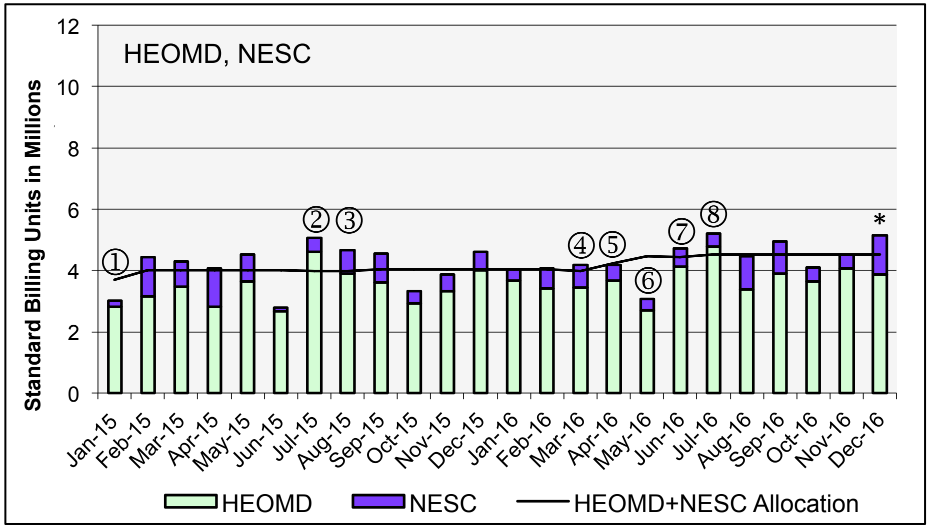


*Electra time was not billed in December, so is not included in December totals

HECC Utilization Normalized to 30-Day Month



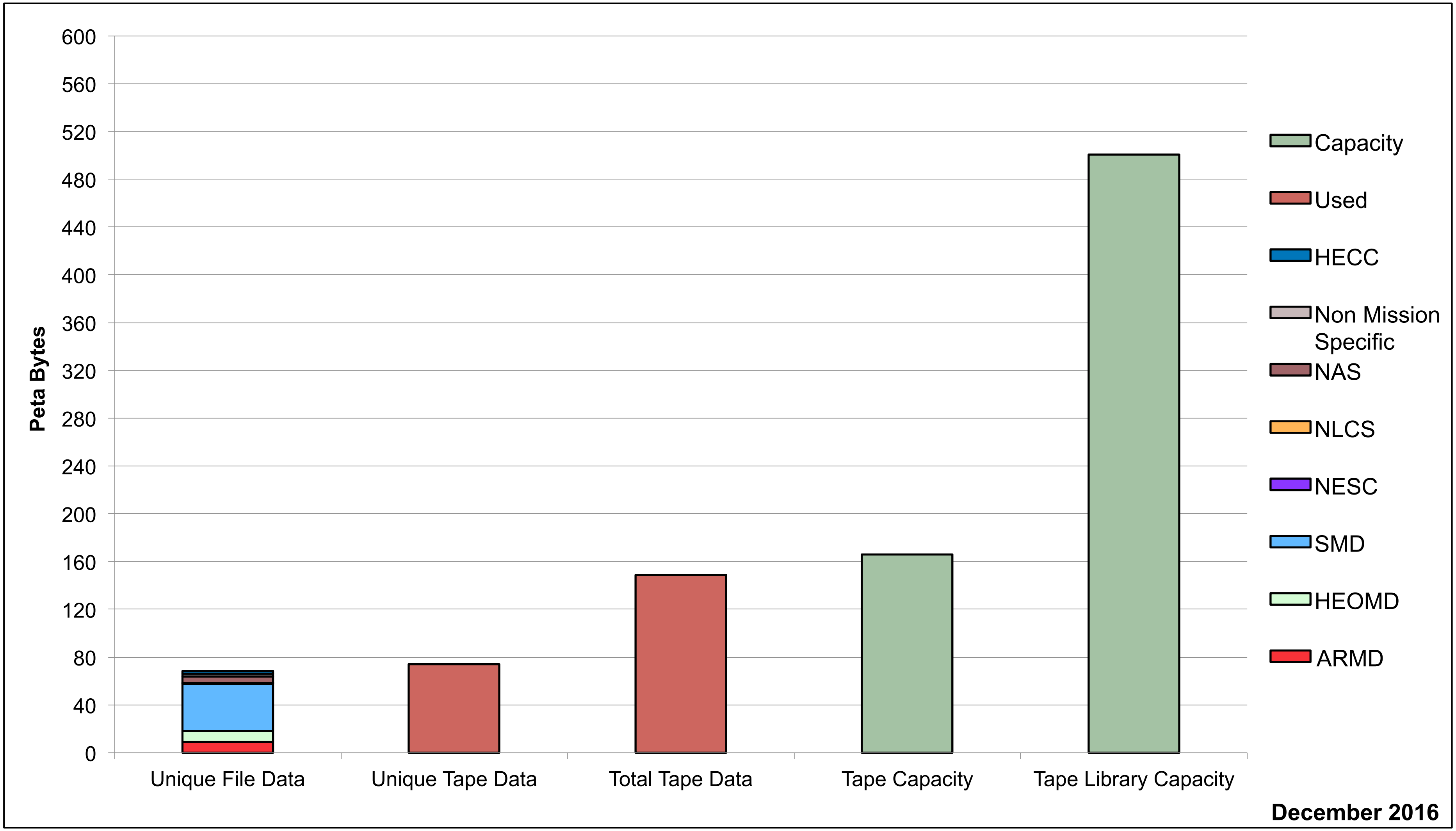




① 14 Haswell racks added to Pleiades
② 7 Nehalem ½ racks retired from Merope
③ 7 Westmere ½ racks added to Merope
④ 16 Westmere racks retired from Pleiades
⑤ 10 Broadwell racks added to Pleiades
⑥ 4 Broadwell racks added to Pleiades
⑦ 14 (All) Westmere racks retired from Pleiades
⑧ 14 Broadwell Racks added to Pleiades

*Electra time was not billed in December, so is not included in December totals

Tape Archive Status



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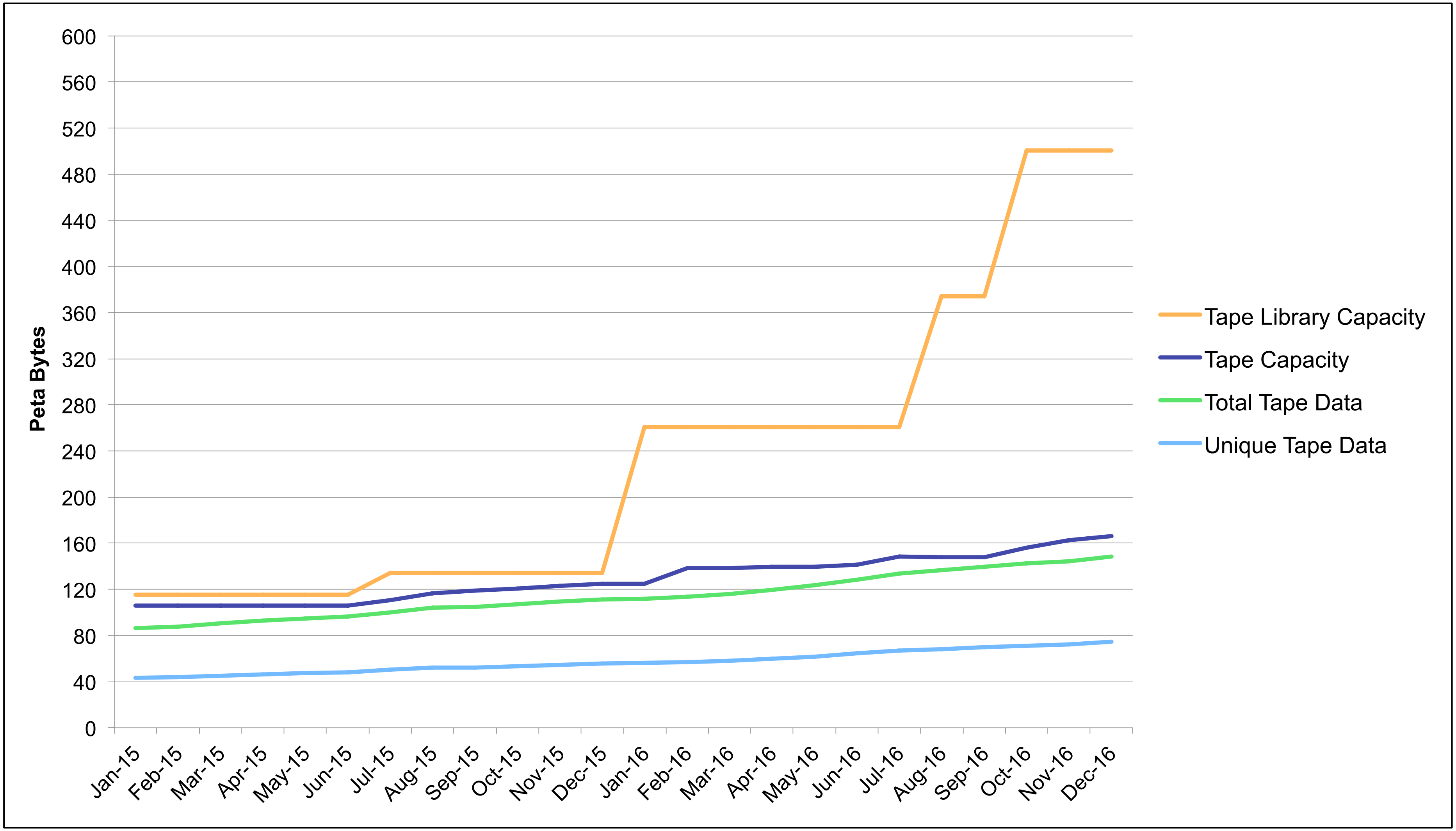
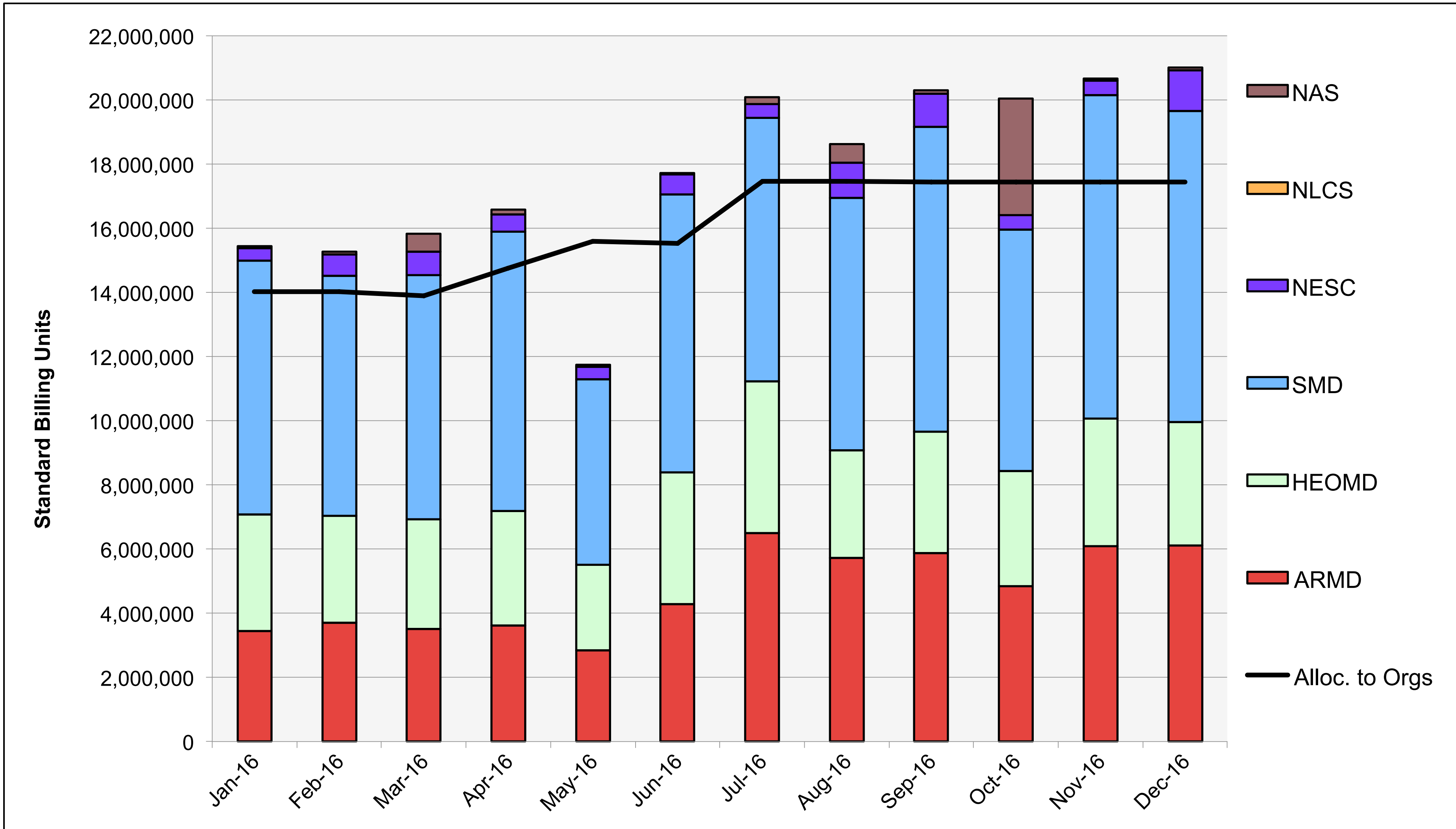
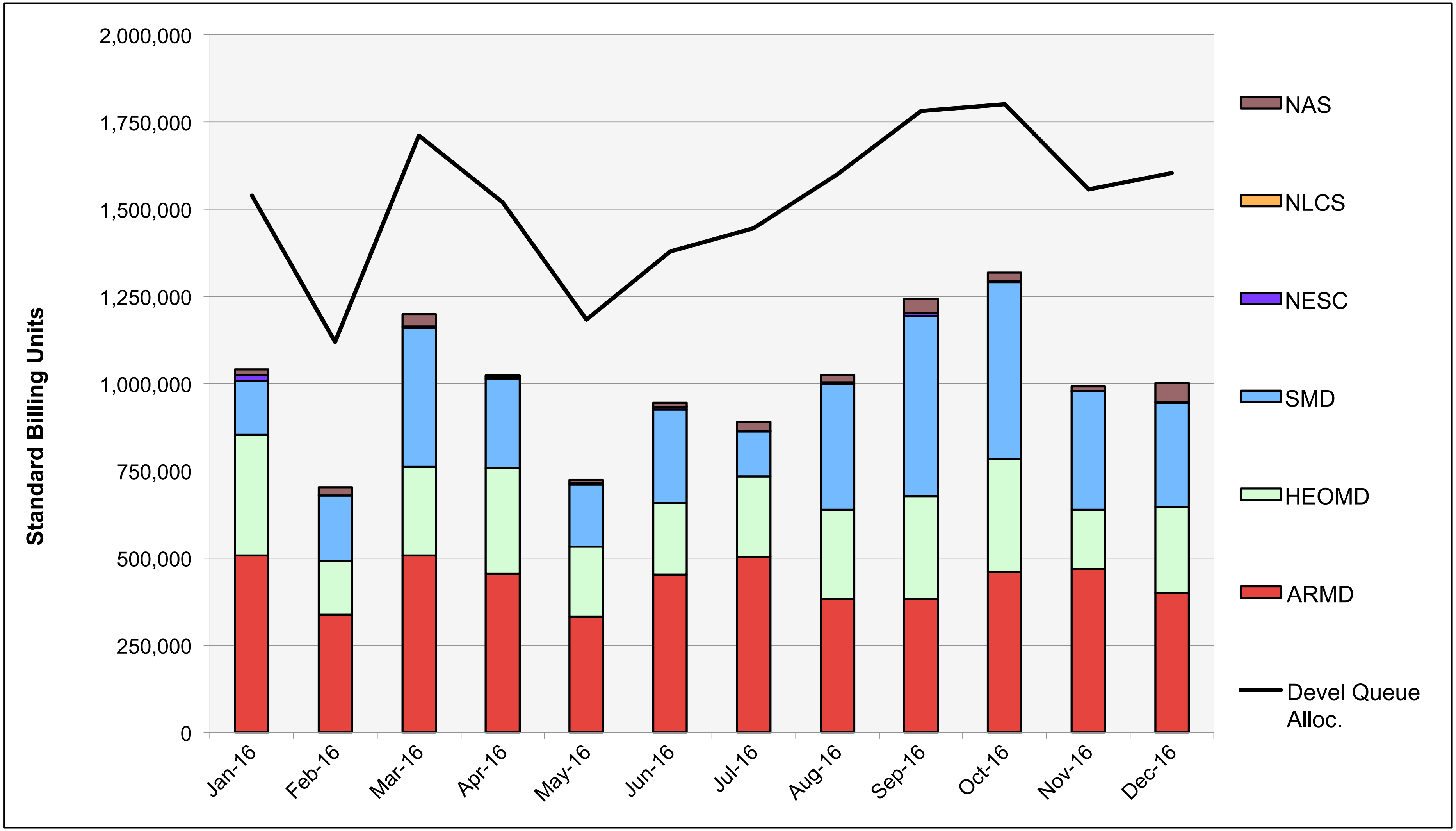


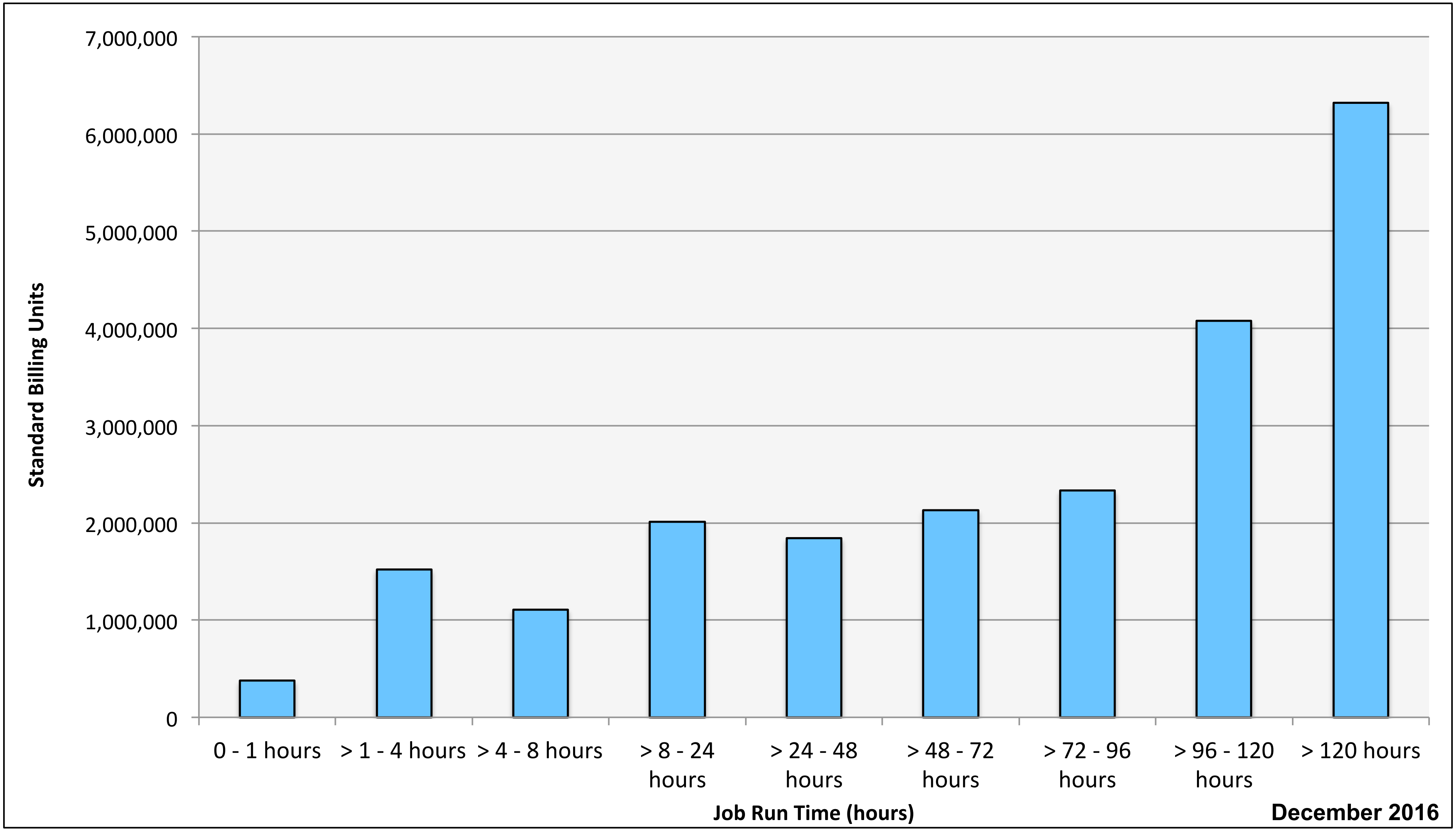
Pleiades: SBUs Reported, Normalized to 30-Day Month



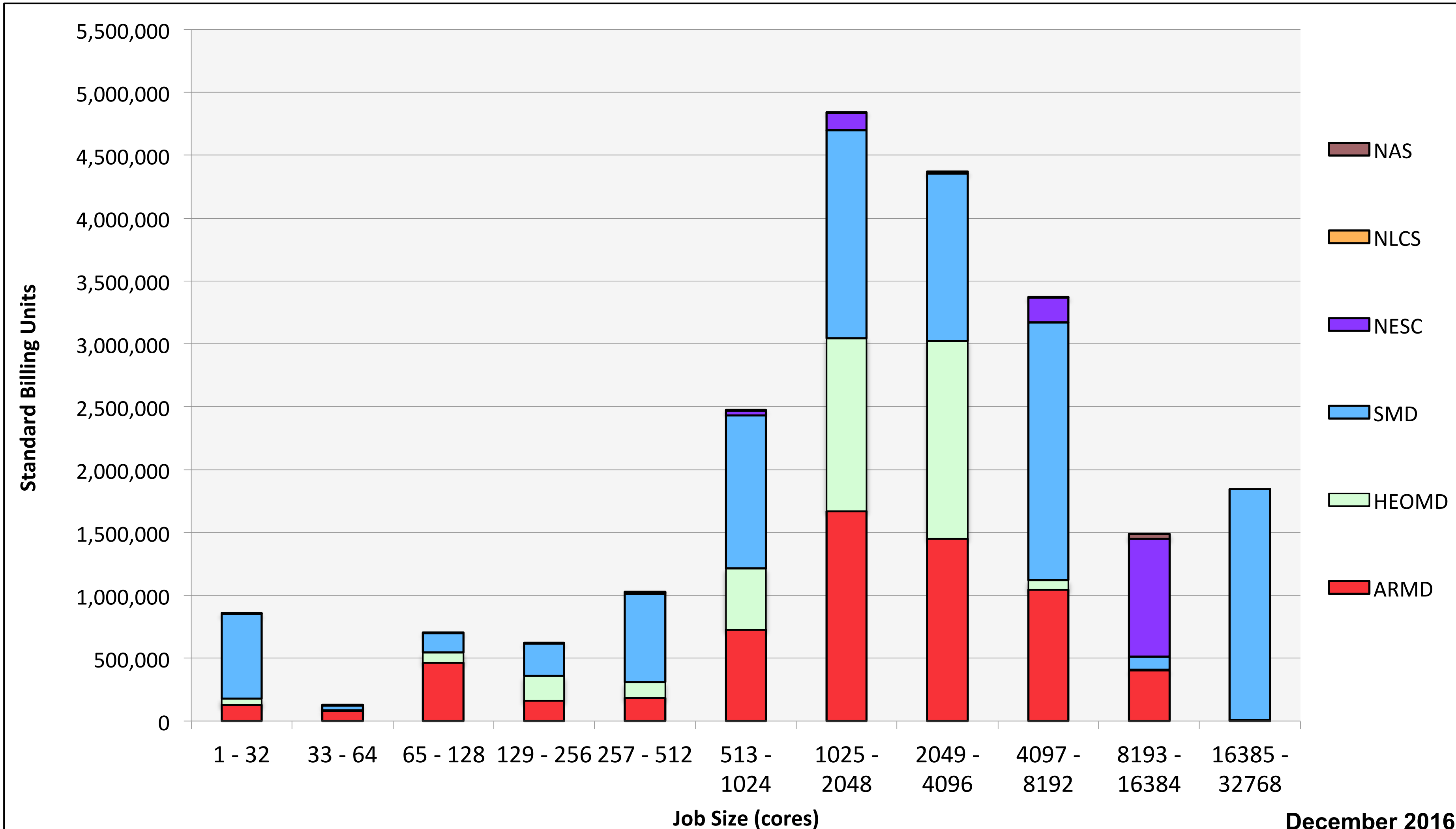
Pleiades: Devel Queue Utilization



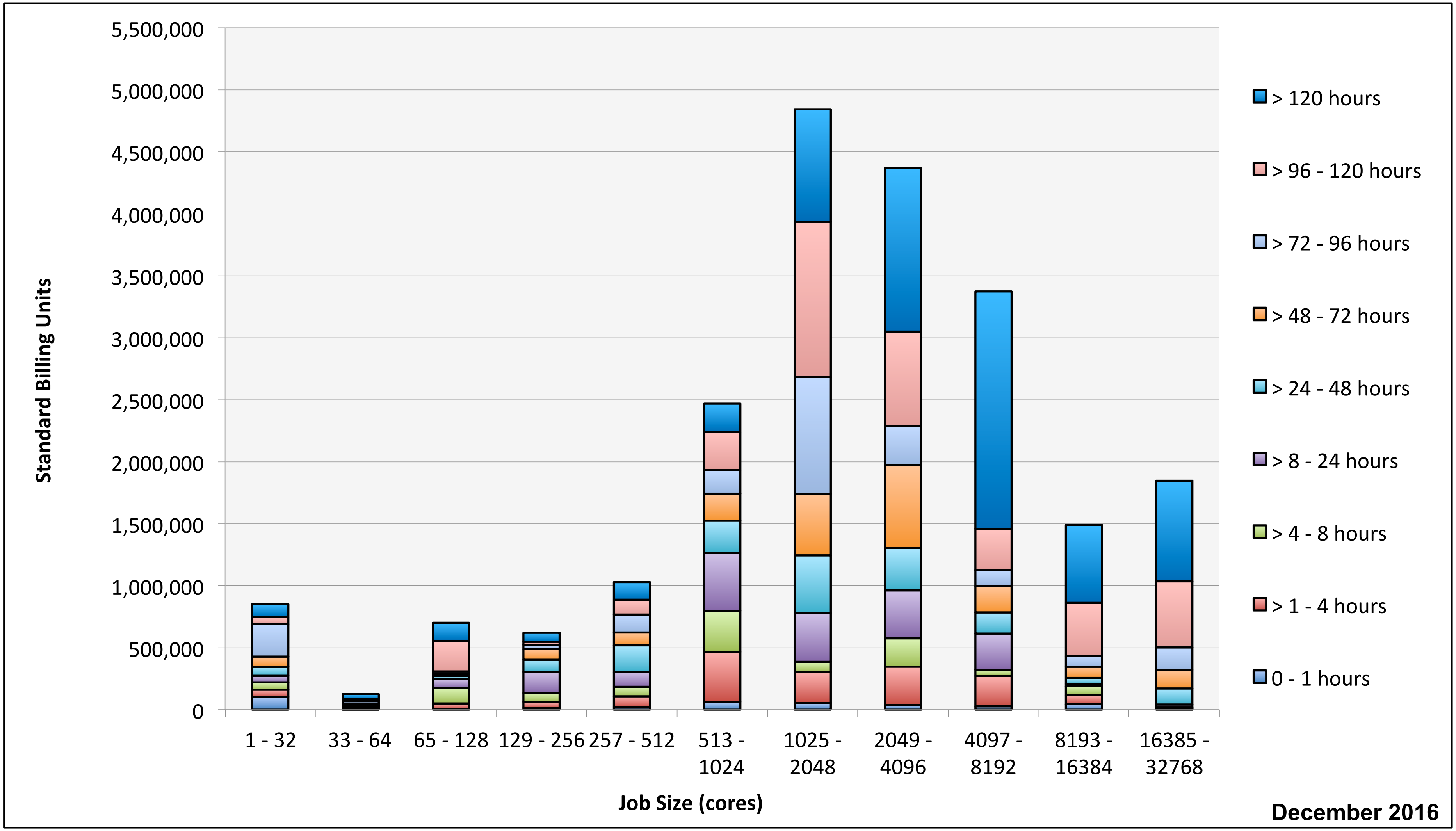
Pleiades: Monthly Utilization by Job Length



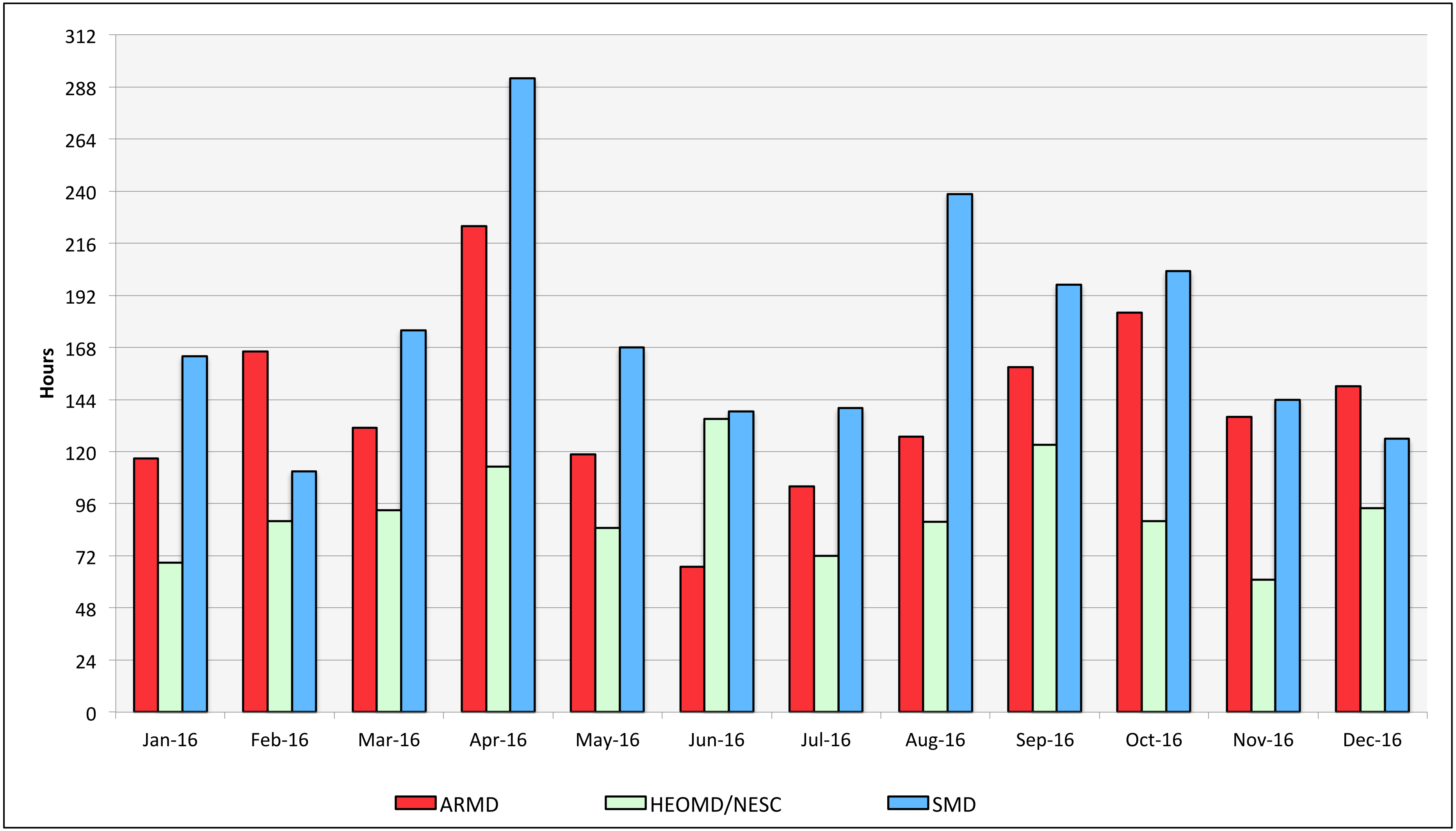
Pleiades:
Monthly Utilization by Size and Mission



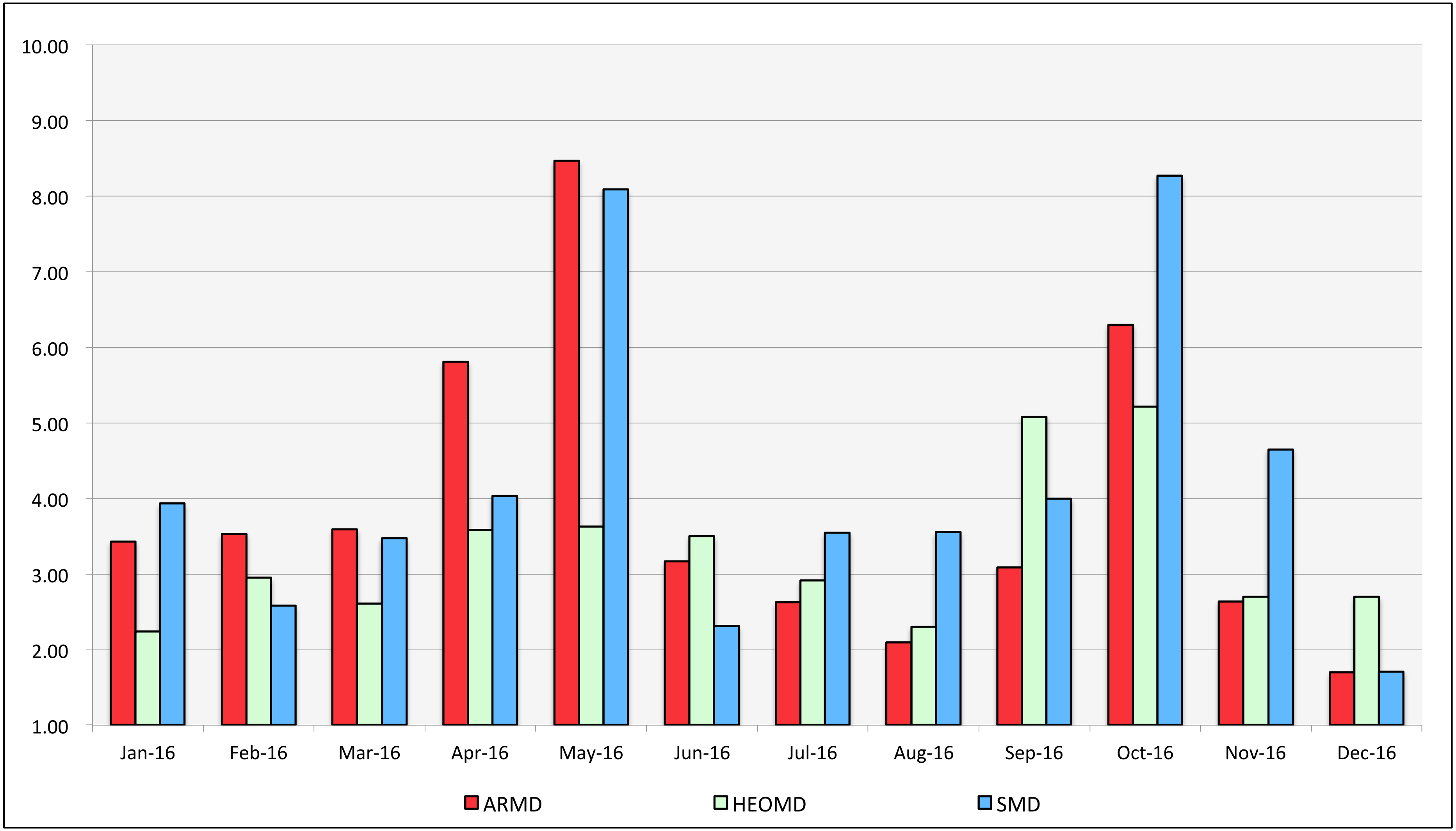
Pleiades: Monthly Utilization by Size and Length



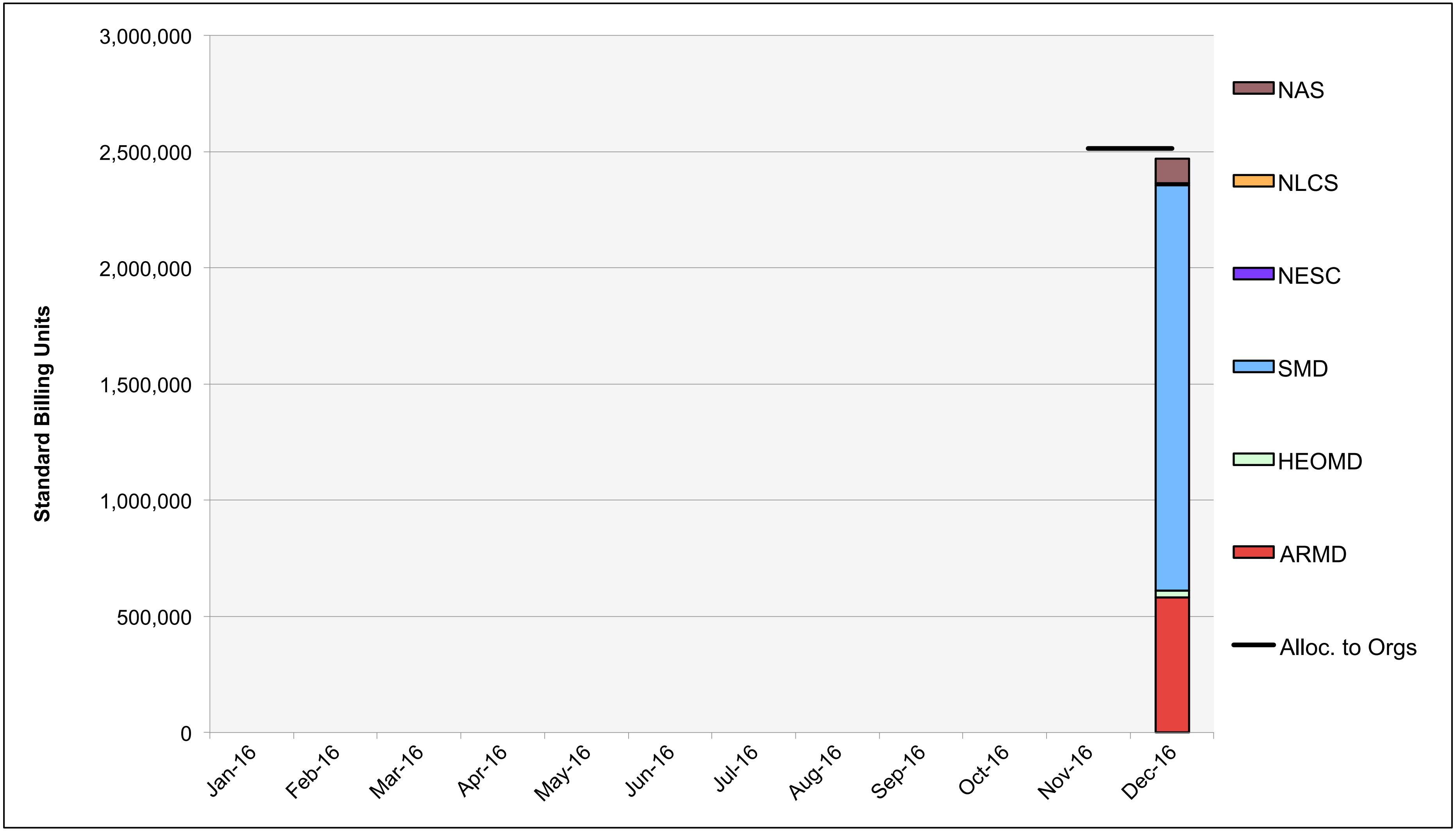
Pleiades:
Average Time to Clear All Jobs



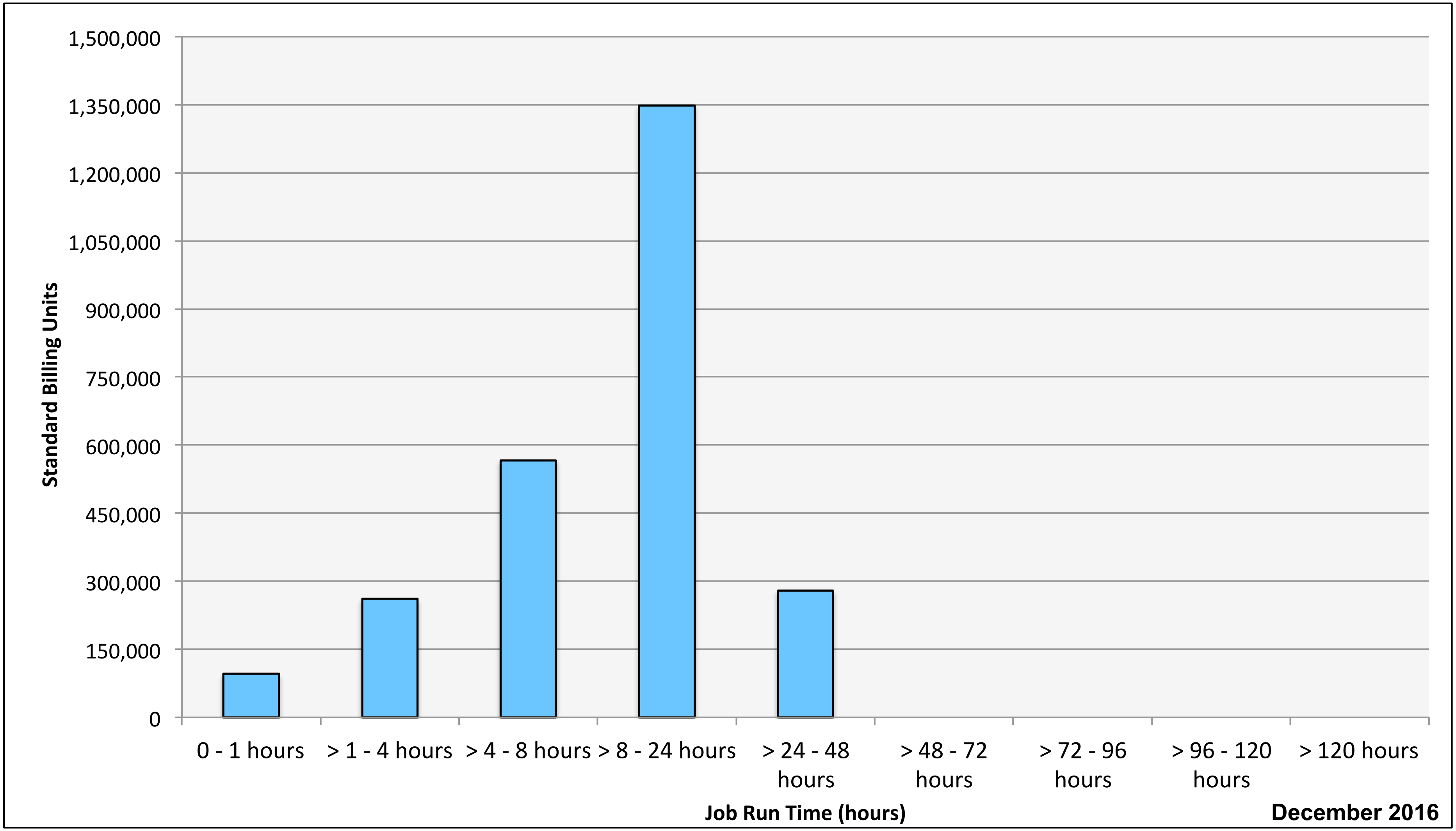
Pleiades: Average Expansion Factor



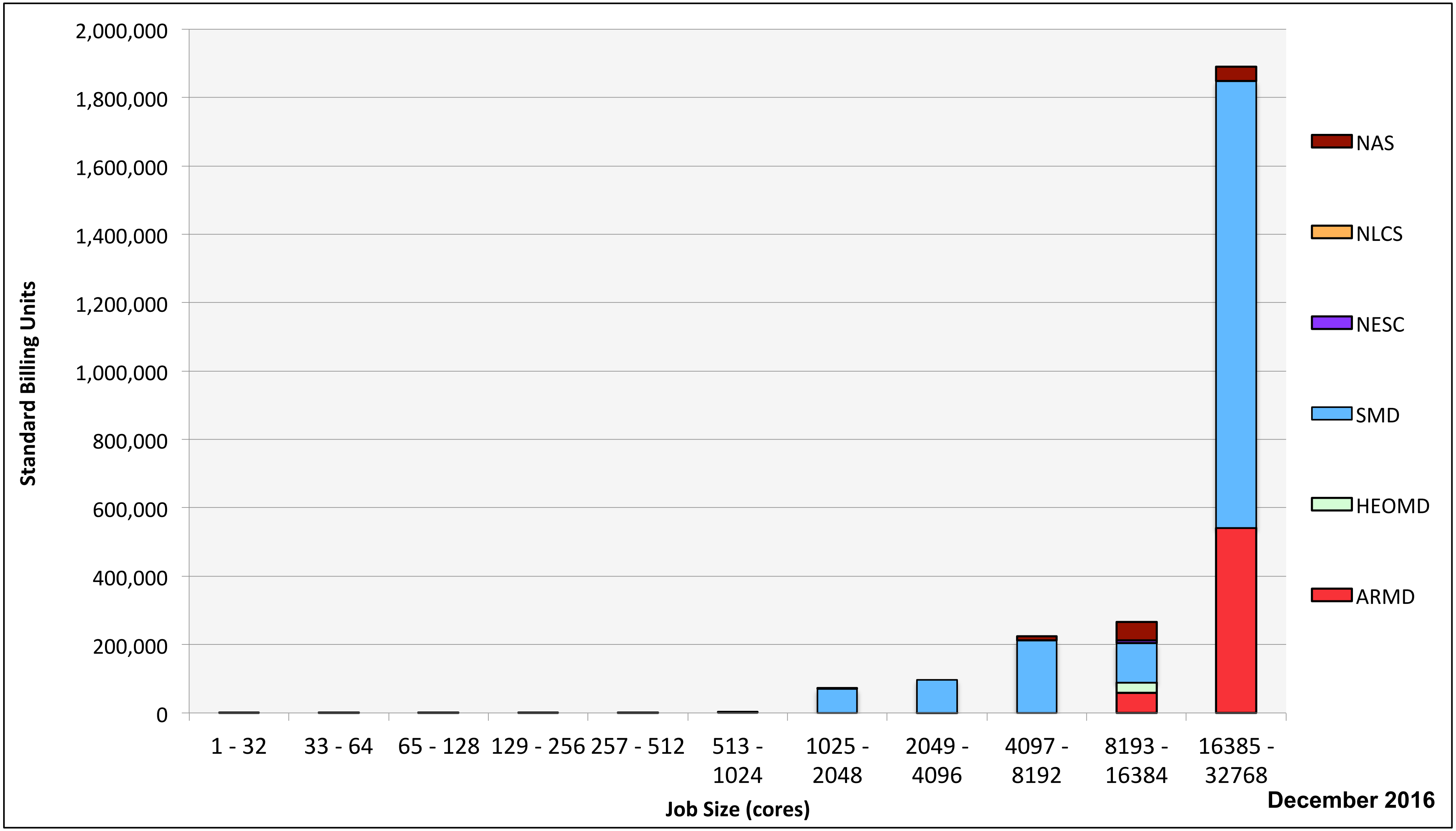
Electra: SBUs Reported, Normalized to 30-Day Month



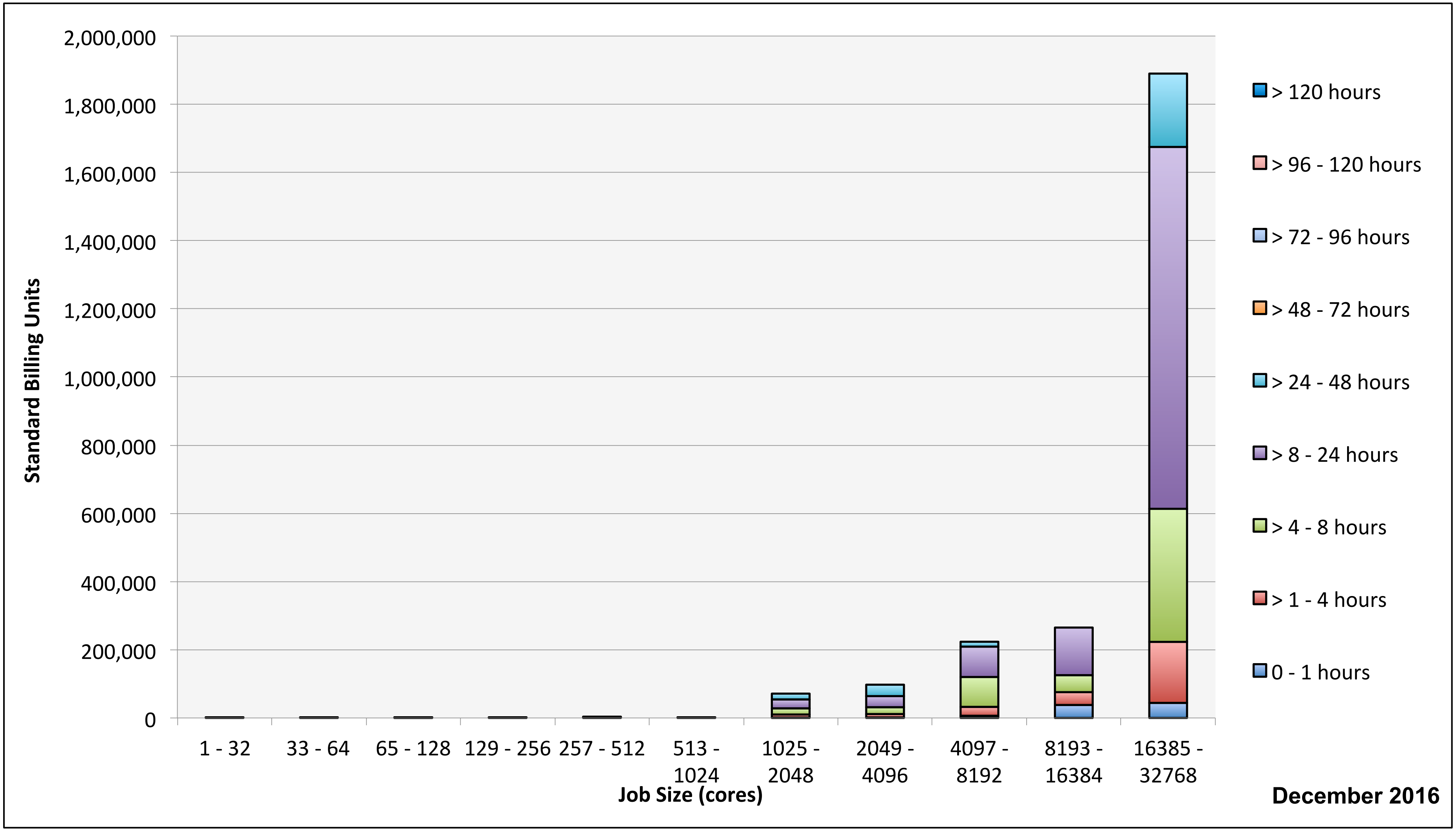
Electra: Monthly Utilization by Job Length



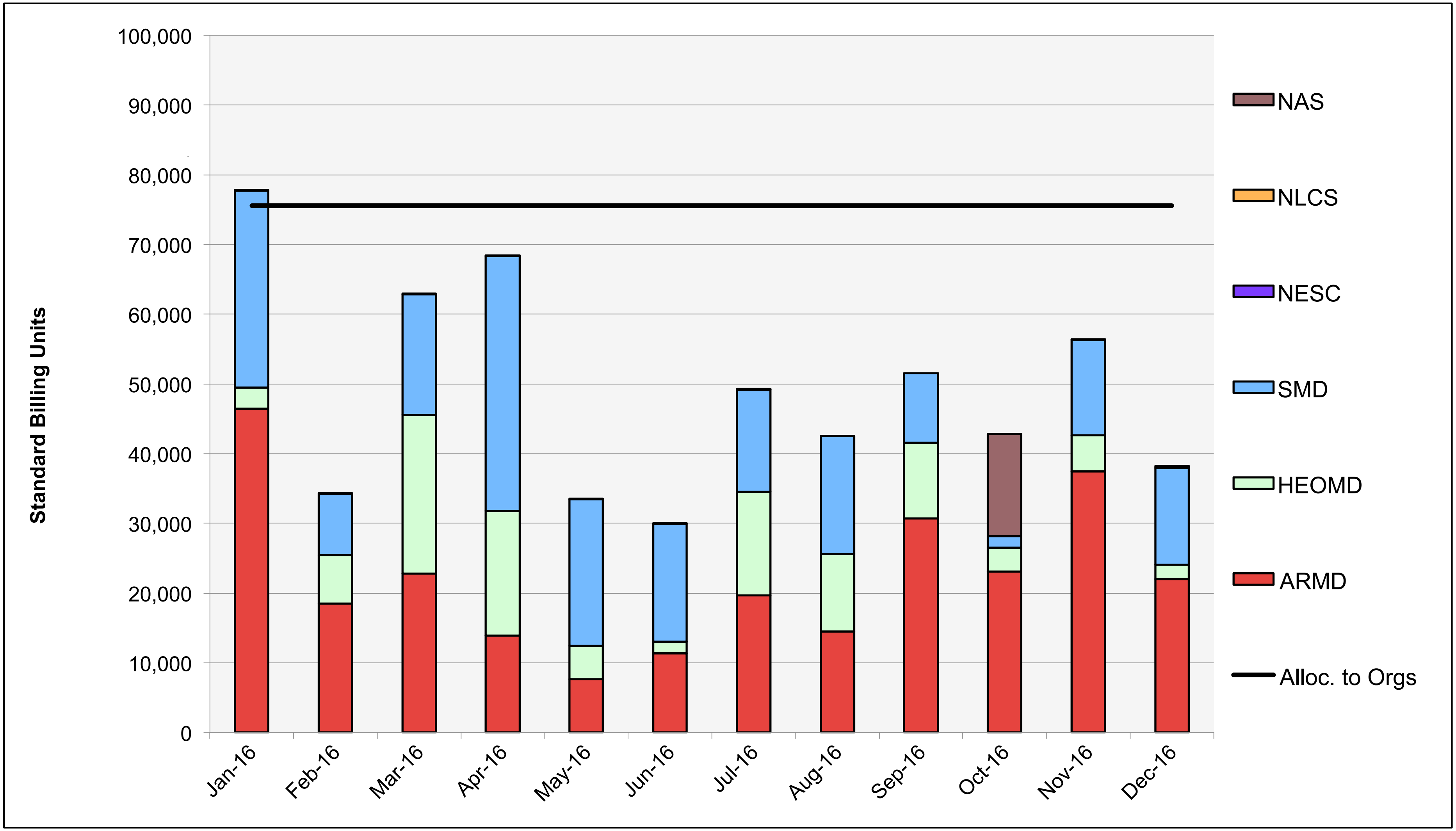
Electra: Monthly Utilization by Size and Mission



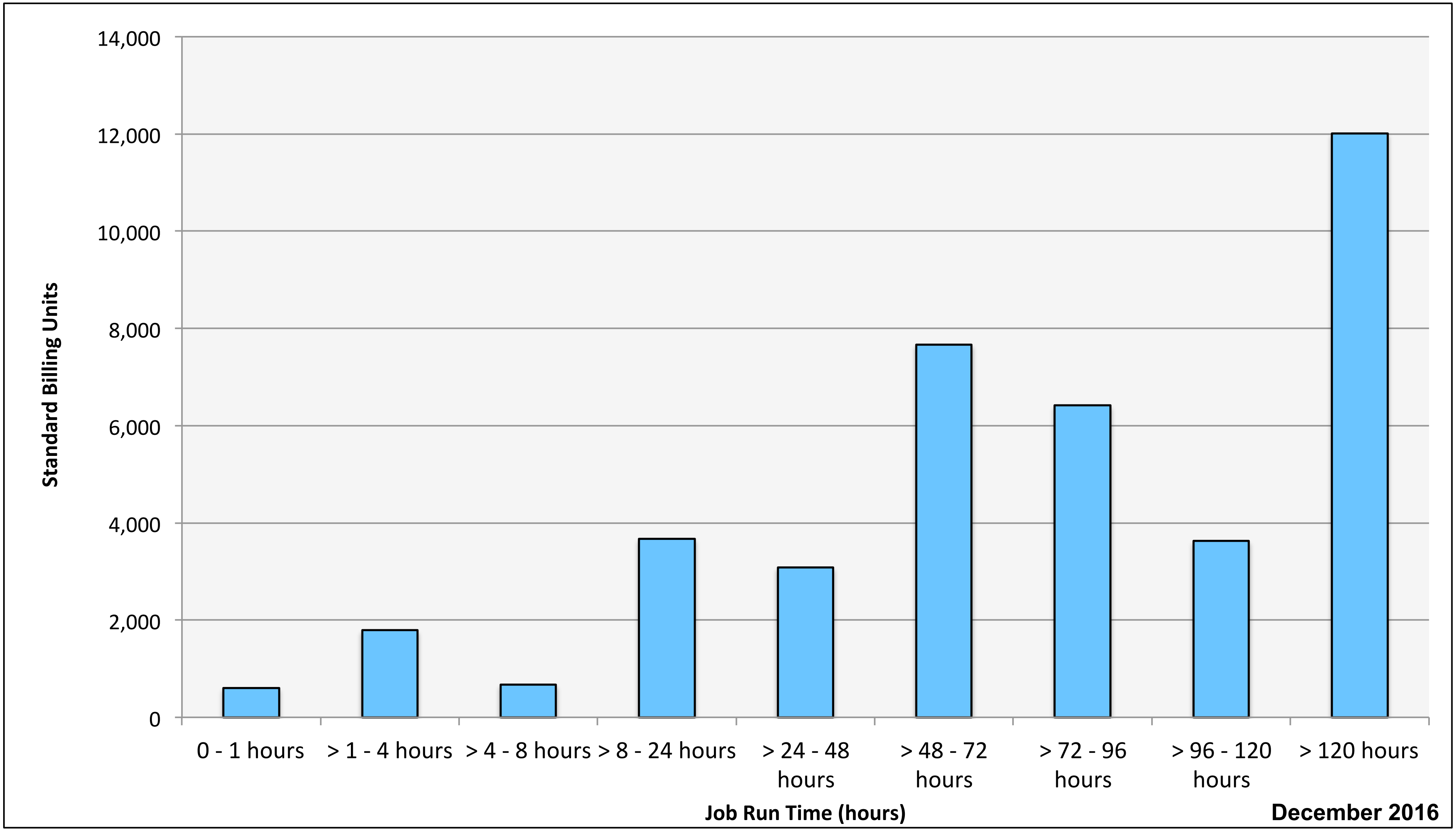
Electra:
Monthly Utilization by Size and Length



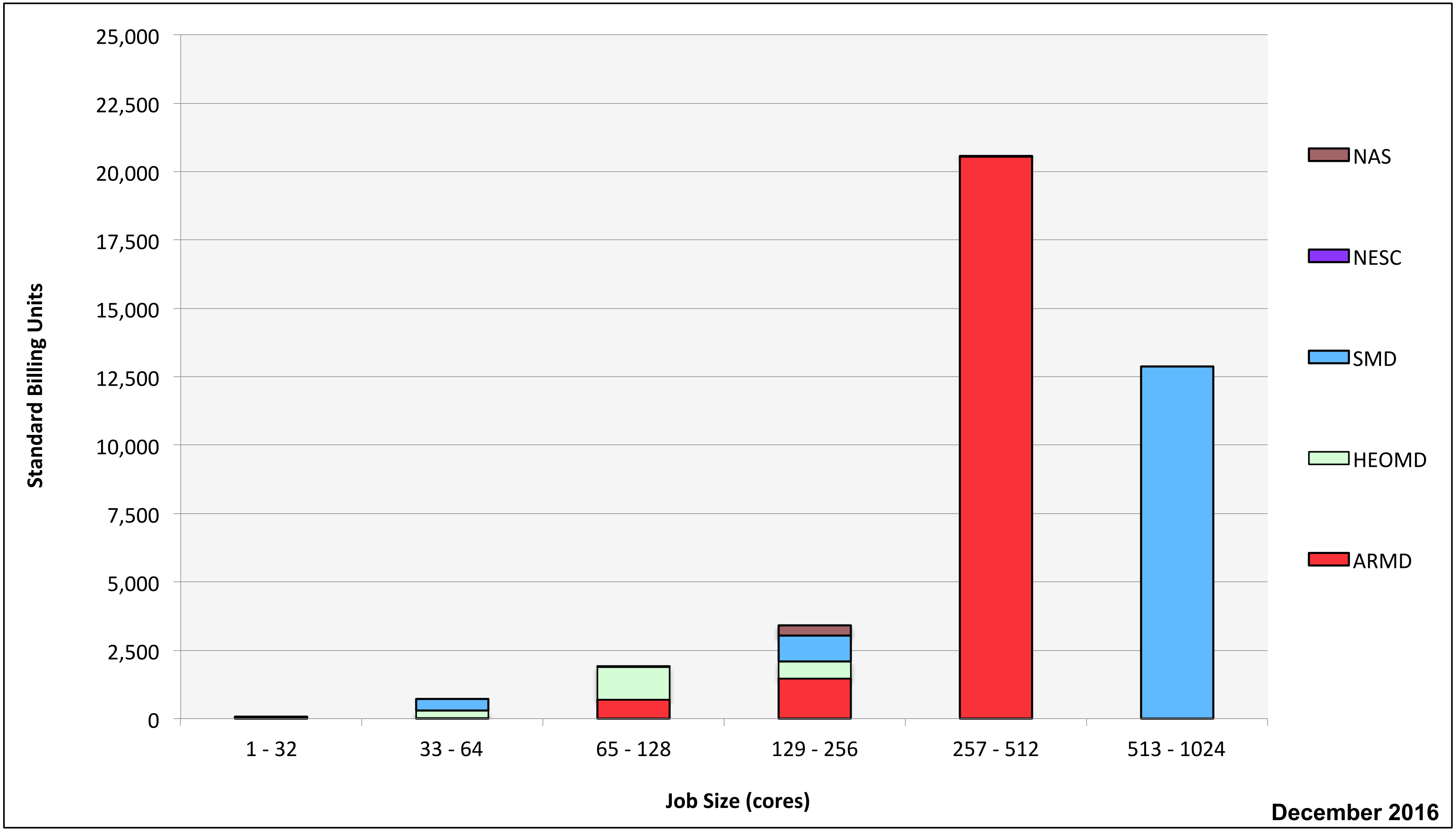
Endeavour:
SBUs Reported, Normalized to 30-Day Month



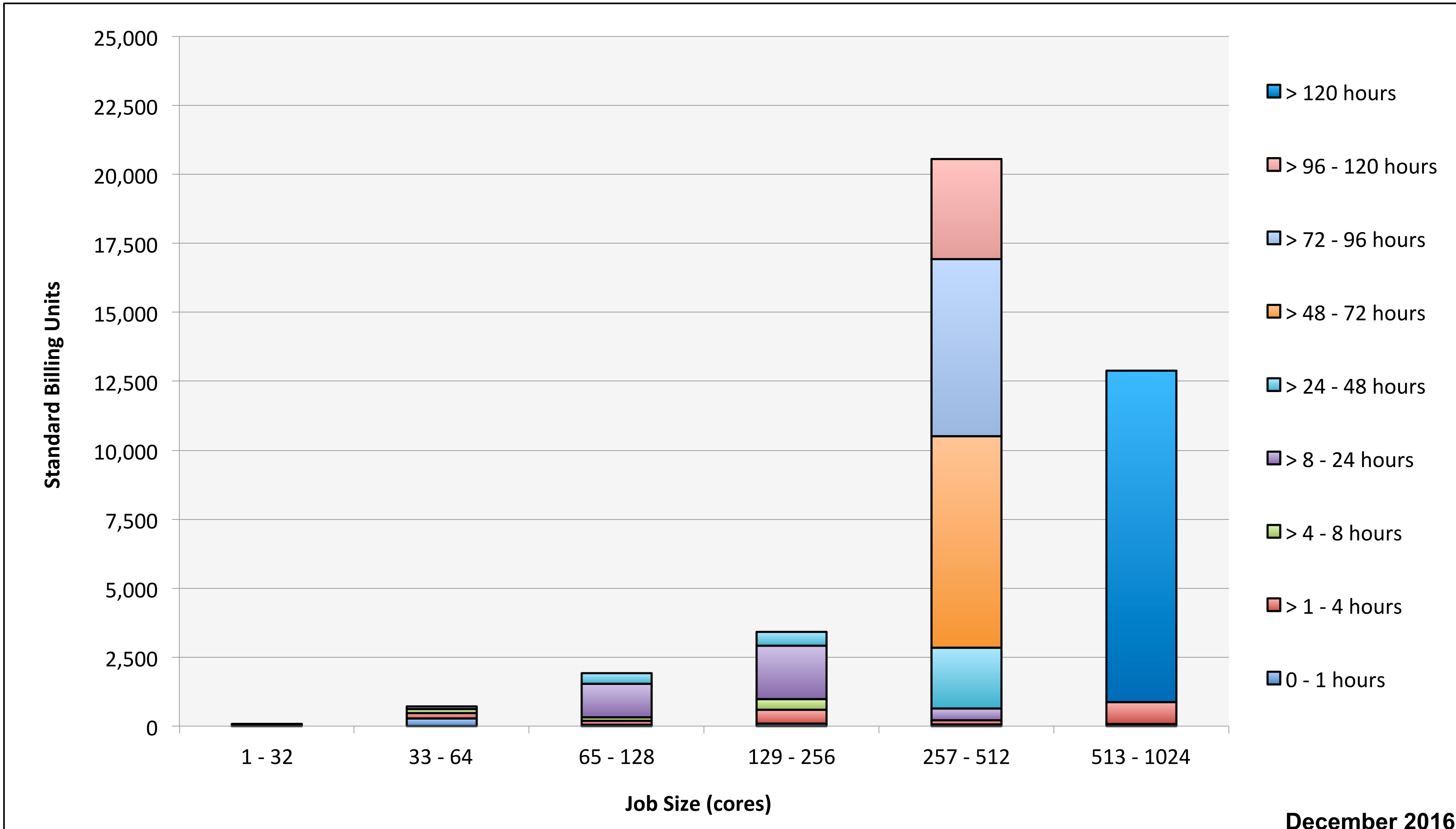
Endeavour:
Monthly Utilization by Job Length



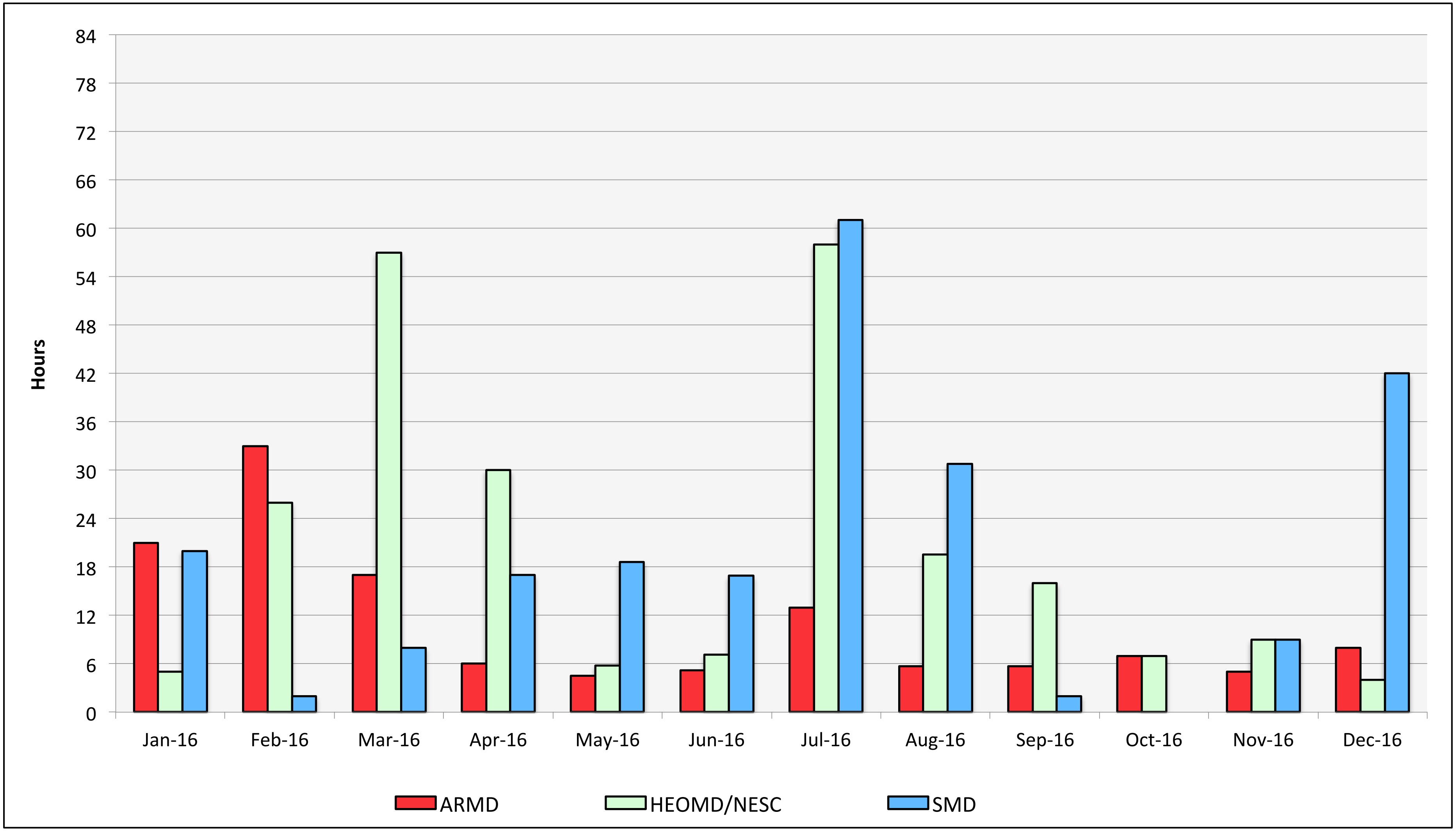
Endeavour:
Monthly Utilization by Size and Mission



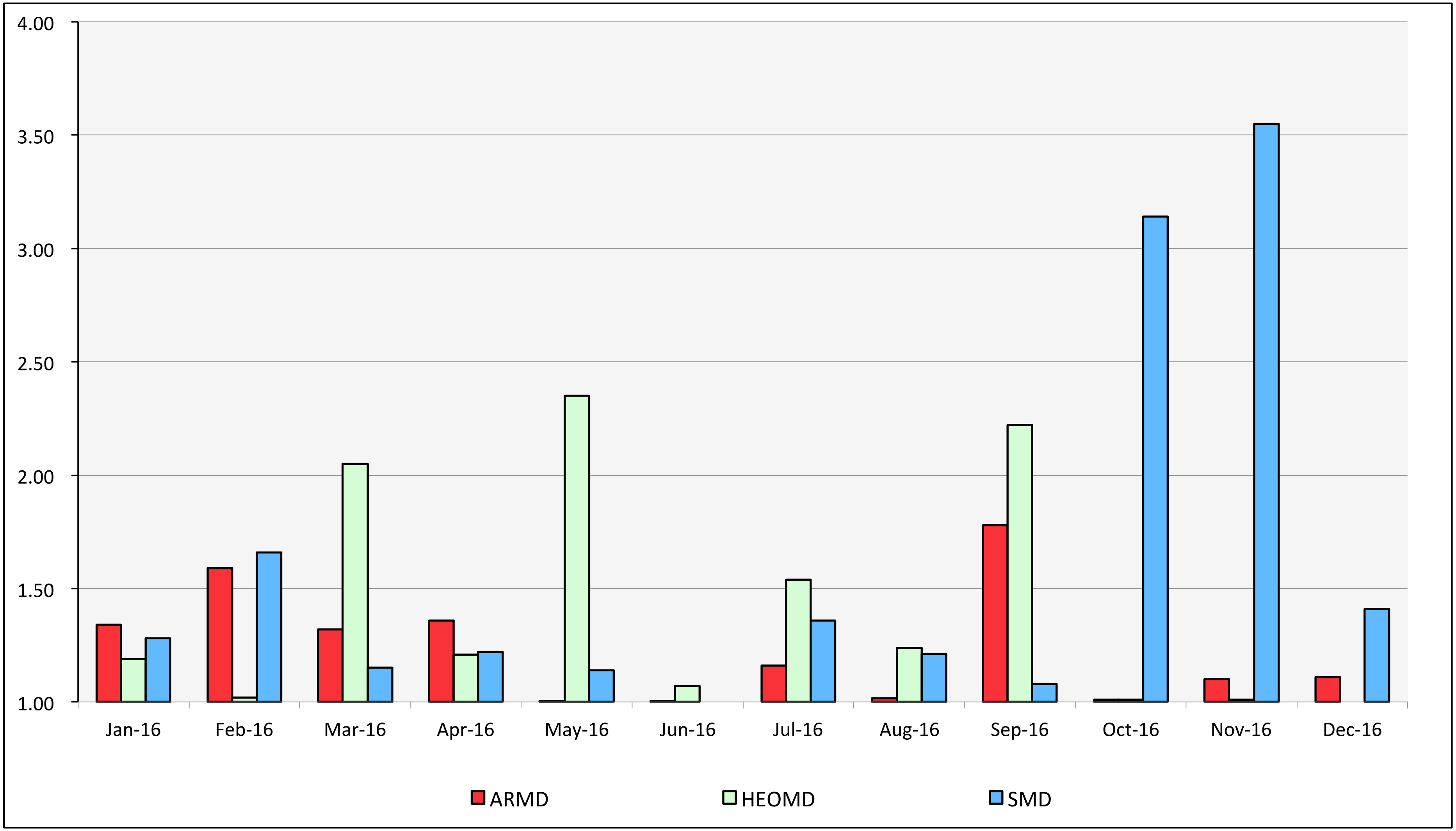
Endeavour:
Monthly Utilization by Size and Length



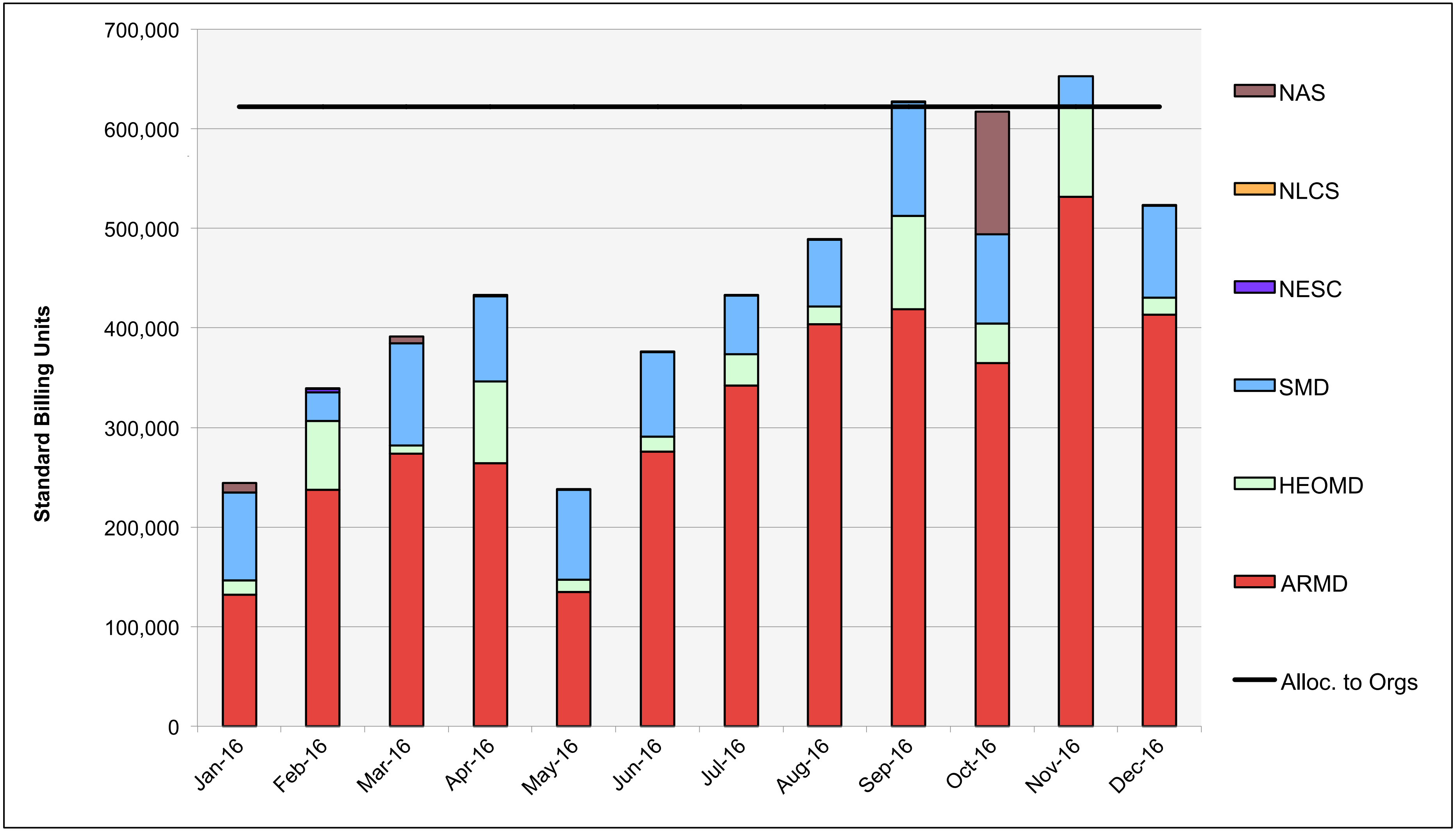
Endeavour:
Average Time to Clear All Jobs



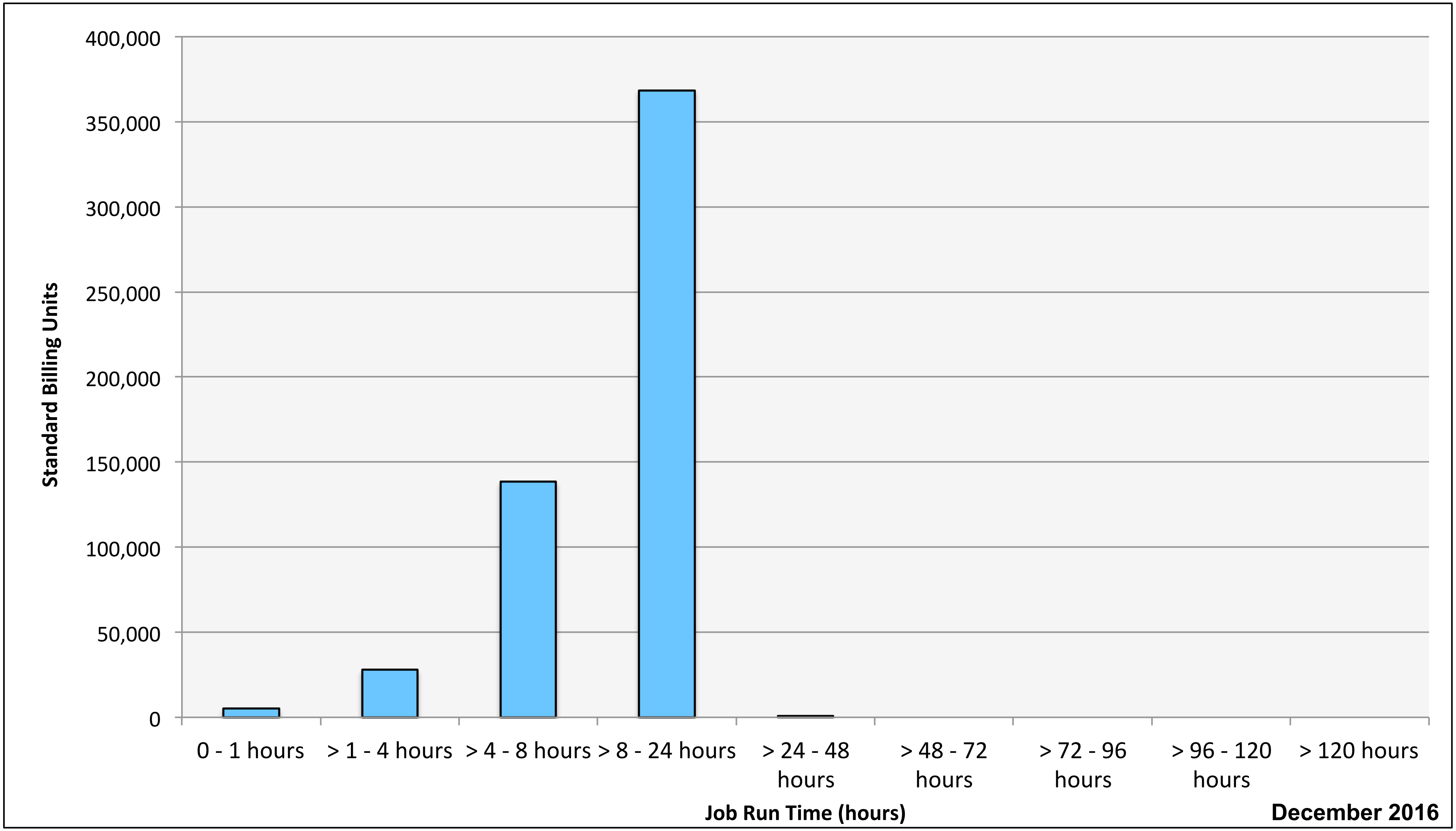
Endeavour: Average Expansion Factor



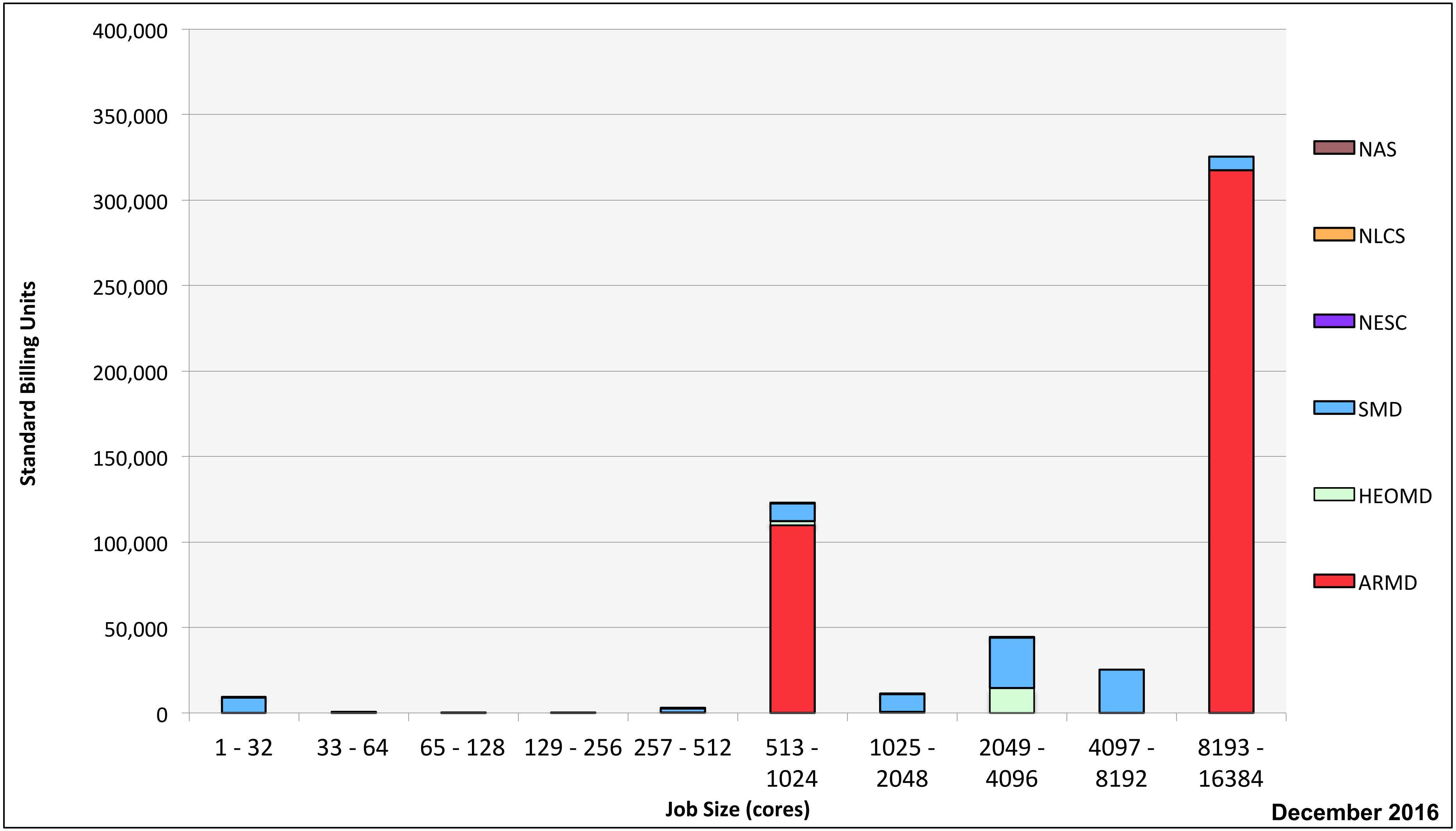
Merope: SBUs Reported, Normalized to 30-Day Month



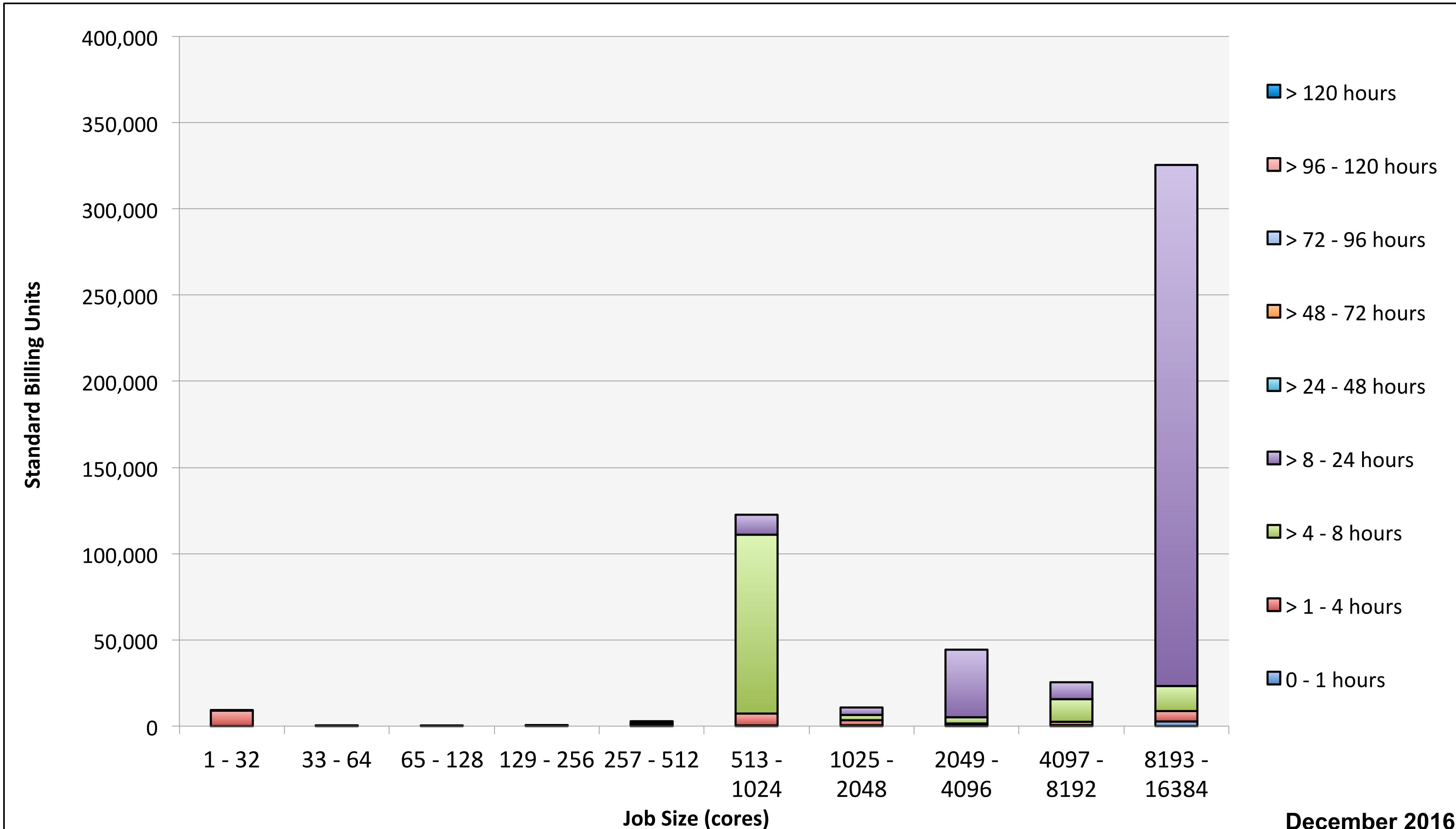
Merope: Monthly Utilization by Job Length



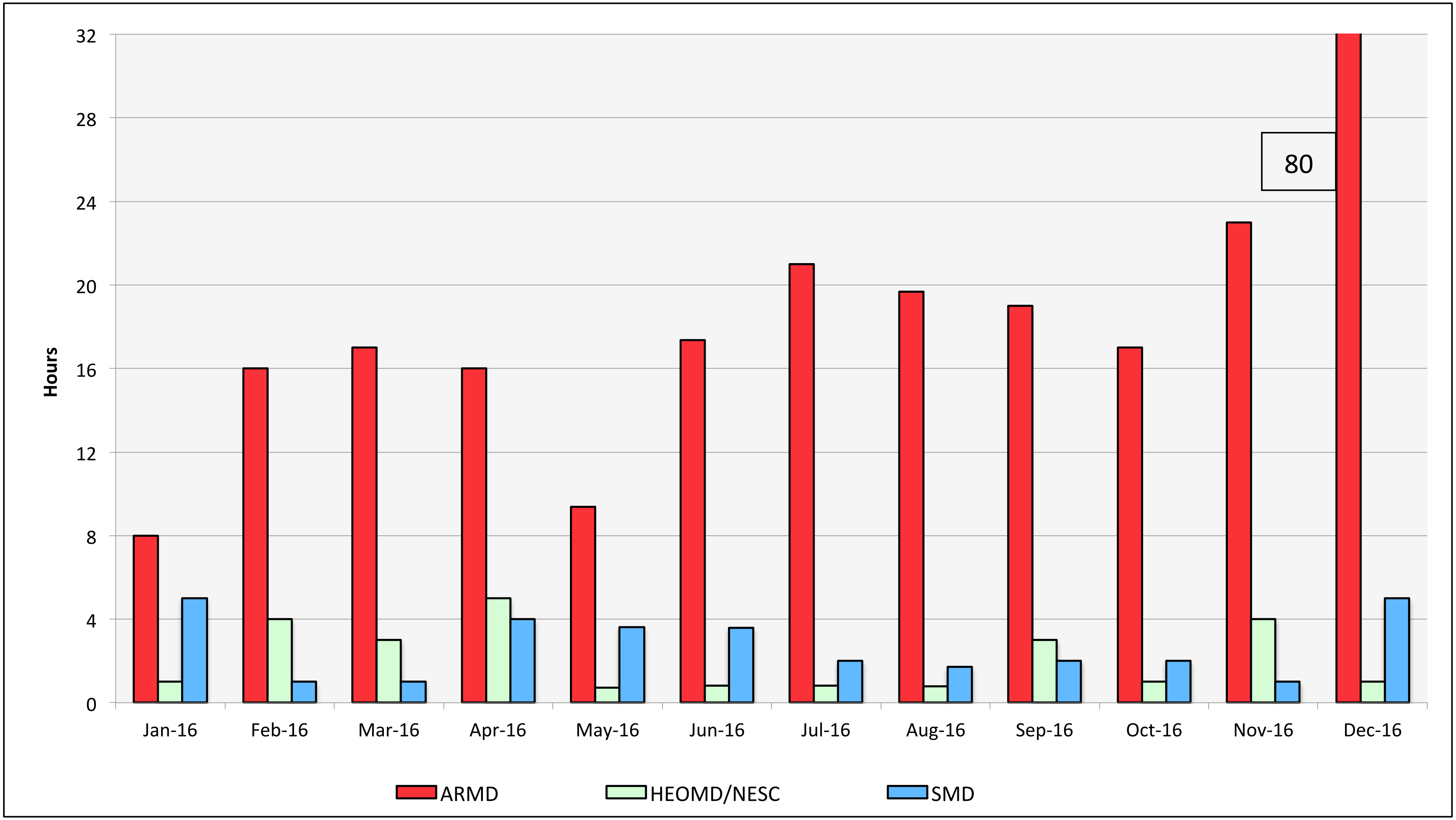
Merope:
Monthly Utilization by Size and Mission



Merope: Monthly Utilization by Size and Length



Merope: Average Time to Clear All Jobs



Merope: Average Expansion Factor