

National Aeronautics and Space Administration

High-End Computing Capability

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HECC Completes Hardware Component of Grace Hopper System Installation

- Vendor Supermicro delivered the Grace Hopper system to the NASA Advanced Supercomputing facility on September 30. The system consists of 350 NVIDIA Grace Hopper nodes and will provide additional graphics processing unit (GPU) capacity for HECC users.
- The initial installation process took approximately two weeks to complete and included:
  - Placed the 15 racks of equipment in two rows.
  - Completed adjustments for the cold water plumbing.
  - Installed the rear cooling doors on each of the racks.
  - Tested the compute nodes and the network performance.
- The vendor also ran the system through basic tests to demonstrate that the system met the required functionality. This included power-on tests, network bandwidth tests, and validation that the nodes are configured identically.
- HECC System Engineers are now beginning the system configuration activities that include software installation, system configuration, and system benchmarking. General user access is targeted for the first quarter of calendar year 2025.

IMPACT: The Grace Hopper system will provide more computational capacity to support HECC users' requirements.

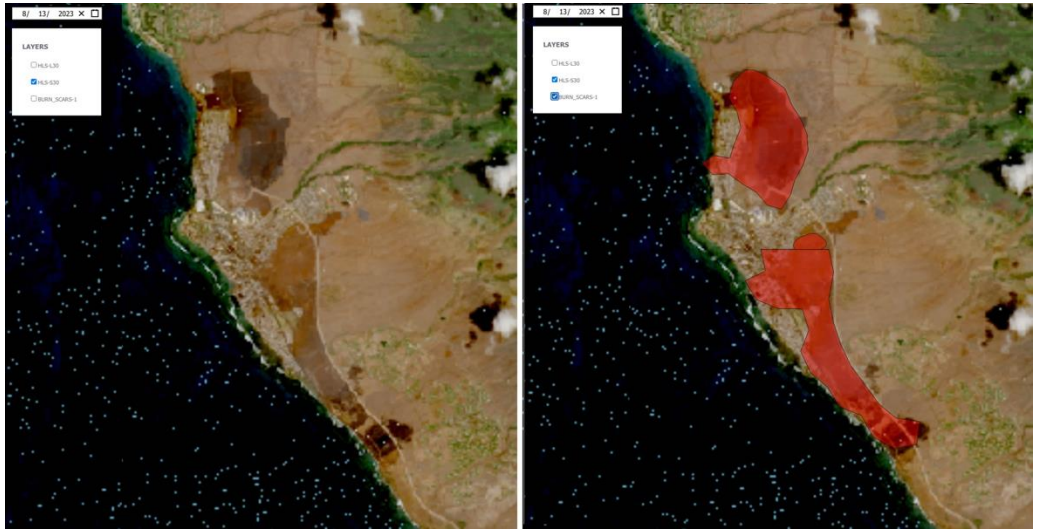


View of the water-cooled doors on the Grace Hopper system installed at the NASA Advanced Supercomputing facility. *Davin Chan, NASA/Ames*

SMD Constructs Foundation Models on Cabeus

- NASA's Science Mission Directorate (SMD) is assessing Foundation Models (FM) as tools to accelerate scientific investigations and forecasting.
  - FMs reduce the need for extensive task-specific data and training time.
  - A single FM can be fine tuned for a wide range of applications.
  - FMs often achieve state-of-the-art performance on various tasks.
- SMD's FM Playbook identifies computing infrastructure as essential.
- HECC fills three roles in the construction of FMs:
  - Processing the data to prepare it for use in pre-training or fine tuning.
  - Pre-training the model using dozens of GPU nodes on the Cabeus supercomputer for one week periods with multiple terabytes of data.
  - Enable experiments to assess model performance, using Cabeus and Pleiades.
- SMD's goal is to develop a foundation model for each division to experiment with and evaluate. The Earth Science Division (ESD) and Heliophysics Division (HPD) are furthest along: ESD has three; HPD has one.
- The science evaluations will determine credibility and acceptance by NASA science communities. Downstream applications compare FM output with existing studies of the same science, for example, the Lahaina, Hawaii burn scar.

IMPACT: NASA Foundation Models will democratize science by enabling broader use of remote sensing data, and will improve speed of discovery by the NASA science communities.

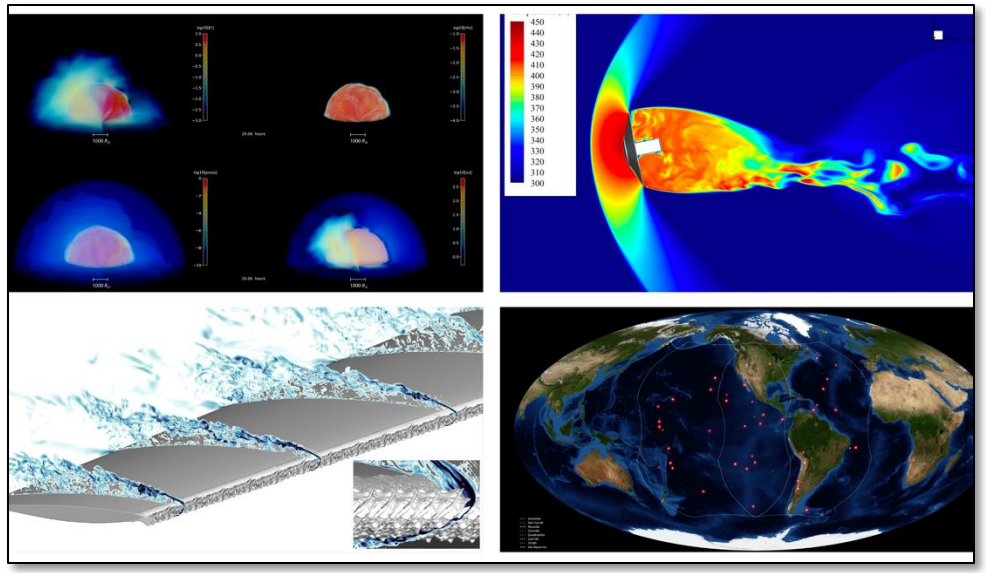


Foundation Models are evaluated using downstream applications, such as this comparison of burn scars from the 2023 Lahaina, Hawaii wildfires. *Ramachandran, NASA IMPACT Office*

New Allocation Period for Supercomputer Time Begins for NASA Mission Directorates

- The new operational period (NOP) for all NASA mission directorates began October 1.
- Mission directorates allocated approximately 175.8 million Standard Billing Units (SBUs) of CPU time and 52.3 million SBUs of GPU time to 721 projects.
  - The Aeronautics Research Mission Directorate allocated over 56 million CPU SBUs and 24.5 million GPU SBUs to 155 projects.
  - The Exploration Systems Development, Space Operations, and Space Technology mission directorates, and the NASA Engineering and Safety Center collectively allocated more than 50.9 CPU million SBUs and 6.8 million GPU SBUs to
    75 projects.
  - The Science Mission Directorate allocated more than 68.3 million CPU SBUs and 21 Million GPU SBUs to 491 projects.
- Requests exceeded capacity, so some allocations were reduced. Principal Investigators (PI) have been encouraged to request additional resources later in the fiscal year, if needed.
- The HEC Request Management System (RMS) provides a streamlined process and interface for PIs to manage their allocations.

IMPACT: NASA programs and projects periodically review the distribution of supercomputer time to assess demand for resources and assure consistency with mission-specific goals and objectives.



Clockwise from top left: Volume renderings of a supernova shock breakout; free-flight simulation showing the speed of aerodynamic flow around a planetary entry vehicle; still from a timelapse animation of detected bolides over four years of lightning data collection; snapshot of a simulation of flow over the outboard portion of a scaled Common Research Model wing with high-fidelity leading-edge ice.

HECC Successfully Completes 2024 Annual Inventory

- Property custodians responsible for HECC/NASA Advanced Supercomputing (NAS) facility property completed the 2024 Annual Equipment Inventory of more than 1,009 pieces of decaled equipment with a 100% scan rate.
- 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 FY24 included:
  - Tagged 74 new pieces of equipment.
  - Excessed 343 pieces of equipment.
  - Closed 173 tickets, most relating to equipment location and ownership updates.

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.



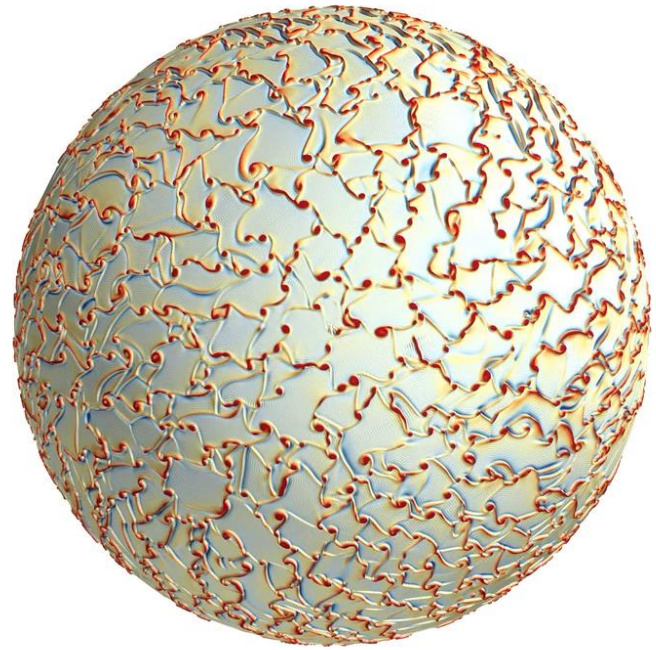
During the annual equipment inventory, HECC property custodians account for all equipment associated with the NASA Advanced Supercomputing (NAS) facility, including all components of the Pleiades supercomputer. *NASA*

Exploring Dynamics of the Deep Solar Interior*

- Deep beneath the solar surface, winds of ionized plasma regenerate and reorganize the solar field throughout the Sun's 22-year sunspot cycle.
  - Large wind patterns can be observed with modern telescopes and are similar to jet streams and large-scale circulations seen in Earth's atmosphere.
  - Beneath the large winds are thought to lie much smaller-scale wind patterns that are similar to tornadoes in structure; very little is understood about the detailed structure and wind speed of these small-scale winds that cannot be observed.
- Scientists at the Southwest Research Institute (SWRI) and the University of Colorado, Boulder (CU) explored how new observations might be leveraged to provide indirect insight into the structure and behavior of these small-scale winds.
- The science team ran 3D simulations of convecting solar plasma, typically produced using 4,000 cores on HECC's Pleiades supercomputer for 3–4 weeks at a time.
- The team found that the size and distribution of the small-scale plasma tornadoes are tightly linked to their wind speed and the structure of the large-scale winds that develop.
- Results are being used to examine the indirect observational consequences of these small-scale motions, such as their spatial scale and lifetime, which are otherwise impossible to observe directly.

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

IMPACT: These findings contribute to NASA's goal to better understand how the universe works and help protect our technology and astronauts in space.



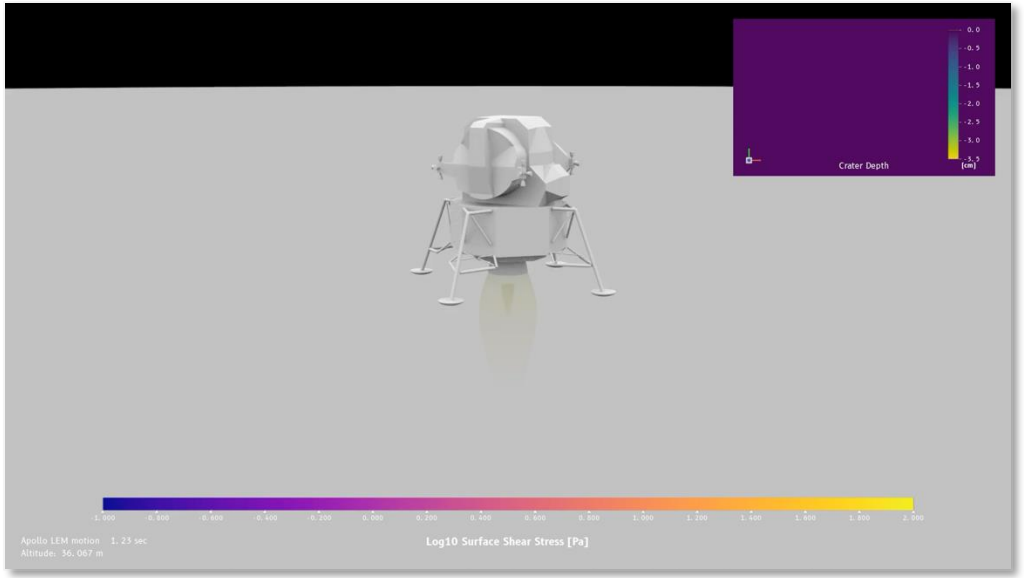
3D visualization of simulated, 160-mph plasma tornadoes near the solar surface as viewed from the north pole of the Sun. *Lydia Korre, Catherine Blume, University of Colorado, Boulder; Nick Featherstone, Southwest Research Institute*

New Tools for Modeling Plume-Surface Interactions*

- Using HECC resources, researchers from the Fluid Dynamics Branch at NASA's Marshall Space Flight Center performed plume-surface interaction (PSI) simulations between lander engine plumes and unprepared regolith surfaces.
  - To support NASA's goal to land the next human on the Moon, it is crucial have a better understanding of how future landing spacecraft will interact with the unique properties of regolith—the layer of loose, unconsolidated dust and rock on the lunar surface—which can cause hazards like visual obstructions, particulate clouds, and cratering of the landing zone.
- The team developed new computational tools to predict PSI environments for NASA projects and missions including the Human Lander System (HLS), Commercial Lunar Payload Services (CLPS), and future Mars landers.
  - The tools allow the researchers to determine how to best meet simulation and time requirements for each project by varying model fidelity. The highest fidelity tool, the Gas Granular Flow Solver (Loci/GGFS), models gas-particle multi-phase interactions to predict regolith cratering and ejection of particles into the area surrounding the lander.
  - The team also incorporated engineering models into their software suite to create production-ready hybrid tools with reduced fidelity. At the lowest fidelity, the computational fluid dynamics (CFD) code Loci/CHEM+DIGGEM can predict crater depth over time by relating local CFD-predicted surface shear stresses to a model of erosion mass flux.
- Future code optimization and increases in computing resources will allow NASA researchers to make better use of higher fidelity tools for lunar mission planning, while still maintaining production-level runtimes.

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

IMPACT: The new computational tools are already being used to predict cratering and visual obscuration on NASA's upcoming CLPS and HLS missions, as well as for long-term lunar site planning.

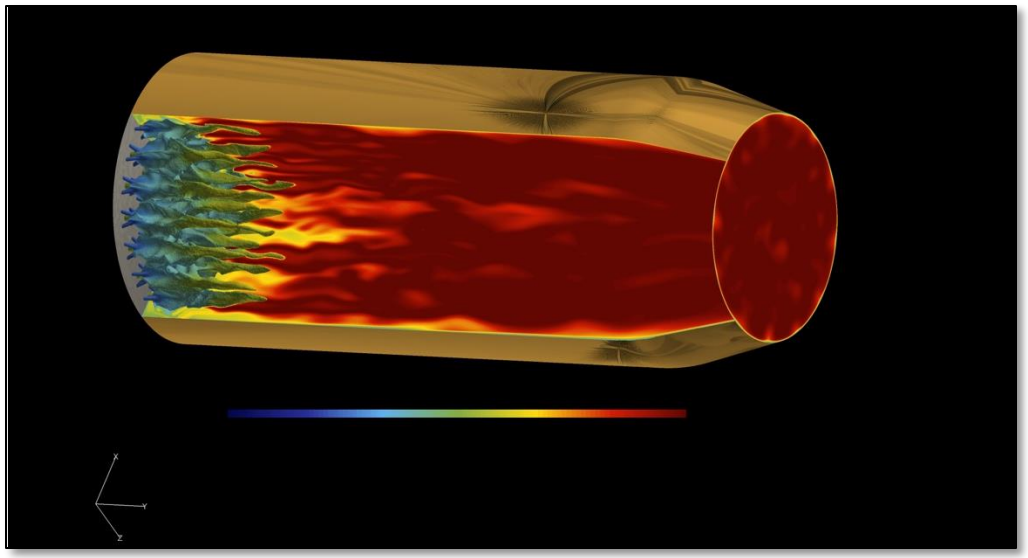


In this simulation of the Apollo 12 landing, a crater depth of 1.5 centimeters is predicted at engine shut-off, which matches the estimated actual depth. The Loci/CHEM+DIGGEM code reduces model fidelity and computational needs by eliminating the particle phase, allowing for quicker turnaround.
Andrew Weaver, NASA/Marshall; Patrick Moran, NASA/Ames

Simulating Rocket Engine Combustion New Fuels*

- As NASA develops vehicles to take humans to the Moon, Mars, and beyond, new engine systems are needed to guide these spacecraft to their destinations. While hydrogen fuel was used in the Apollo-era lunar landing missions, methane fuel has become a popular choice for in-space propulsion as it allows for smaller storage tanks.
- However, methane and oxygen-powered engines are relatively new technologies that requires analysis tools capable of predicting their performance and in-flight behavior, so researchers at NASA's Marshall Space Flight Center are using the CFD tool Loci-STREAM to model the complex, combusting flow inside various engine design concepts.
- The team conducted CFD simulations on the Aitken supercomputer of reacting flow inside oxygen-methane spacecraft engine design concepts, requiring about 9.6 million processor hours over a period of 2.5 months.
- Loci-STREAM's compressible thickened-flame flamelet model was found to significantly reduce computational resource requirements, and this approach, combined with HECC systems, enabled efficient modeling of an engine with hundreds of injector elements.
- A combustion stability model is being developed using flame responses extracted from these simulations, and future model improvements will enable simulations of time-varying engine start-up and shutdown operations.

IMPACT: The computational analysis of new fuel performance is helping NASA engineers to make design recommendations for future engine hardware development, faster and at a lower cost than real-world experiments.



Section view through the rocket combustion chamber showing the gas temperature of burning methane and oxygen. Blue contours indicate cold temperature, while red contours are the hottest regions of gas. The 3D isosurface shows the injection of the methane and oxygen and the initial reactions, which occur at relatively low temperature.
Brian Richardson, NASA Marshall Space Flight Center

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

Papers

- "**A Sub-Earth-Mass Planet Orbiting Barnard's Star: No Evidence of Transits in TESS Photometry**," A. K. Stefanov, et al., arXiv:2410.00577 [astro-ph.EP], October 1, 2024. *
  https://arxiv.org/abs/2410.00577
- "**Reconstructing Galaxy Cluster Mass Maps using Score-based Generative Modeling**," A. Hsu, et al., arXiv:2410.02857 [astro-ph.CO], October 3, 2024. *
  https://arxiv.org/abs/2410.02857
- "**Spectral Calculations of 3D Radiation Magnetohydrodynamic Simulations of Super-Eddington Accretion onto Stellar-mass Black Hole**," B. Mills, et al., *The Astrophysical Journal*, vol. 974, no. 2, published online October 10, 2024. *
  https://iopscience.iop.org/article/10.3847/1538-4357/ad6b21/meta
- "**K2-370 b: A Strongly Irradiated sub-Neptune Transiting a Very Active Solar-Type Star**," A. Sozzetti, et al., *Monthly Notices of the Royal Astronomical Society*, vol. 535, issue 1, published online October 11, 2024. *
  https://academic.oup.com/mnras/article/535/1/531/7819156
- "**On the Nature of Nonthermal Broadening of Spectral Lines Observed by IRIS**," K. Cho, et al., *The Astrophysical Journal*, vol. 975, no. 1, published online October 23, 2024. *
  https://iopscience.iop.org/article/10.3847/1538-4357/ad7586/meta
- "**Accreting Neutron Stars in 3D General-Relativistic Magnetohydrodynamic Simulations: Jets, Magnetic Polarity, and the Interchange Slingshot**," K. Parfrey, et al., *The Astrophysical Journal*, vol. 975, no. 1, October 24, 2024. *
  https://iopscience.iop.org/article/10.3847/1538-4357/ad737b/meta

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

Papers (cont.)

- "**Estimating Carbon Dioxide Emissions in Two California Cities Using Bayesian Inversion and Satellite Measurements**," S. Hamilton, et al., *Geophysical Research Letters*, vol. 51, issue 20, published online October 25, 2024. * https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2024GL111150
- "**Electron Acceleration in Magnetic Islands in Quasi-Parallel Shocks**," N. Bessho, et al., *The Astrophysical Journal*, vol. 975, no. 1, published online October 28, 2024. * https://iopscience.iop.org/article/10.3847/1538-4357/ad7678/meta
- "**Non-LTE Synthetic Observables of a Multidimensional Mode of Type Ia Supernovae**," S. Boos, et al., arXiv:2410.22276 [astro-ph.HE], October 29, 2024. * https://arxiv.org/abs/2410.22276
- "**Capturing Turbulence with Numerical Dissipation: A Simple Dynamical Model for Unresolved Turbulence in Hydrodynamic Simulations**," V. Semenov, arXiv:2410.23339 [astro-ph.GA], October 30, 2024. * https://arxiv.org/abs/2410.23339

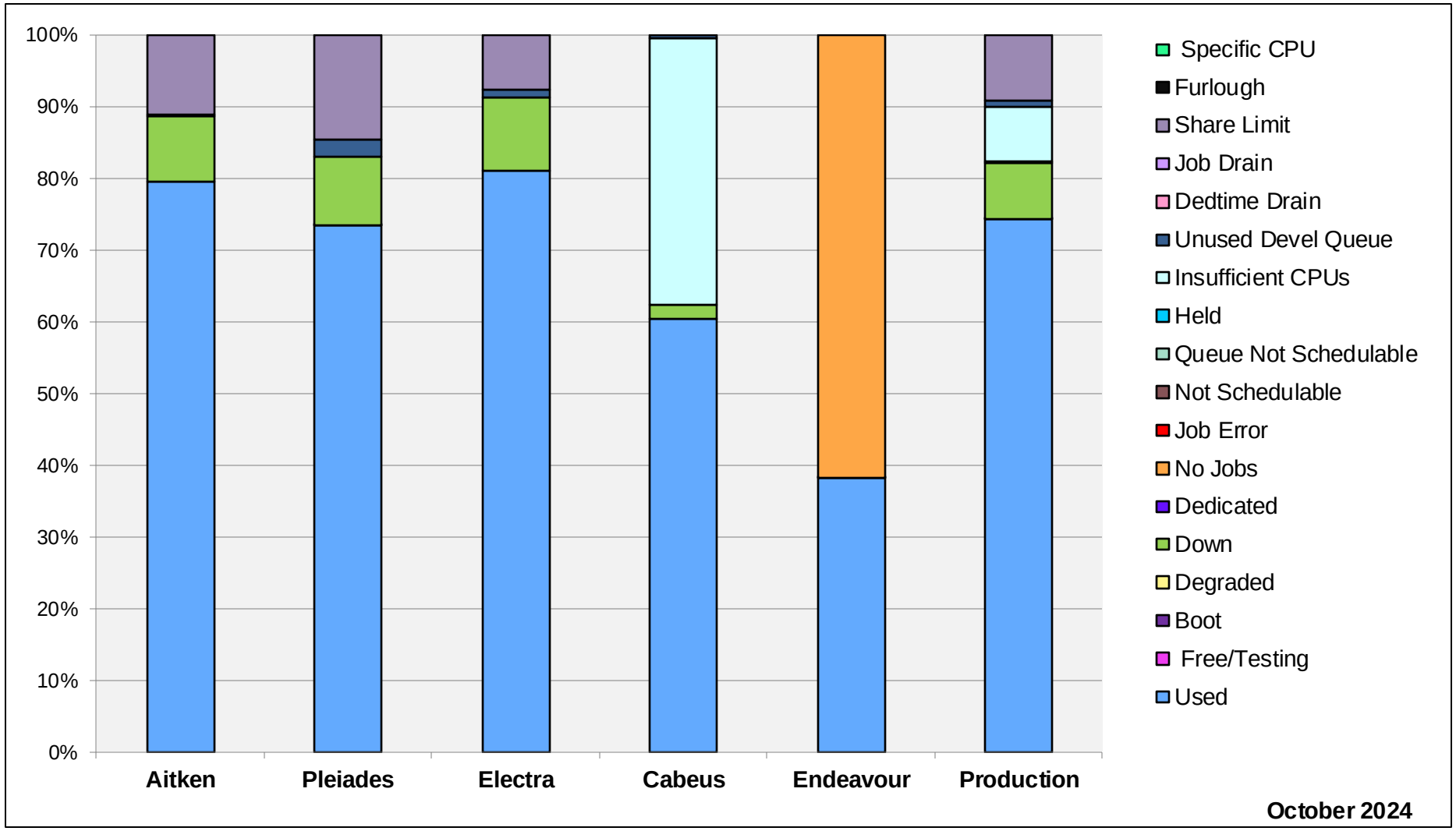
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Presentations

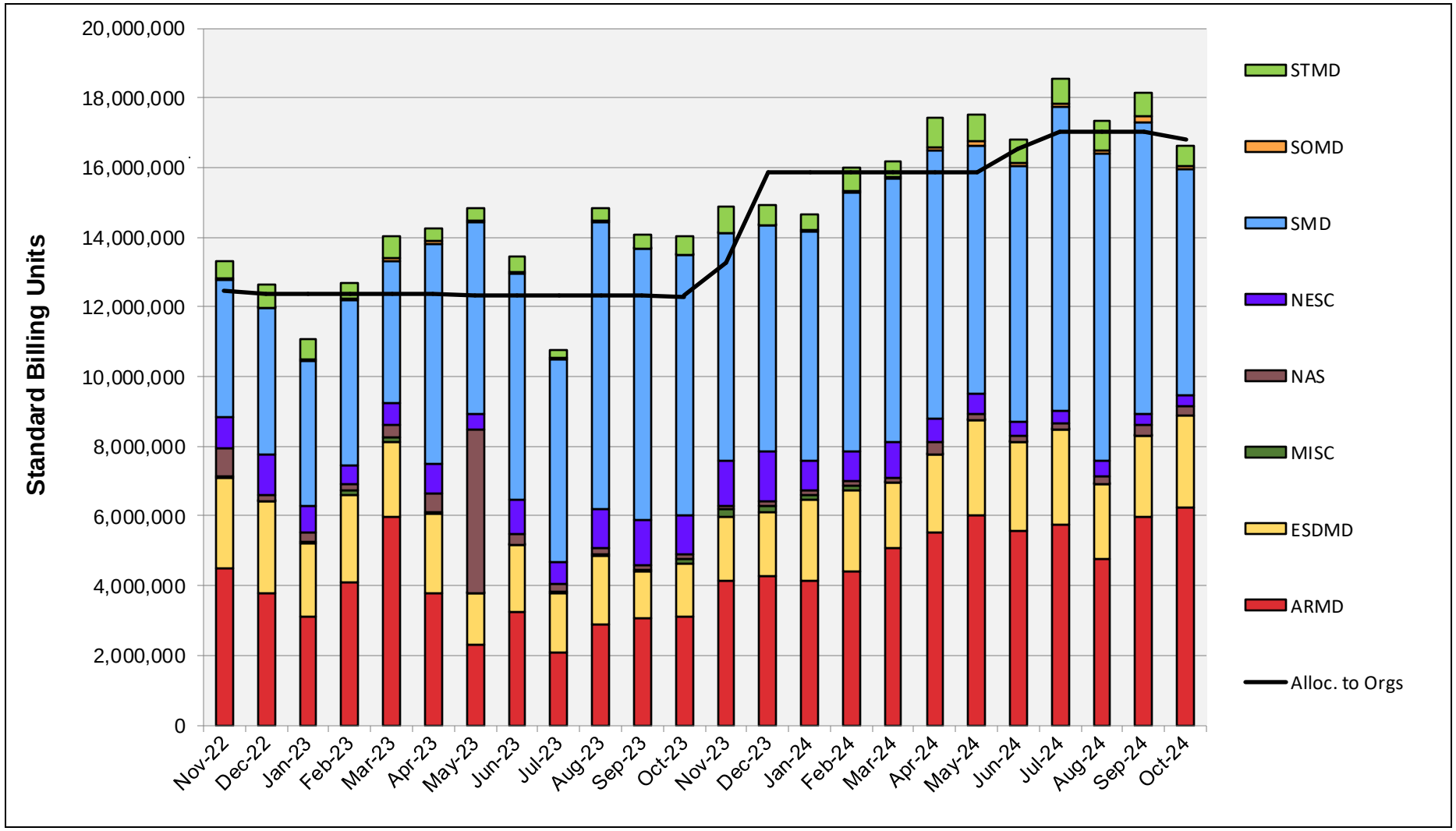
- "**Global Solar Activity Data Portal for Long-Term Forecasting**," I. Kitiashvili, et al, presented at the Operational and Exploration Requirements and Research Capabilities for SEP Environment workshop, Atlanta, Georgia, October 16-19, 2024. *

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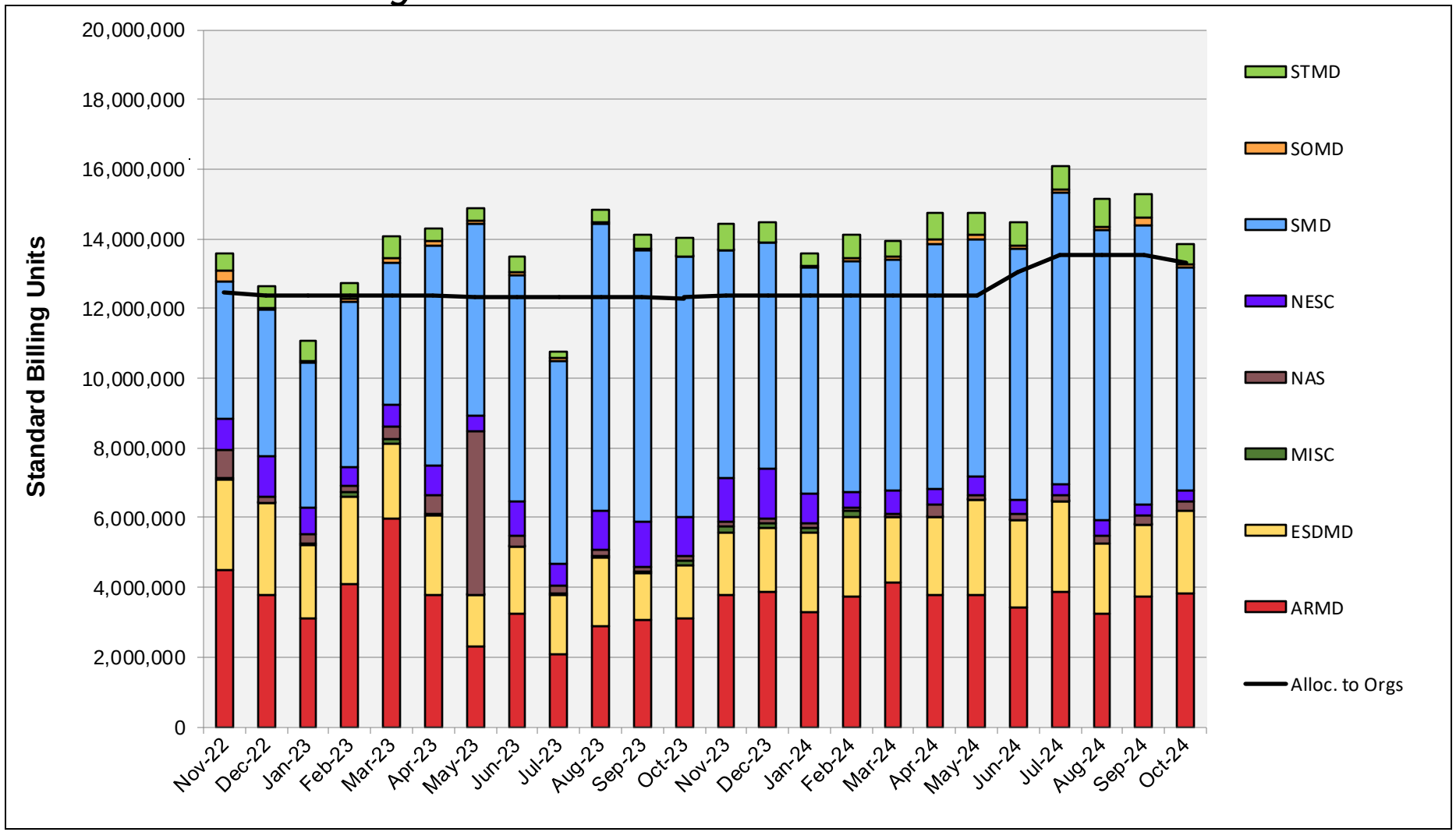
HECC Utilization



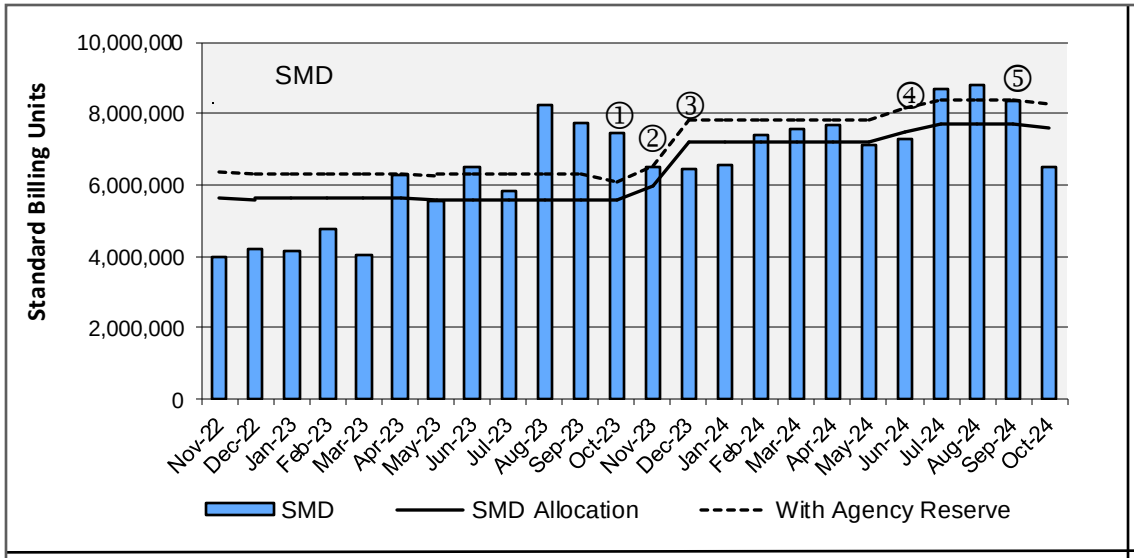
HECC Utilization Normalized to 30-Day Month

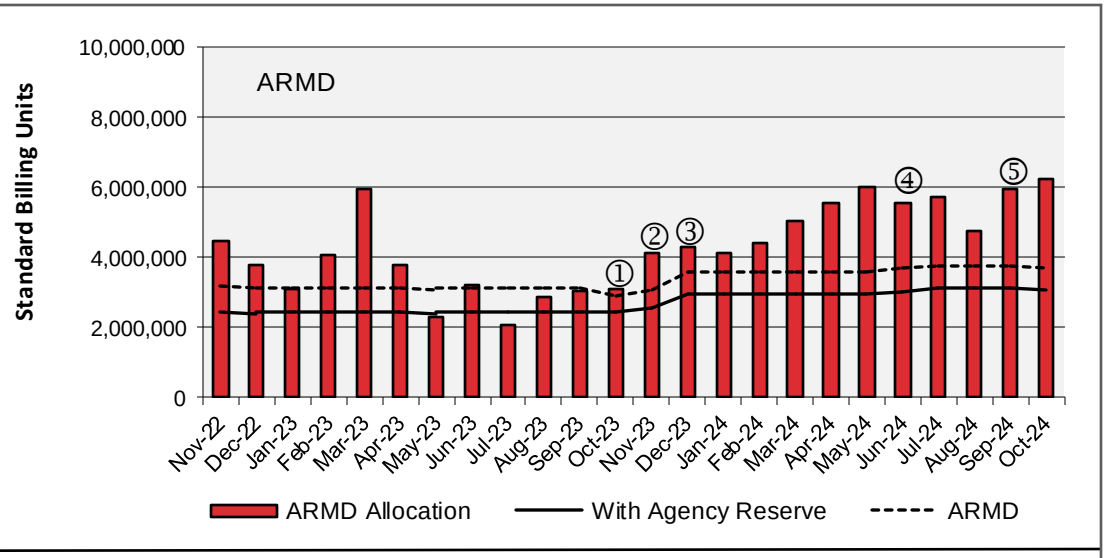


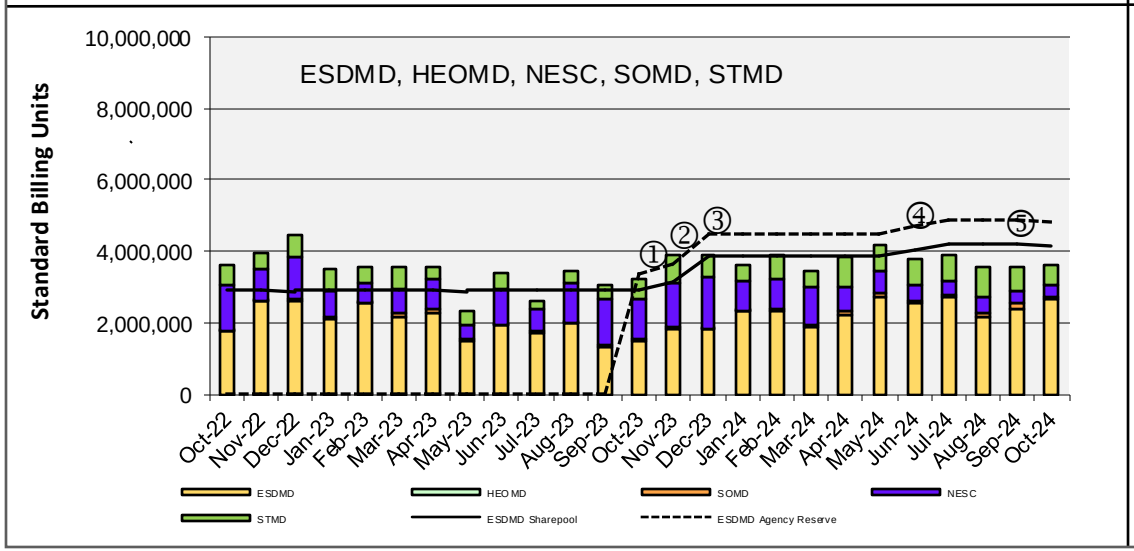
HECC Utilization CPU Only
Normalized to 30-Day Month



HECC Utilization Normalized to 30-Day Month







① 4 Rome Apollo Racks added to Aitken

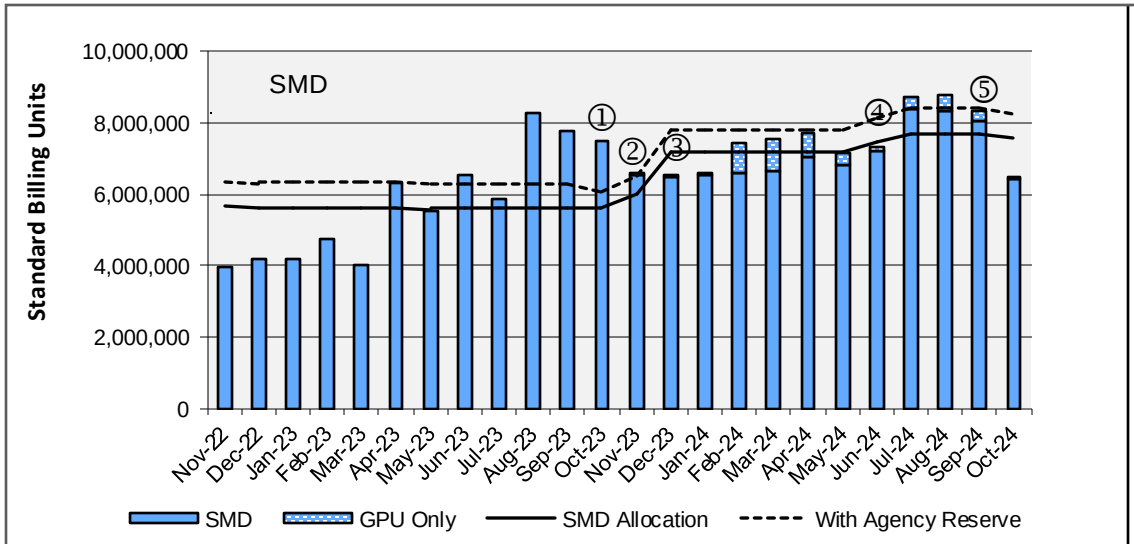
② Cabeus v100 nodes added

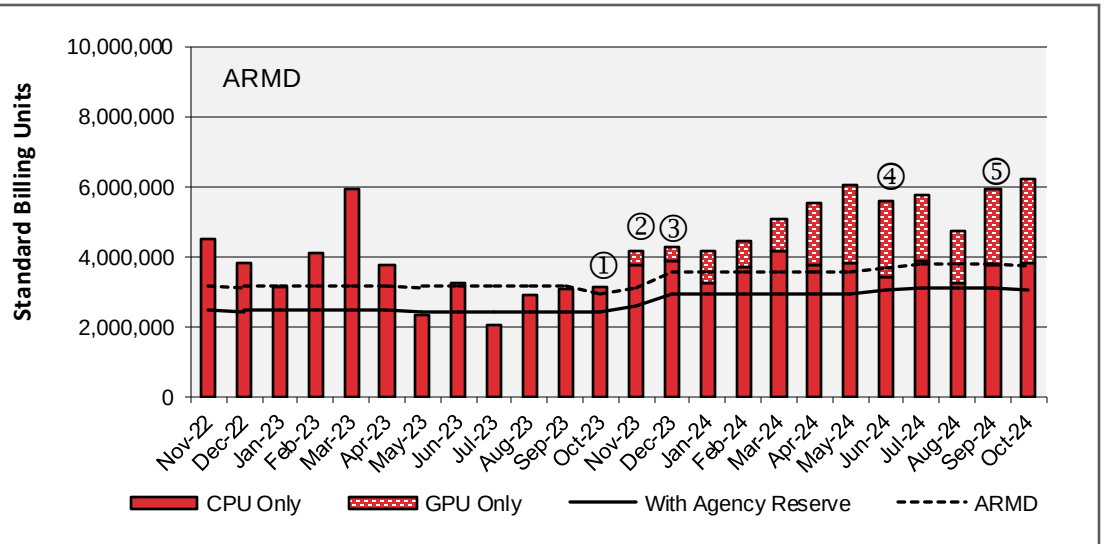
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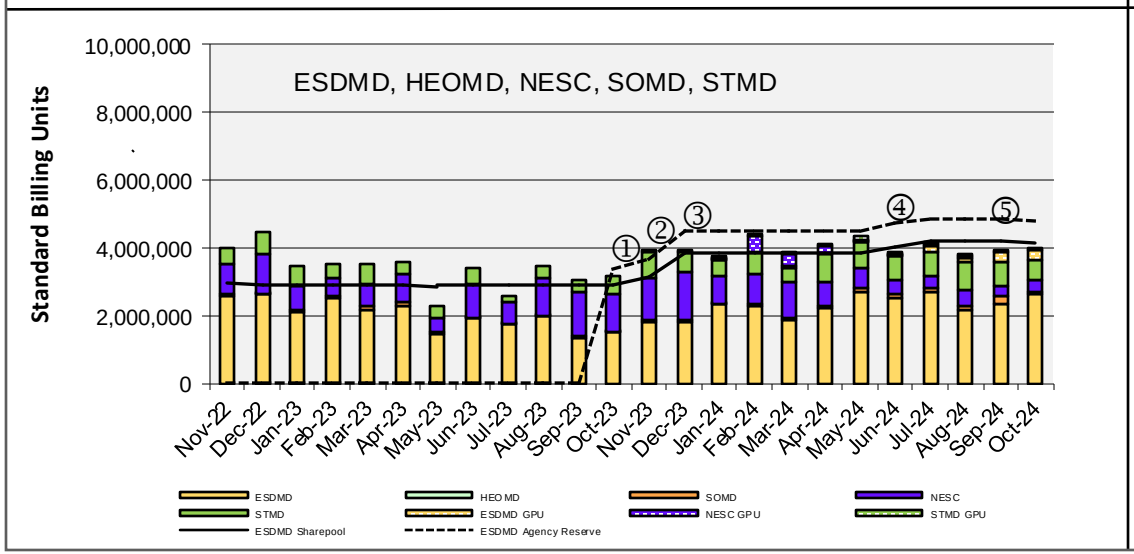
④ Aitken Milan Nodes added

⑤ Sandy Bridge temporarily removed

HECC Utilization Normalized to 30-Day Month







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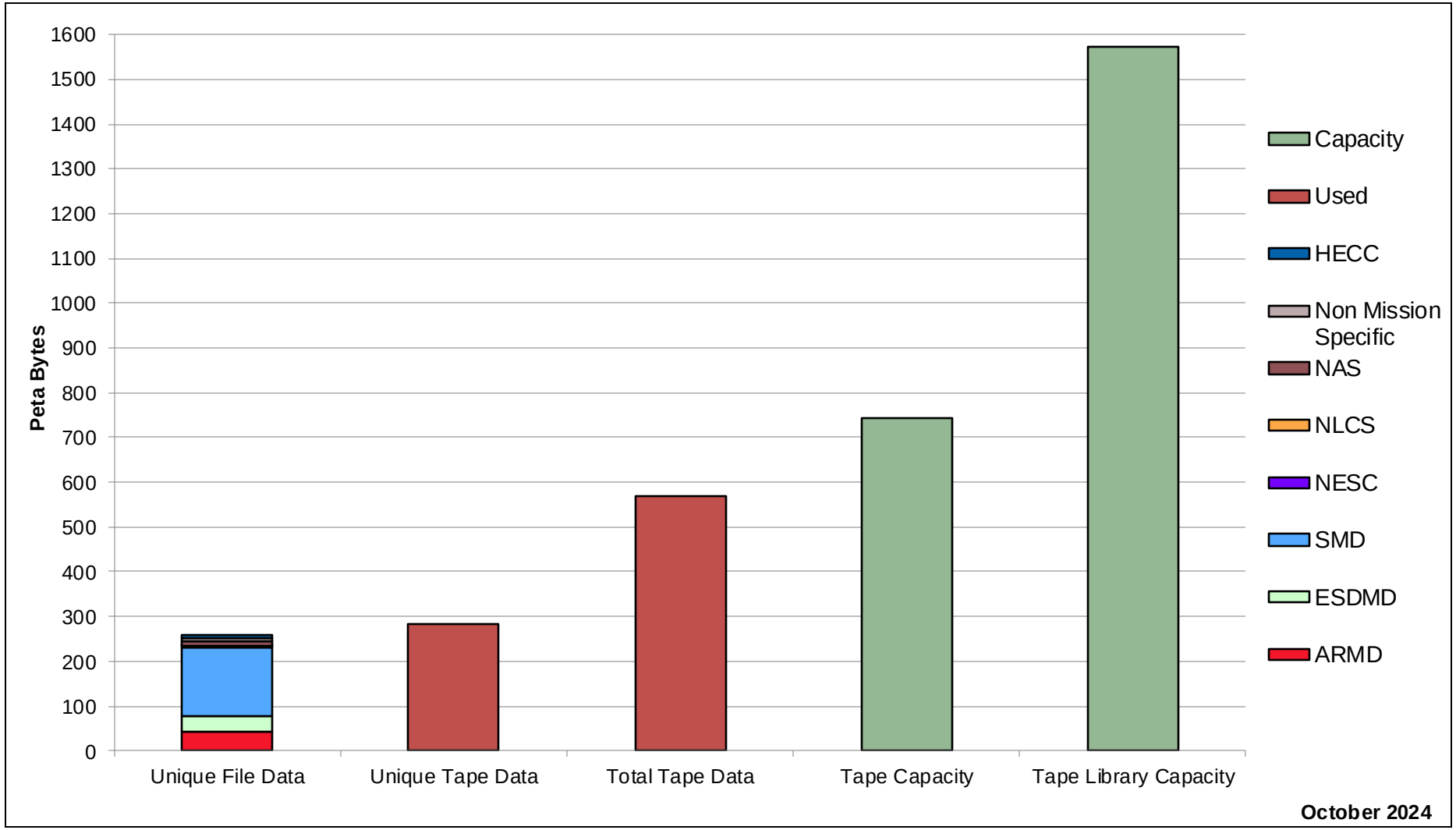
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③ Cabeus Milan a100 nodes added

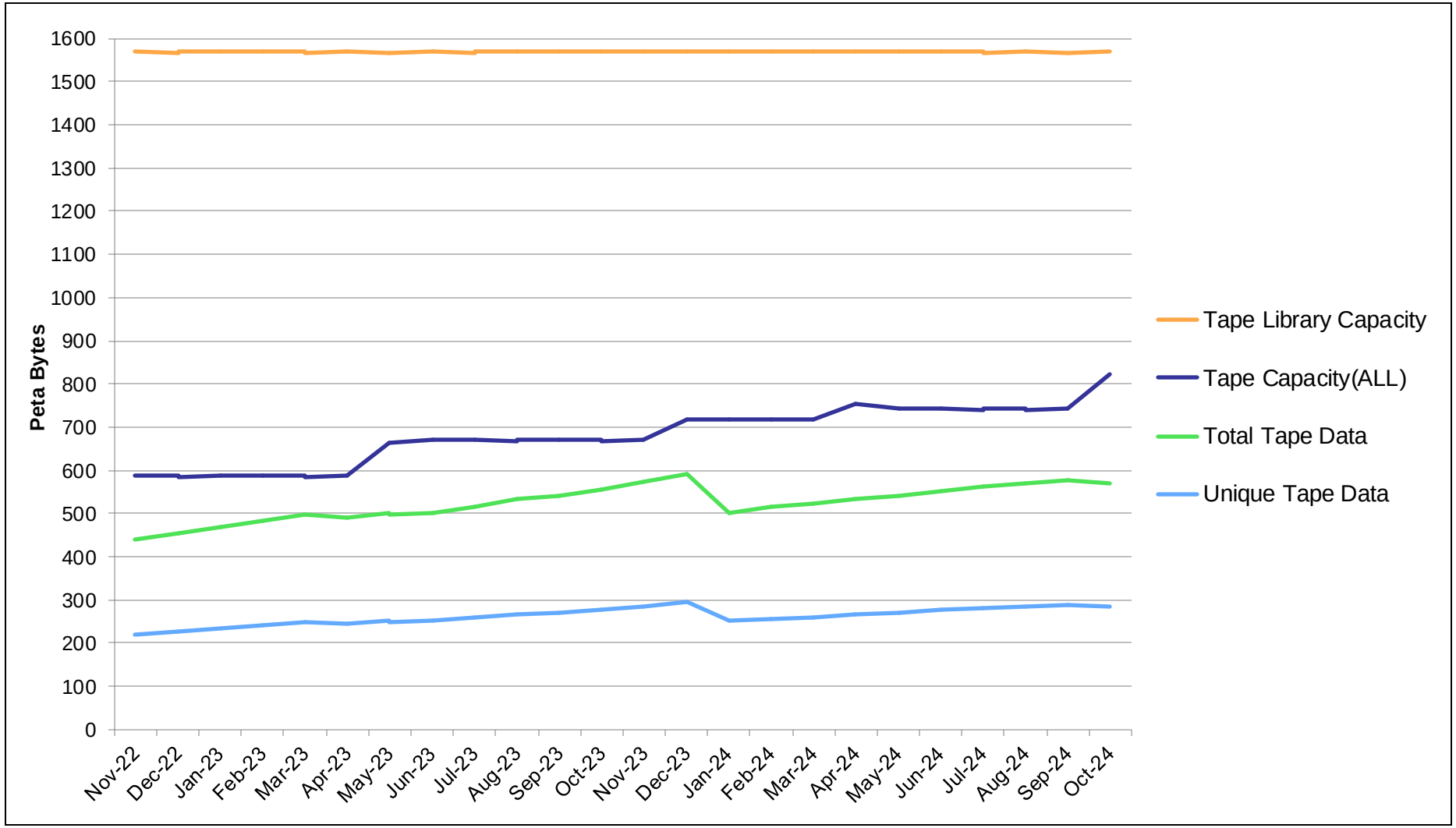
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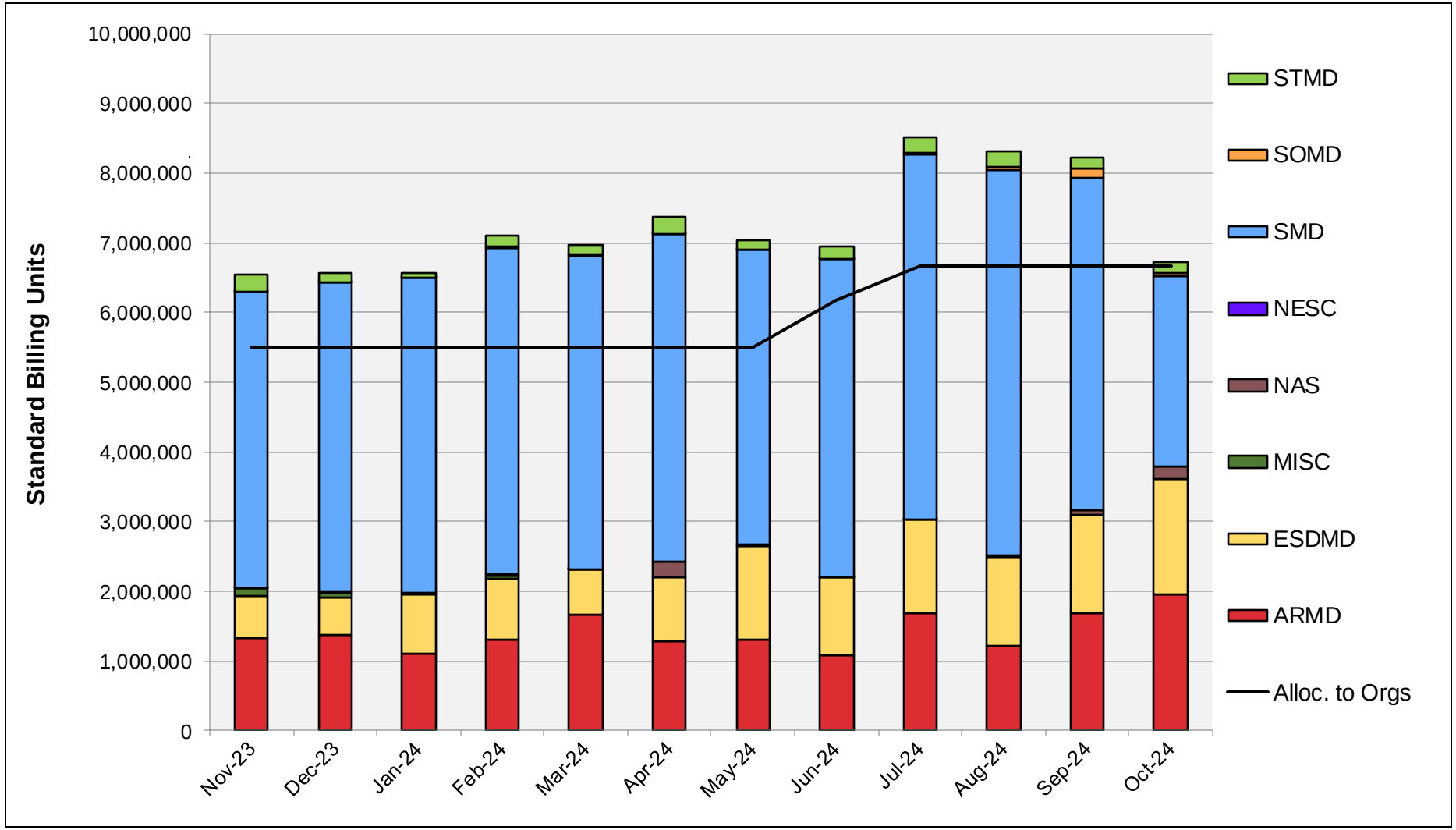
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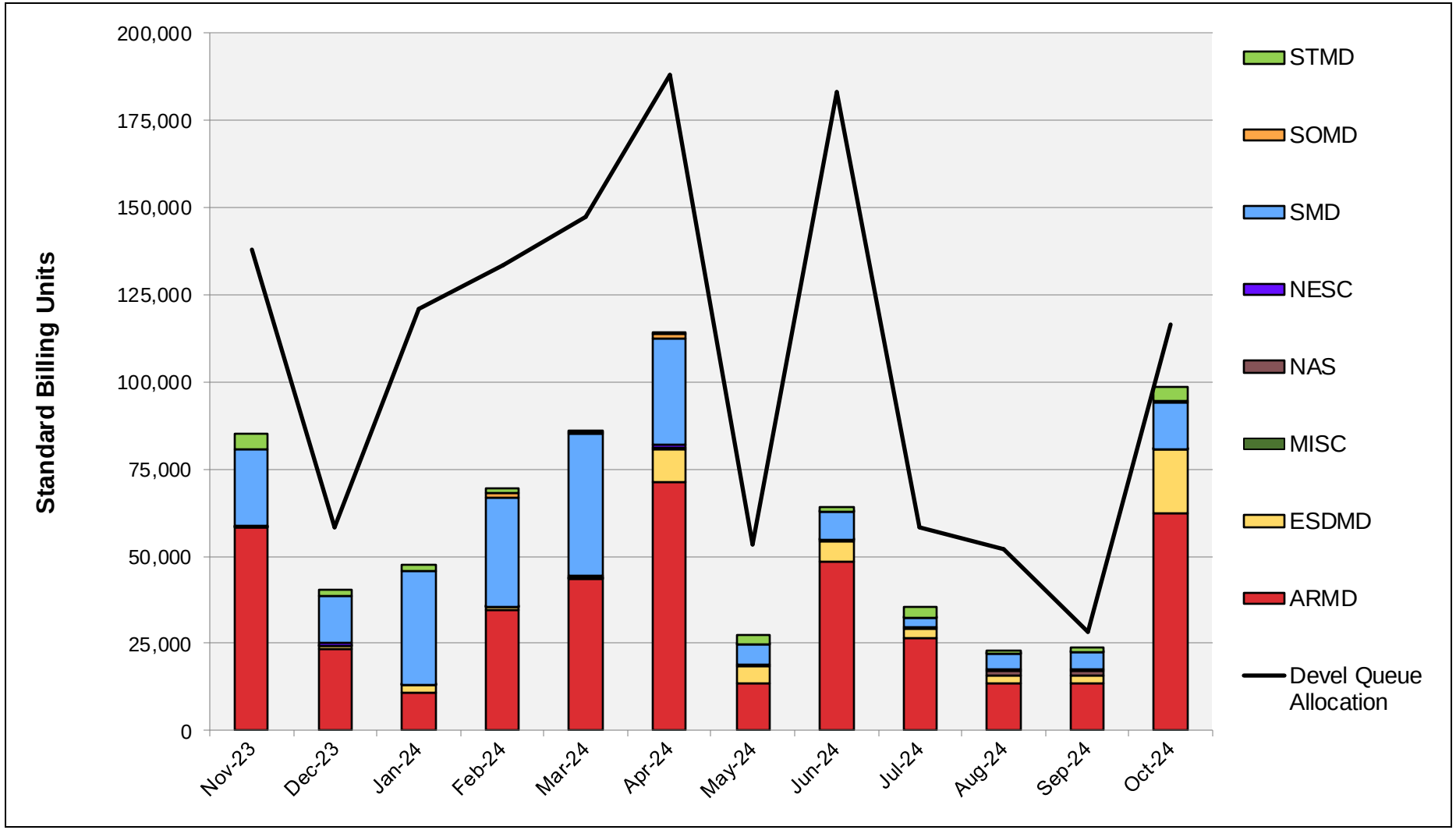
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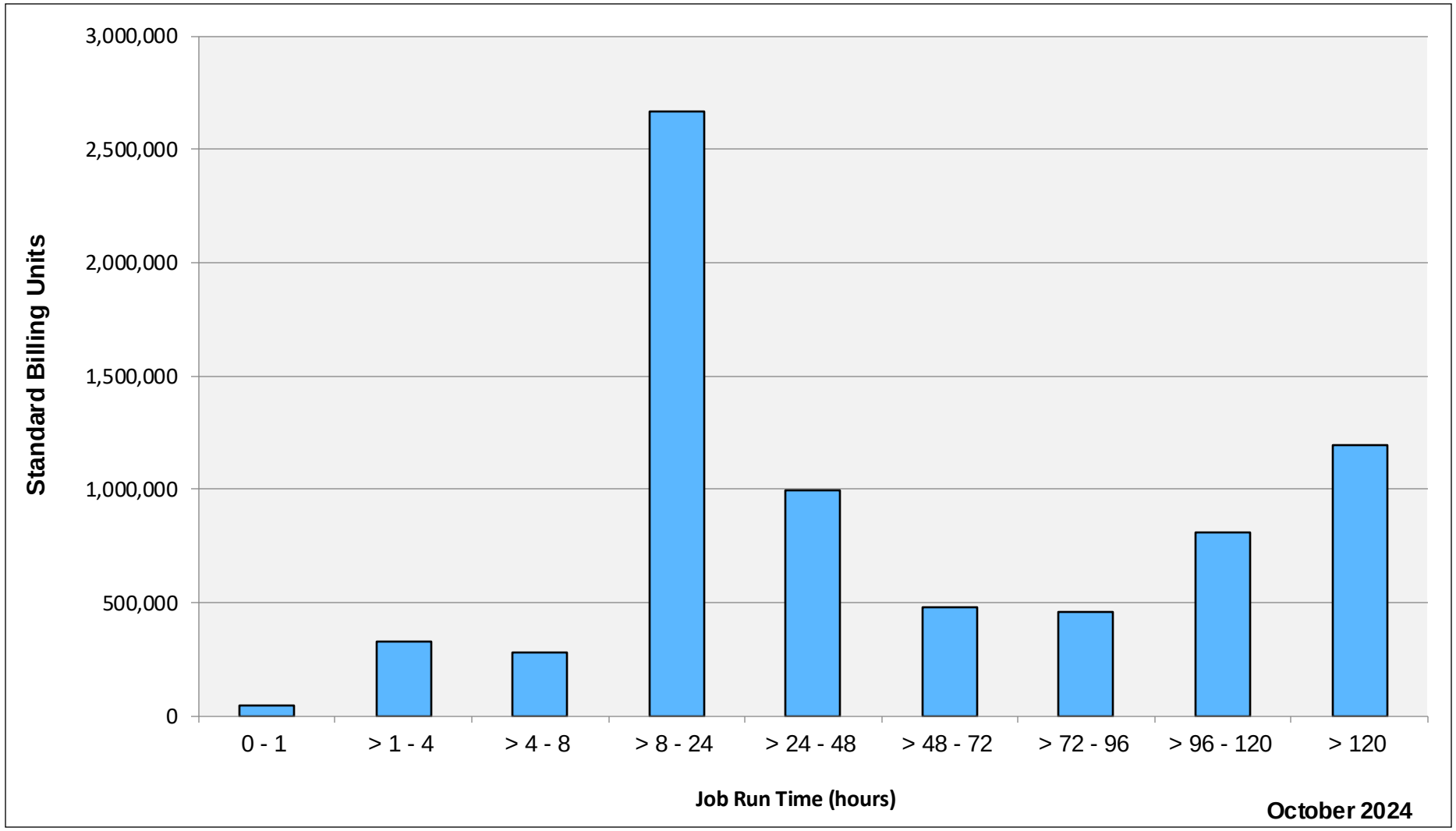
Aitken: SBUs Reported, Normalized to 30-Day Month



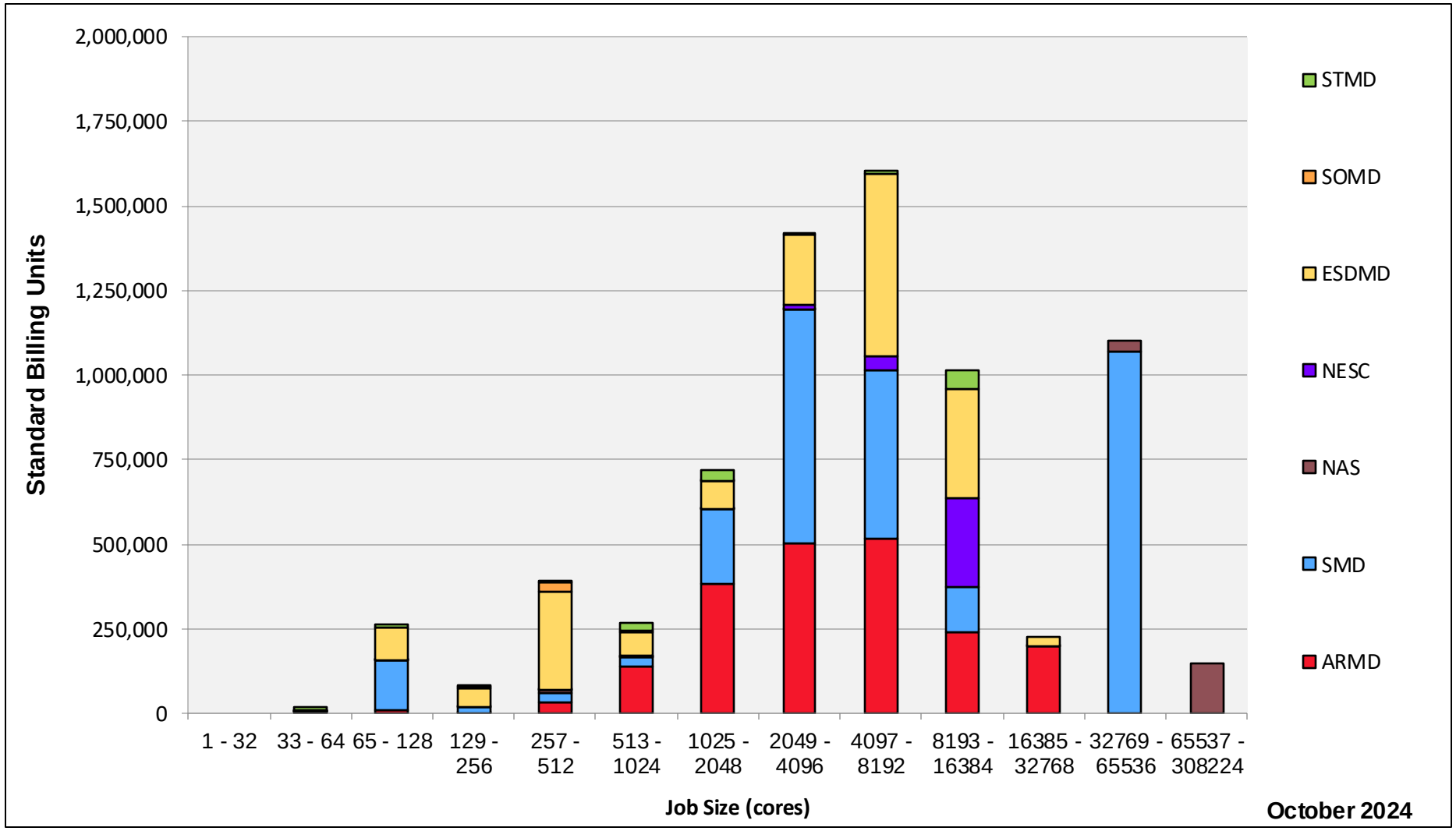
Aitken: Devel Queue Utilization



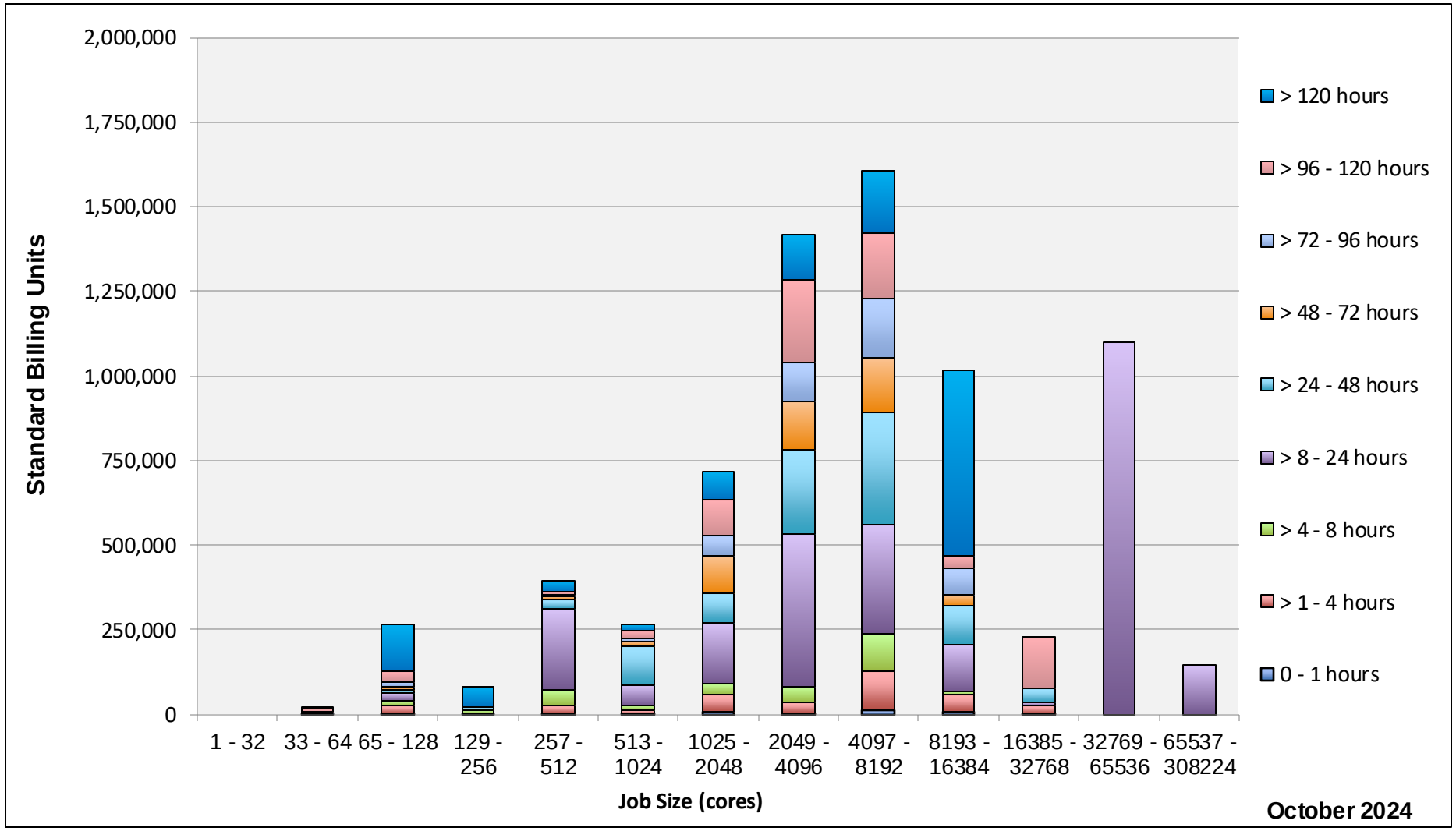
Aitken: Monthly Utilization by Job Length



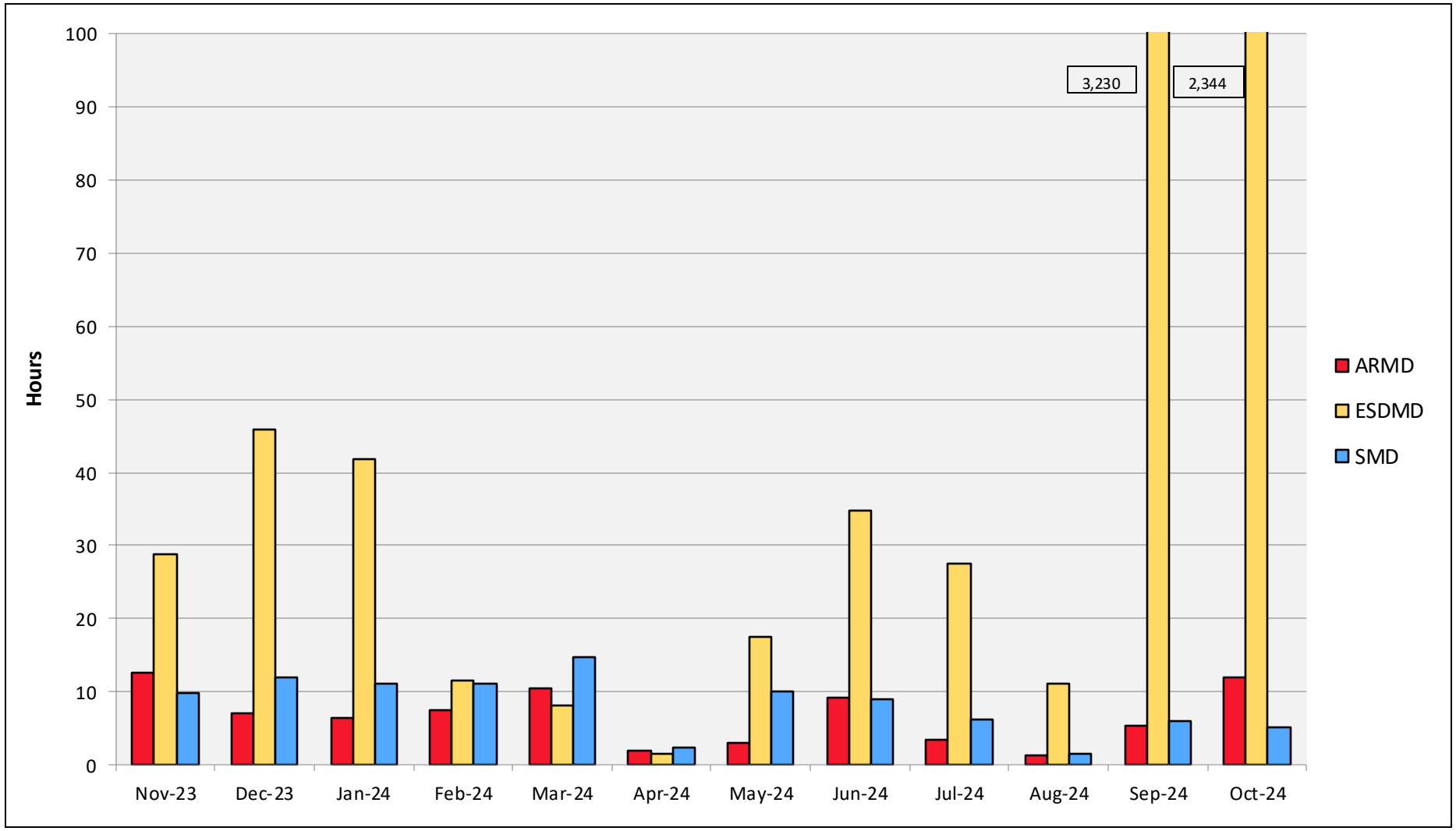
Aitken: Monthly Utilization by Job Size



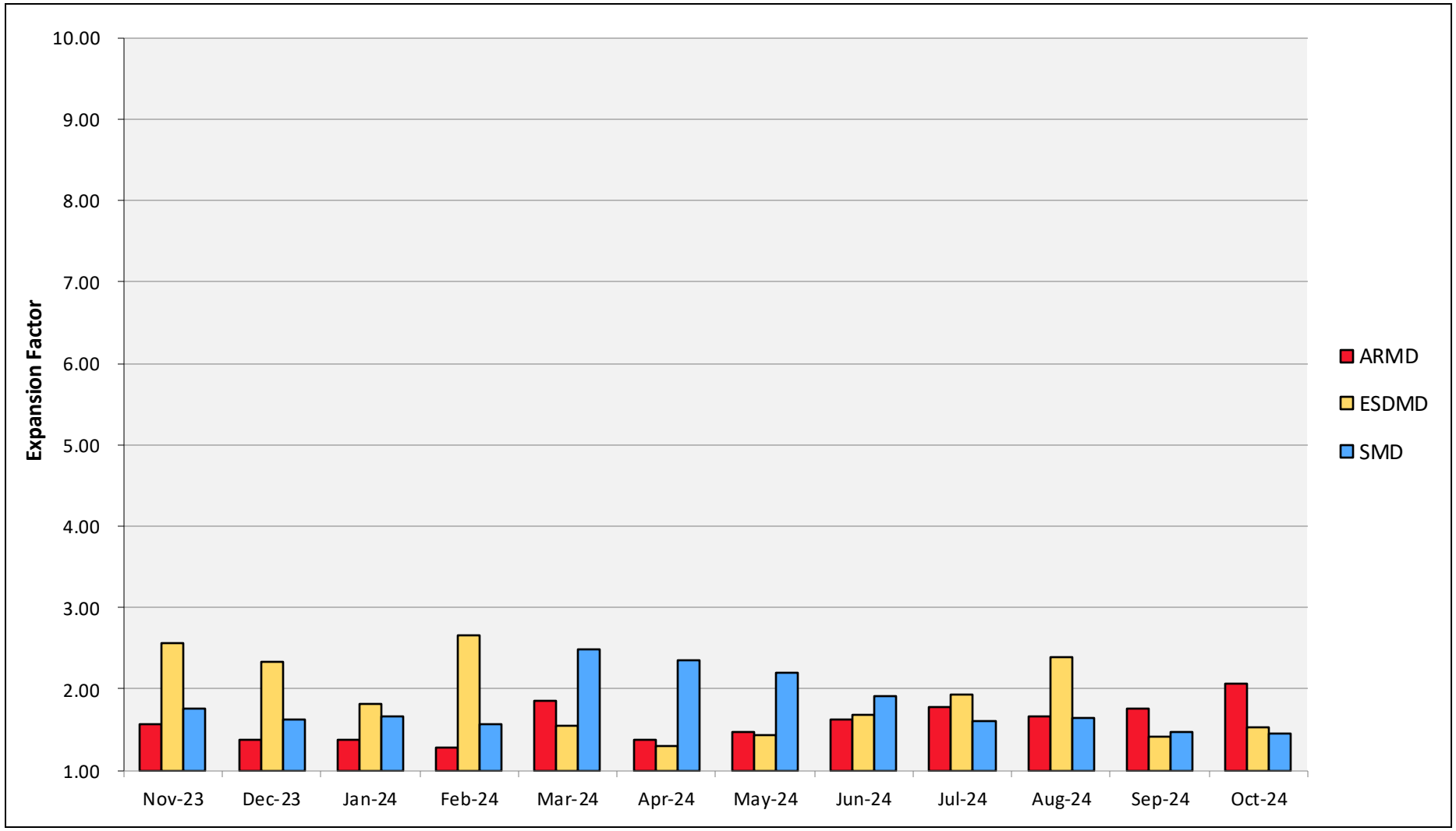
Aitken: Monthly Utilization by Size and Length



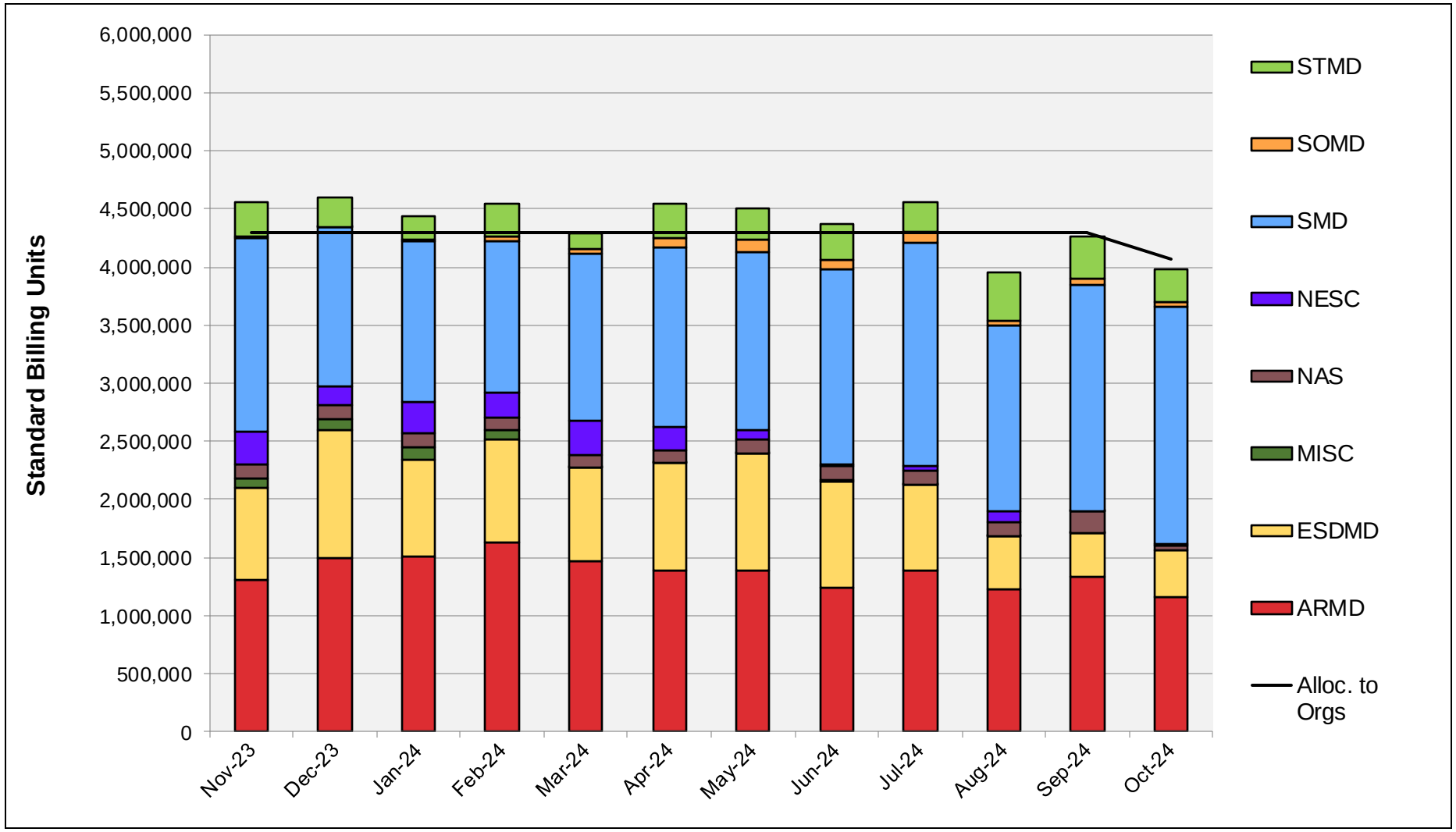
Aitken: Average Time to Clear All Jobs



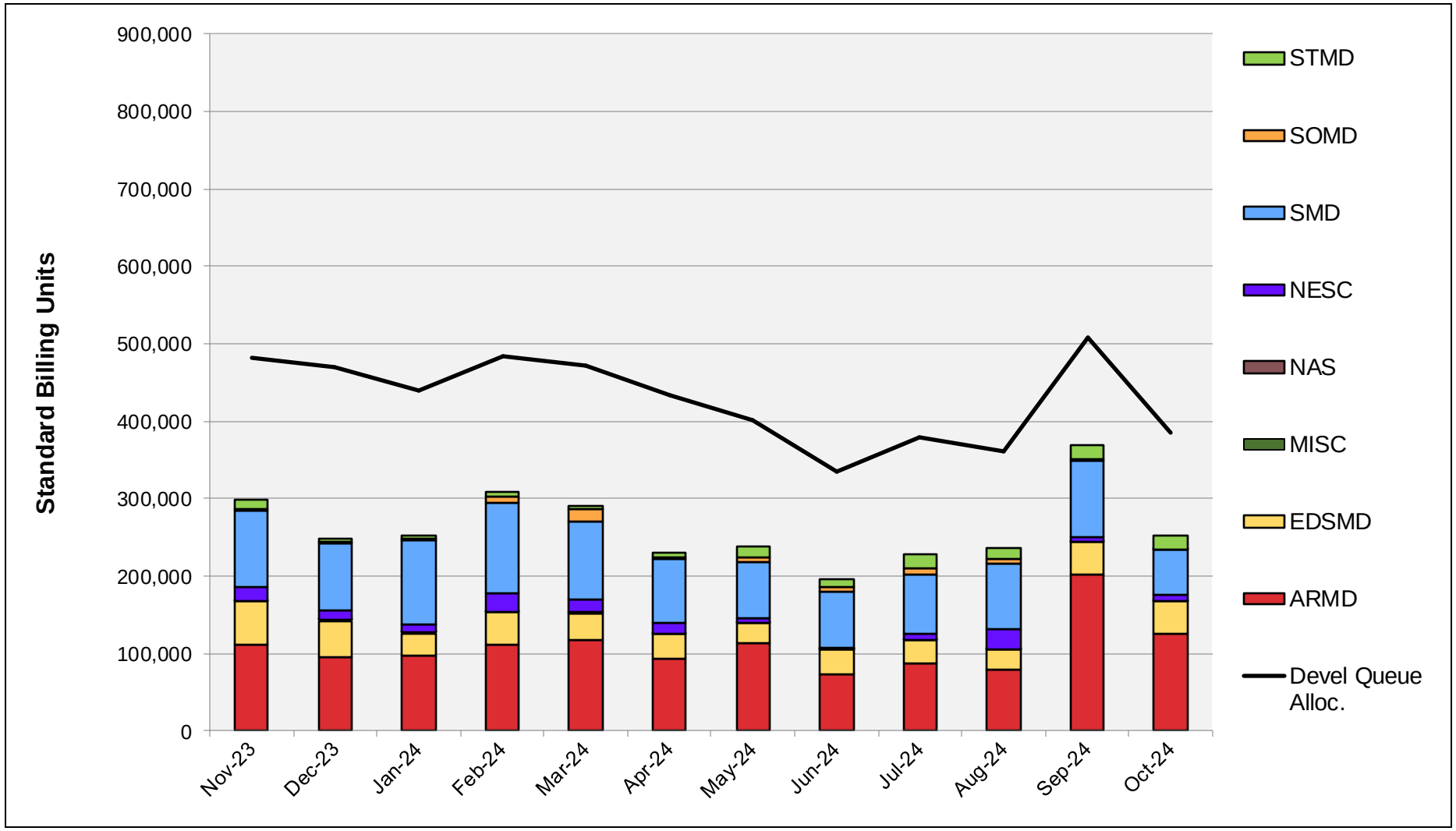
Aitken: Average Expansion Factor



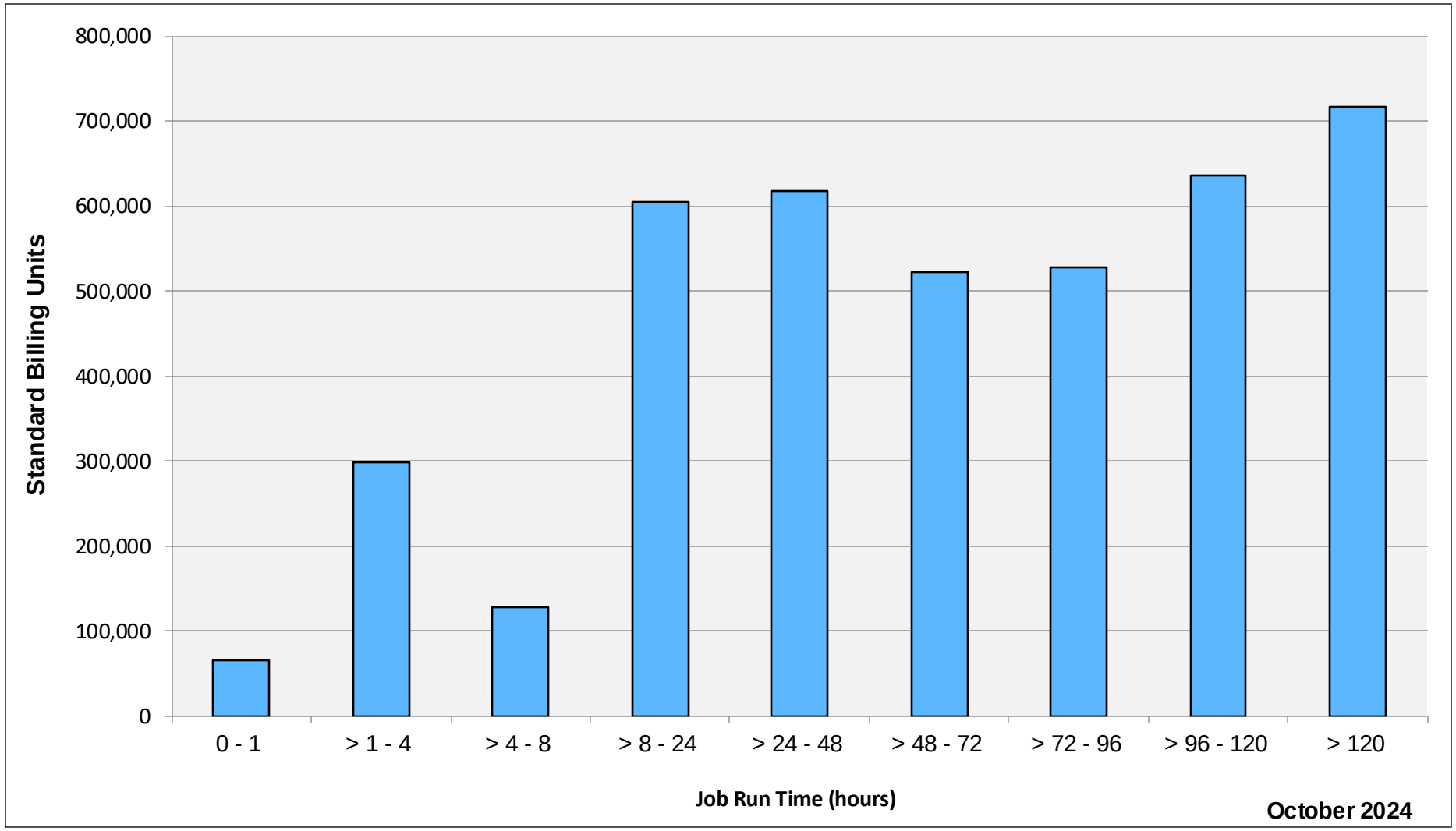
Pleiades: SBUs Reported, Normalized to 30-Day Month



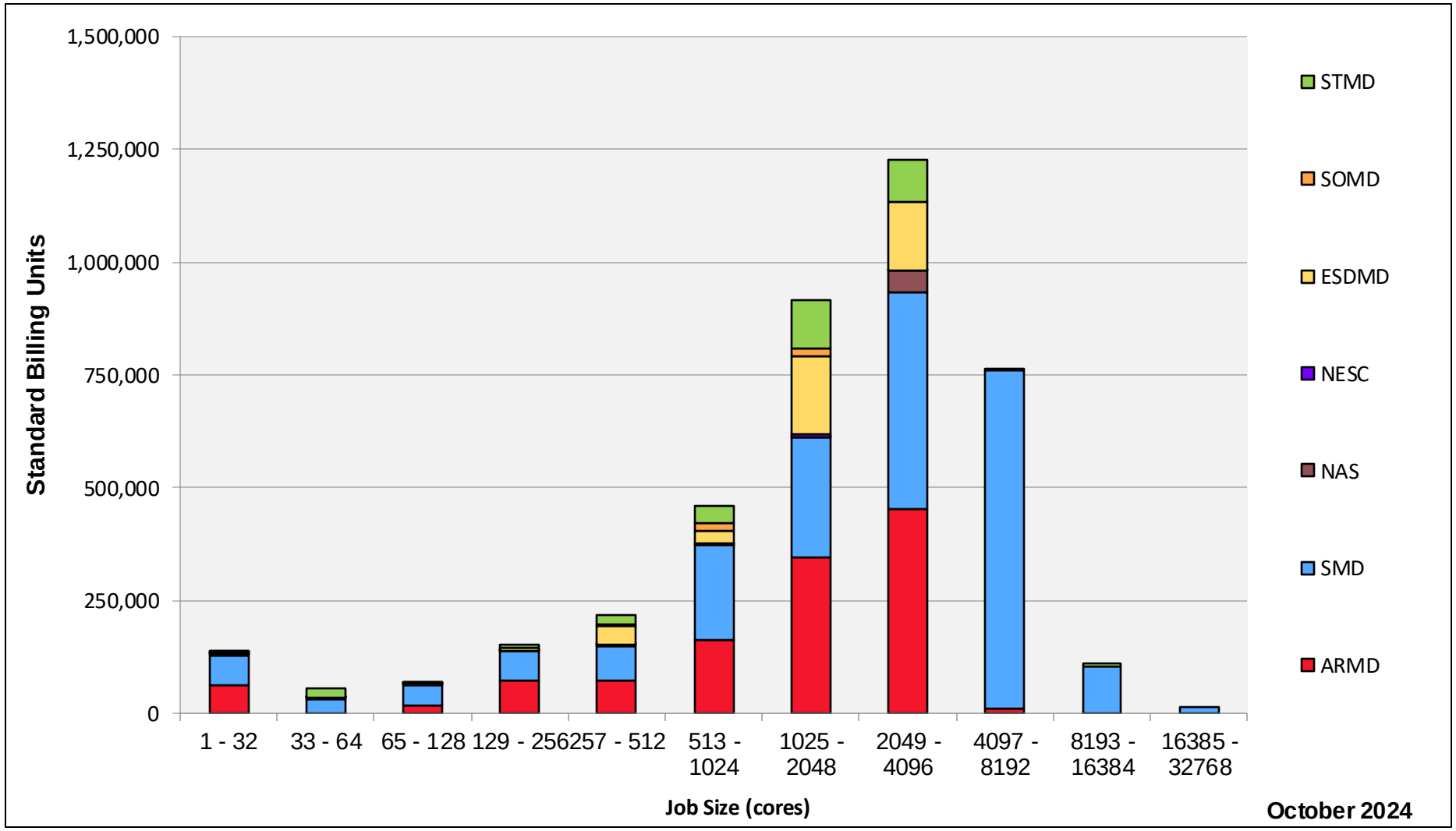
Pleiades: Devel Queue Utilization



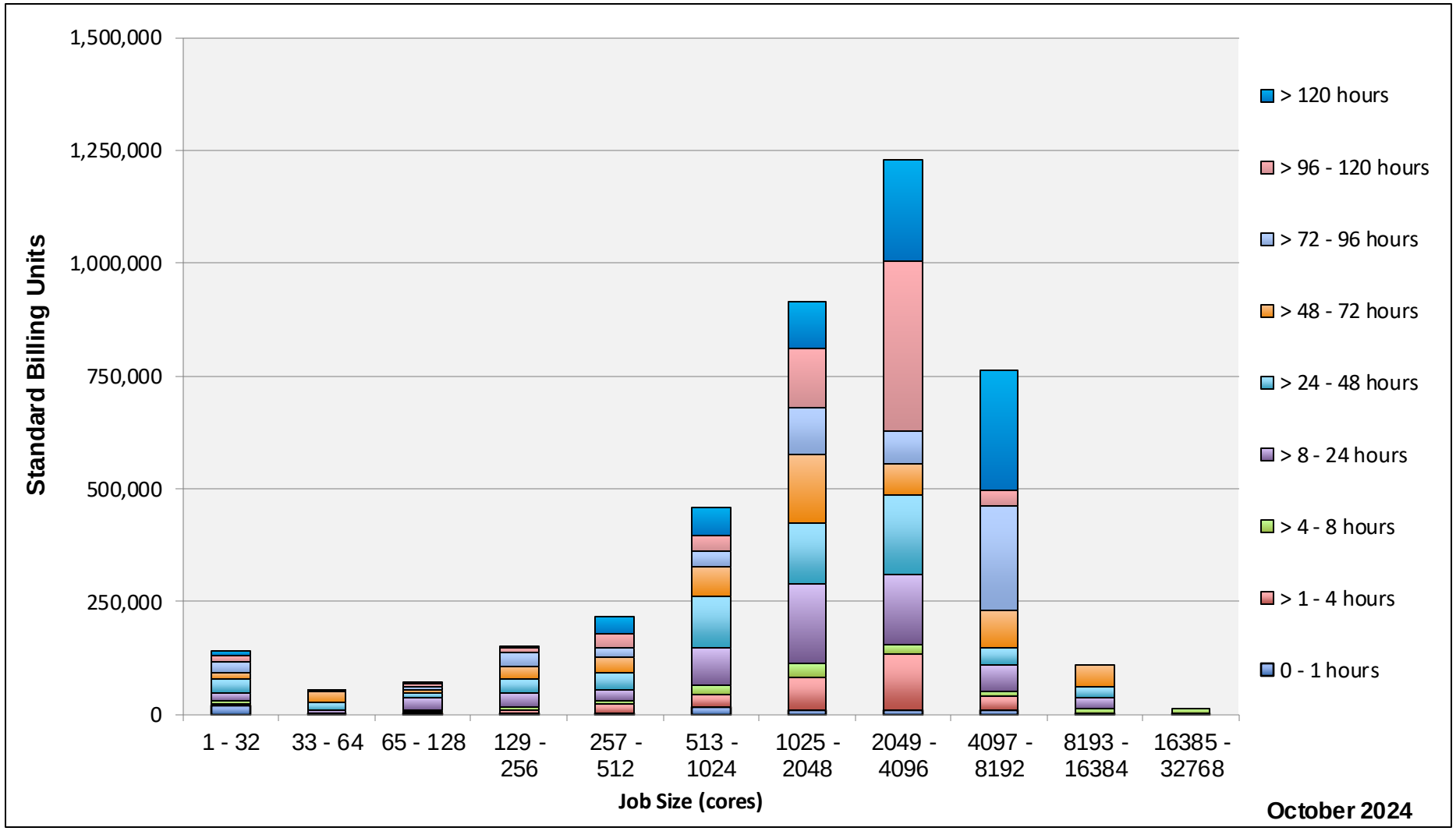
Pleiades: Monthly Utilization by Job Length



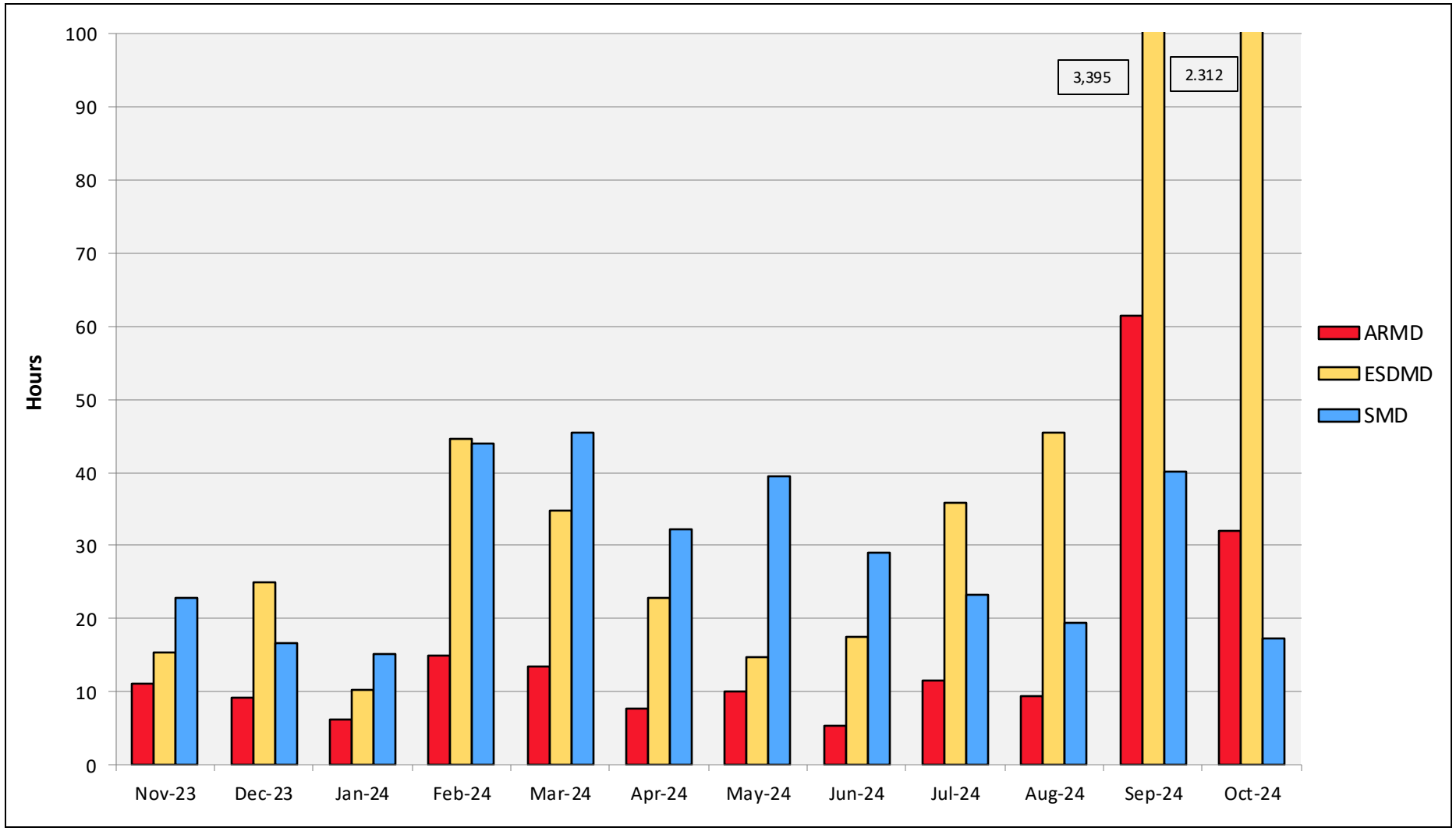
Pleiades: Monthly Utilization by Job Size



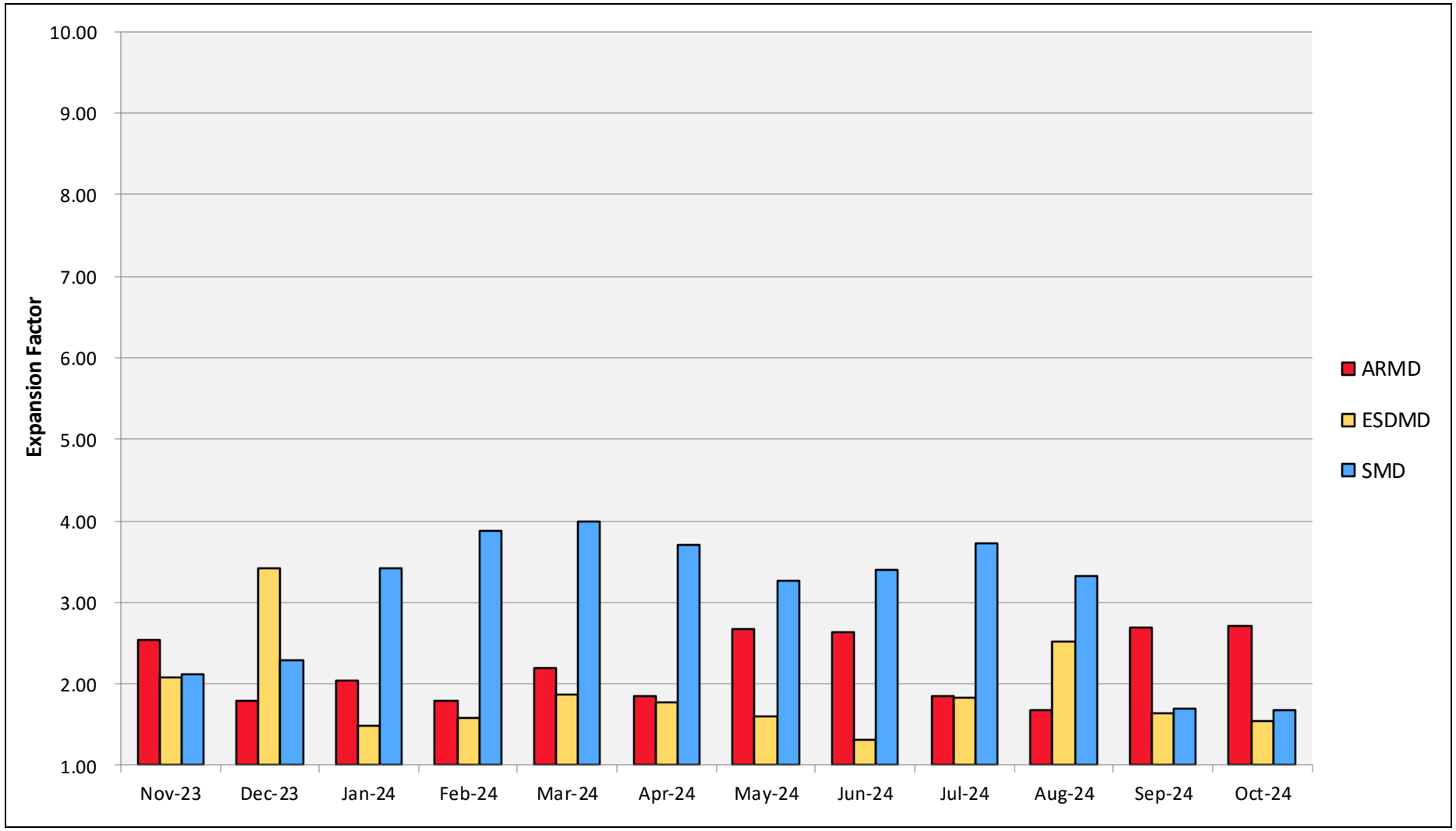
Pleiades: Monthly Utilization by Size and Length



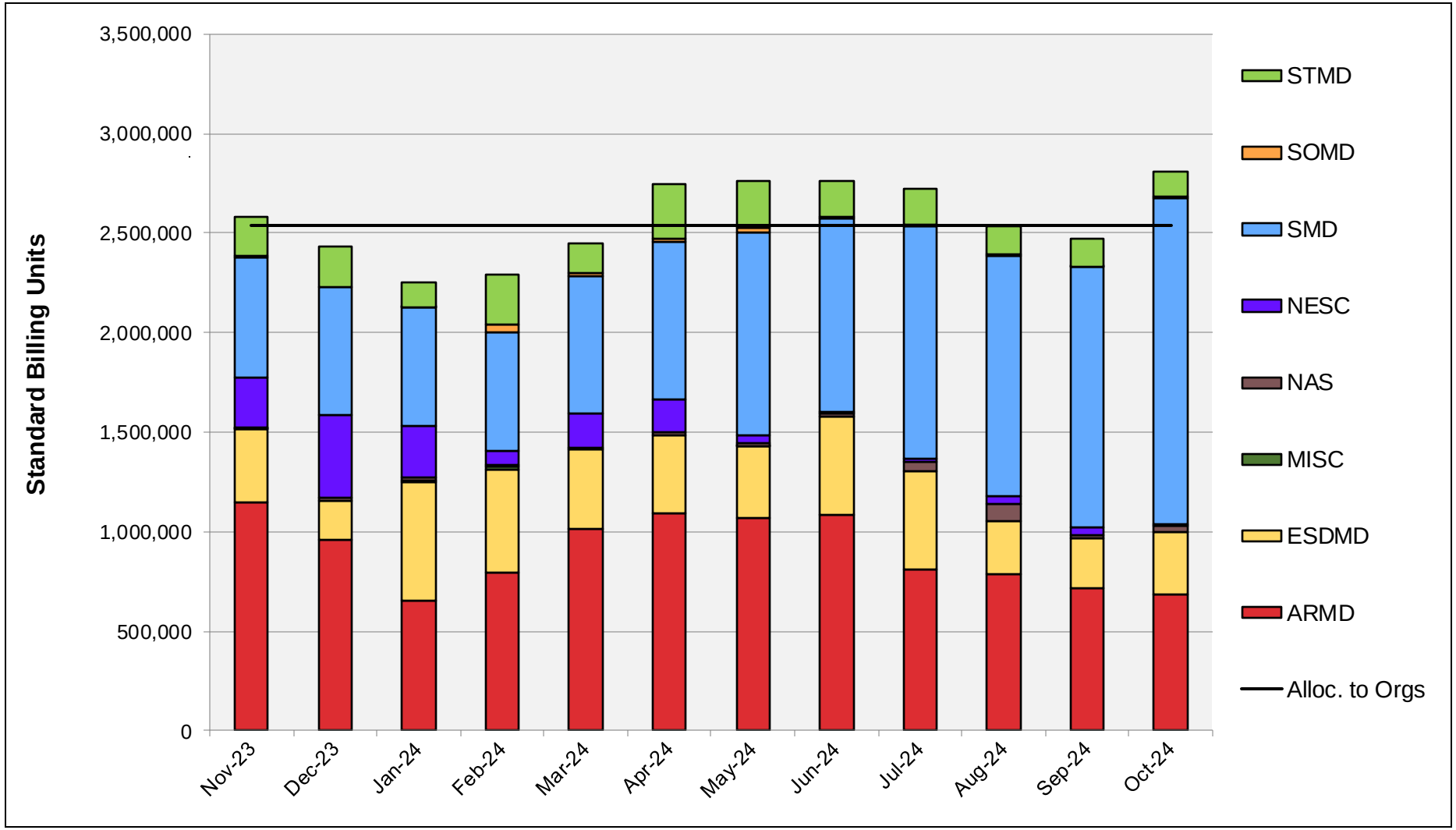
Pleiades: Average Time to Clear All Jobs



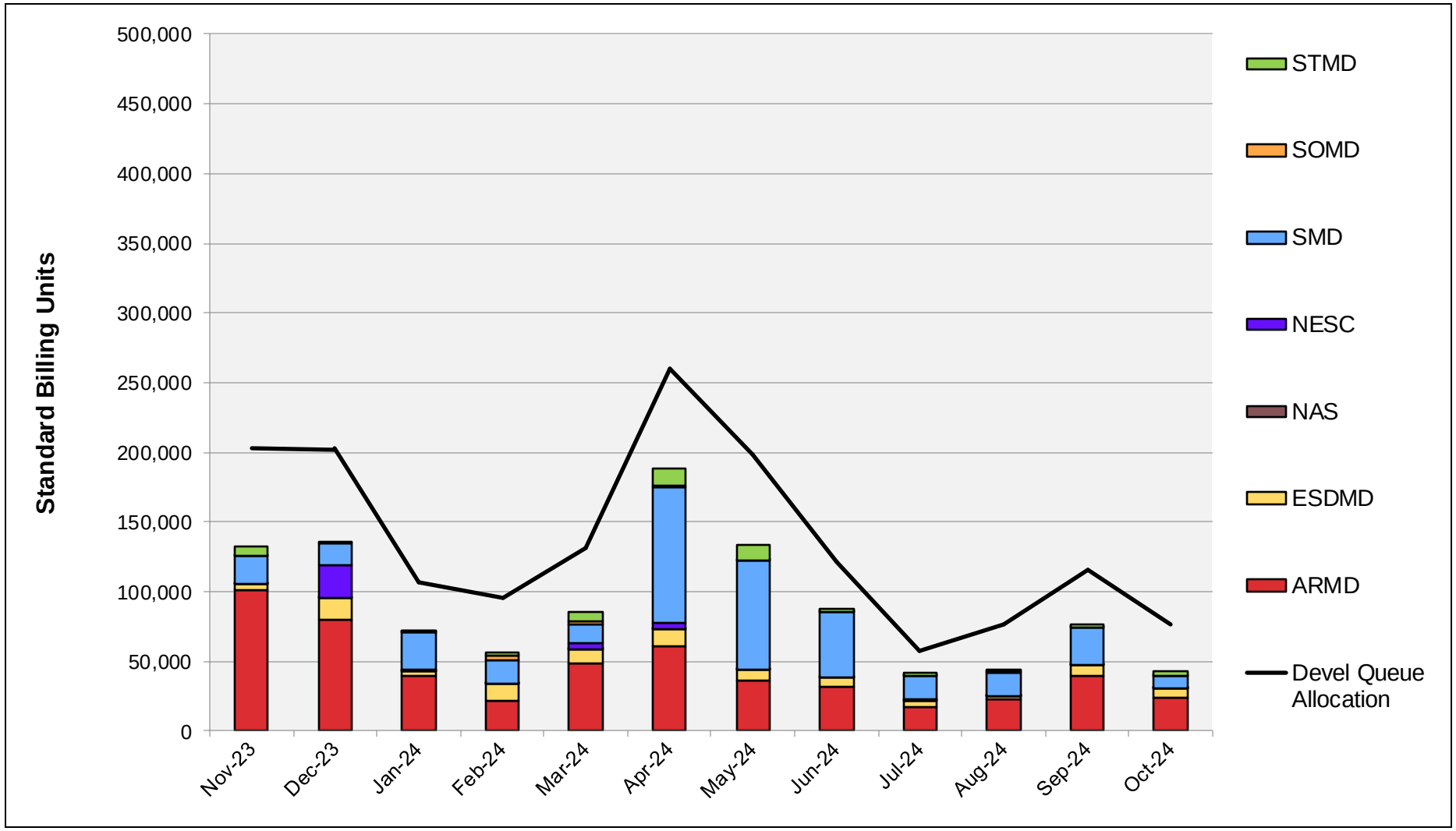
Pleiades: Average Expansion Factor



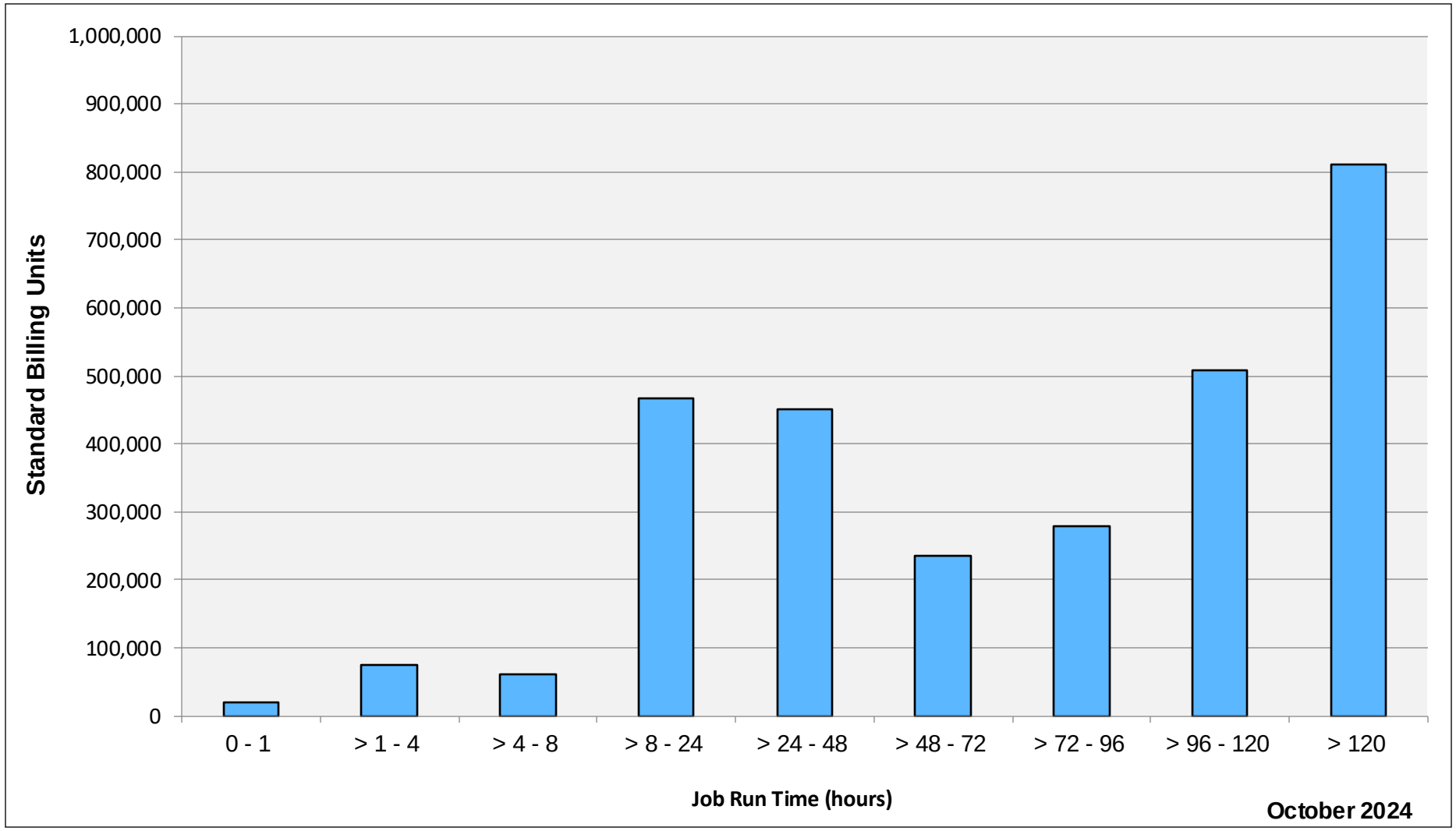
Electra: SBUs Reported, Normalized to 30-Day Month



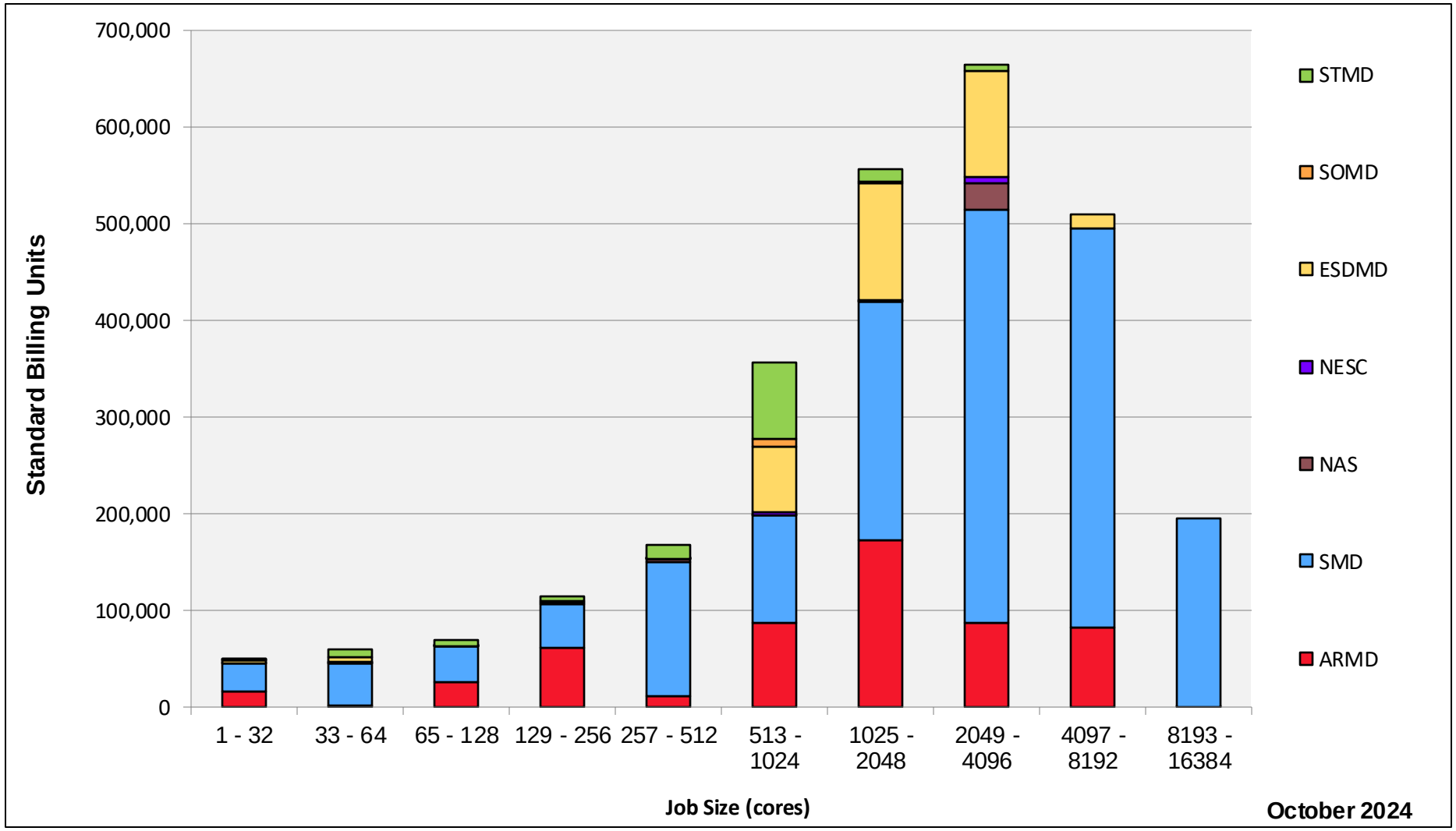
Electra: Devel Queue Utilization



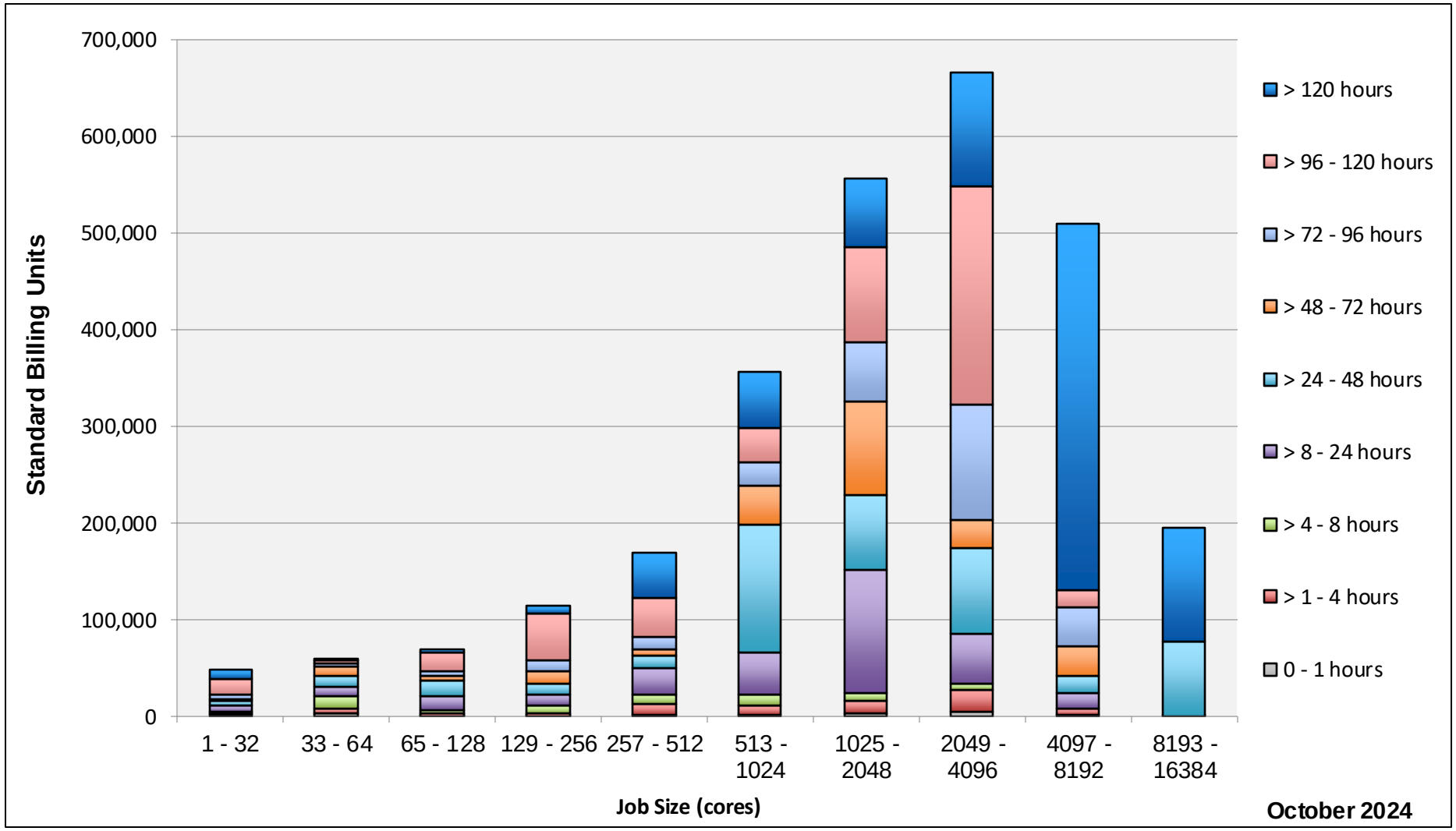
Electra: Monthly Utilization by Job Length



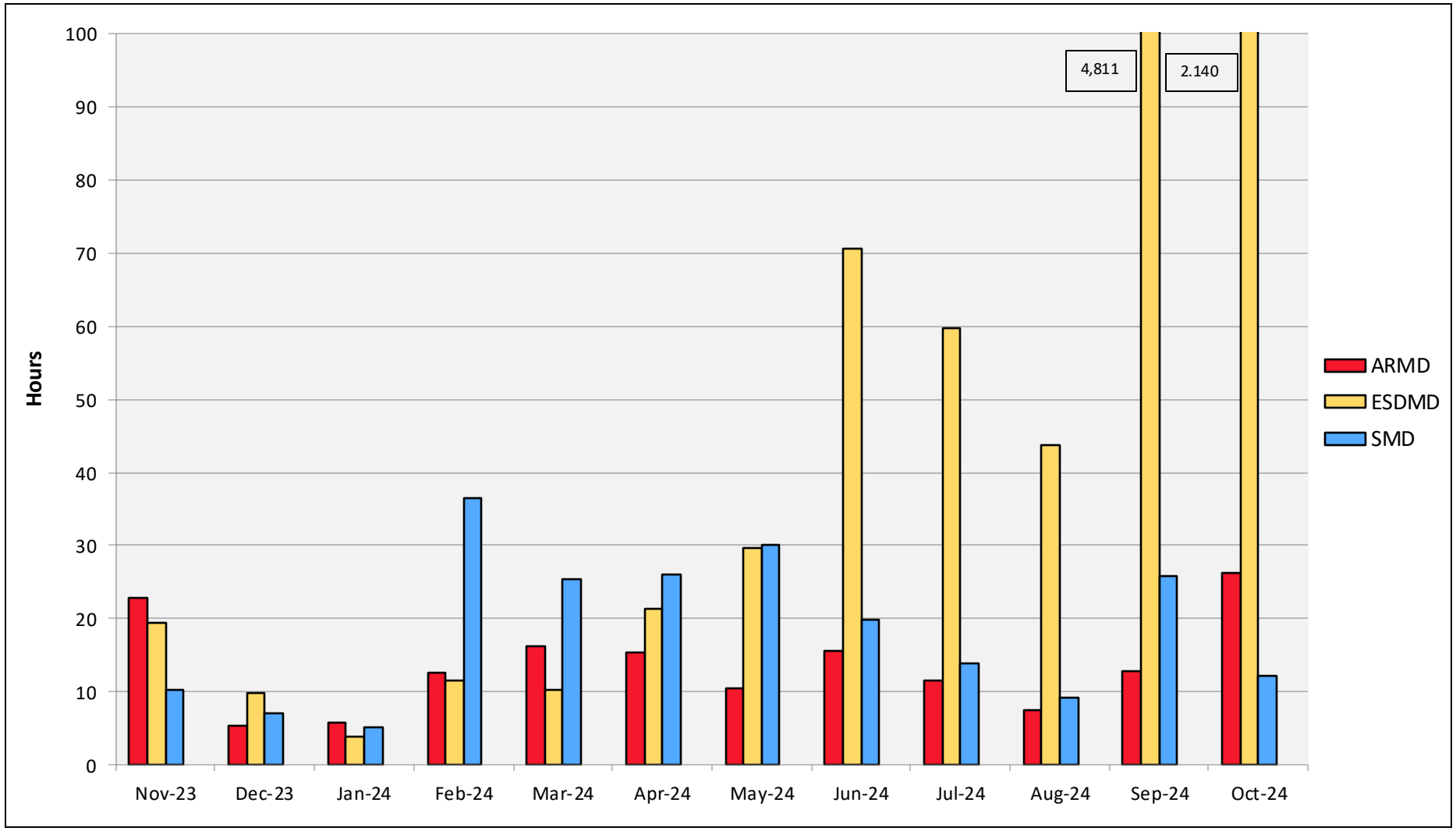
Electra: Monthly Utilization by Job Size



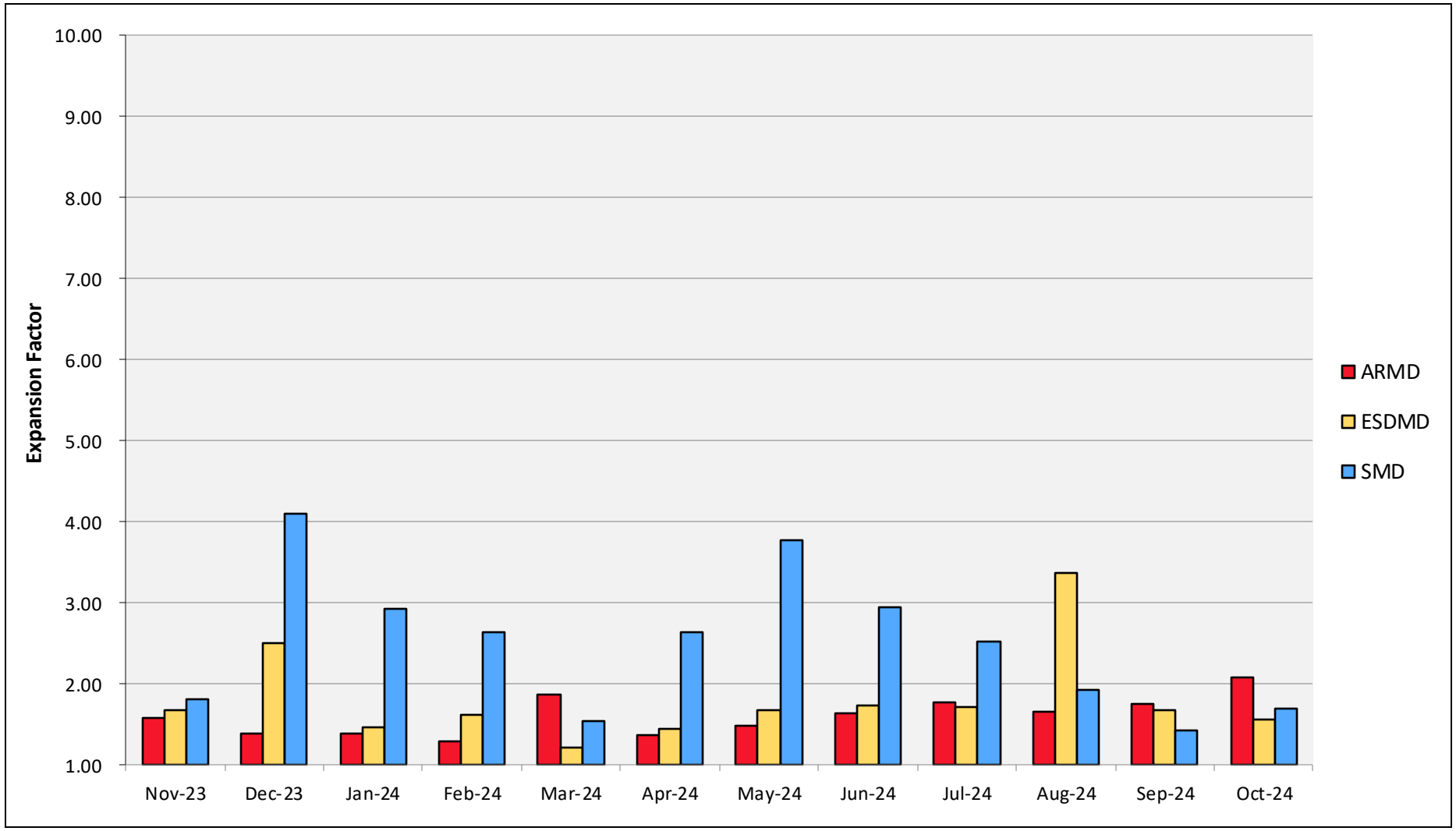
Electra: Monthly Utilization by Size and Length



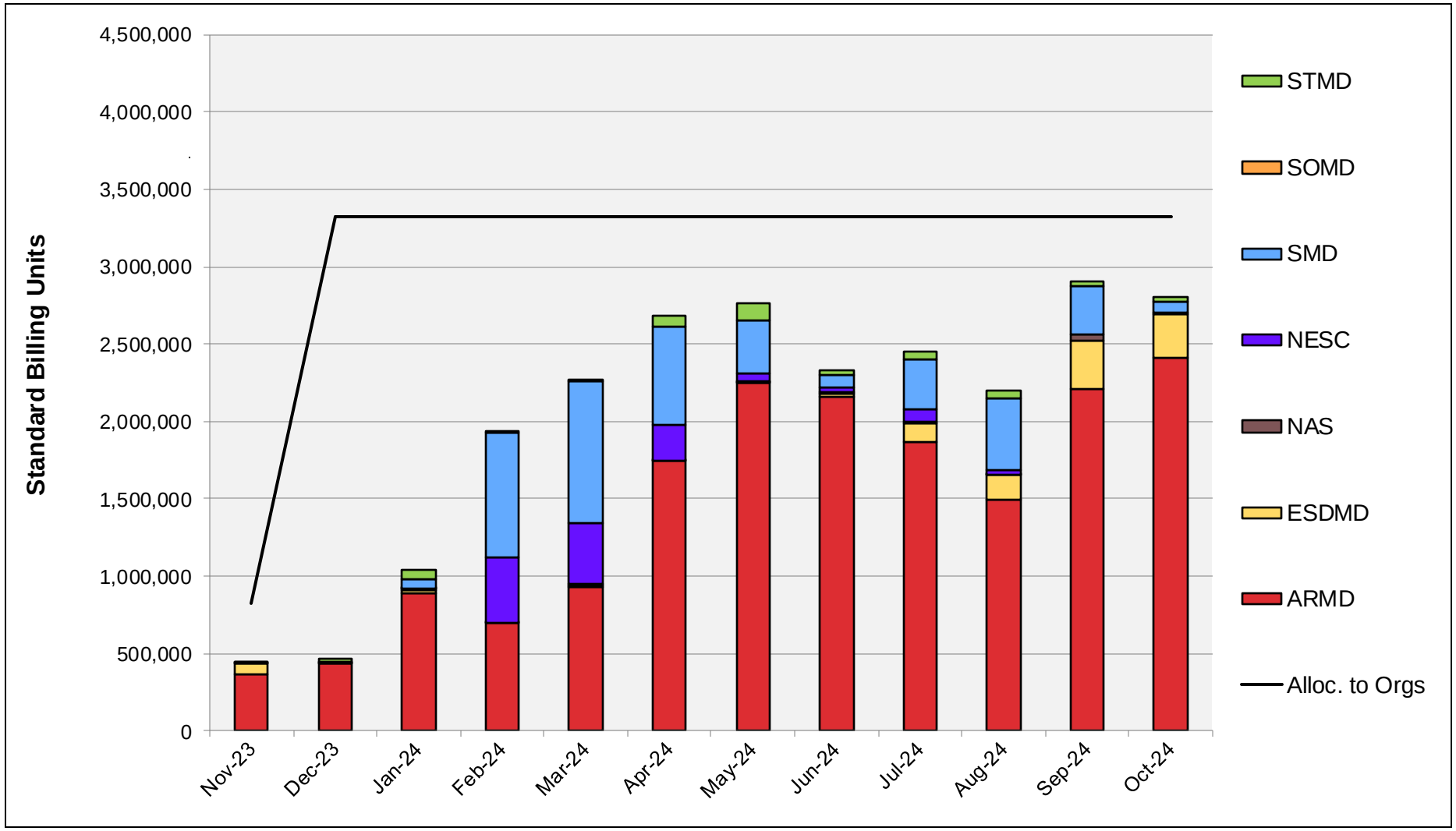
Electra: Average Time to Clear All Jobs



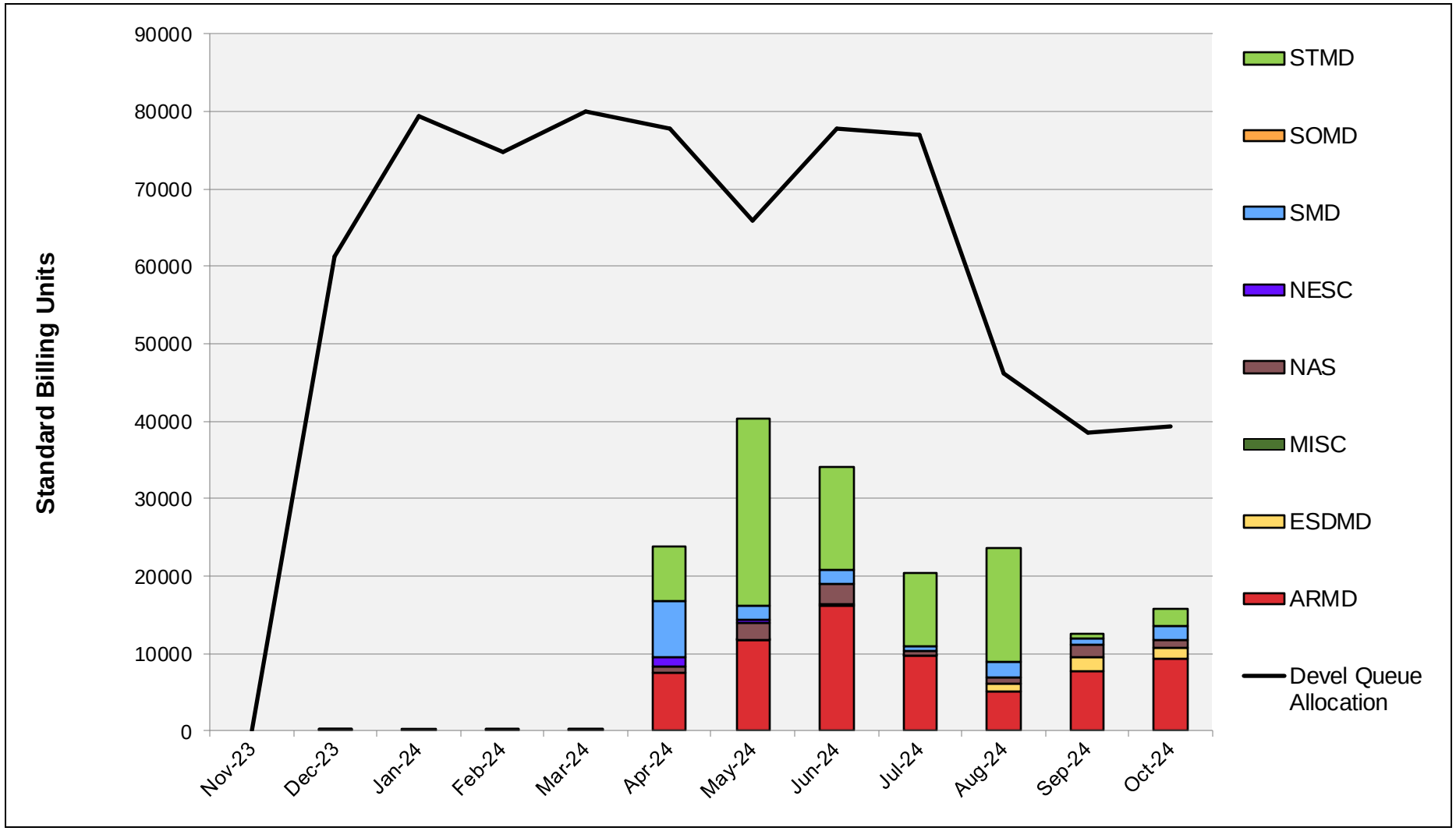
Electra: Average Expansion Factor



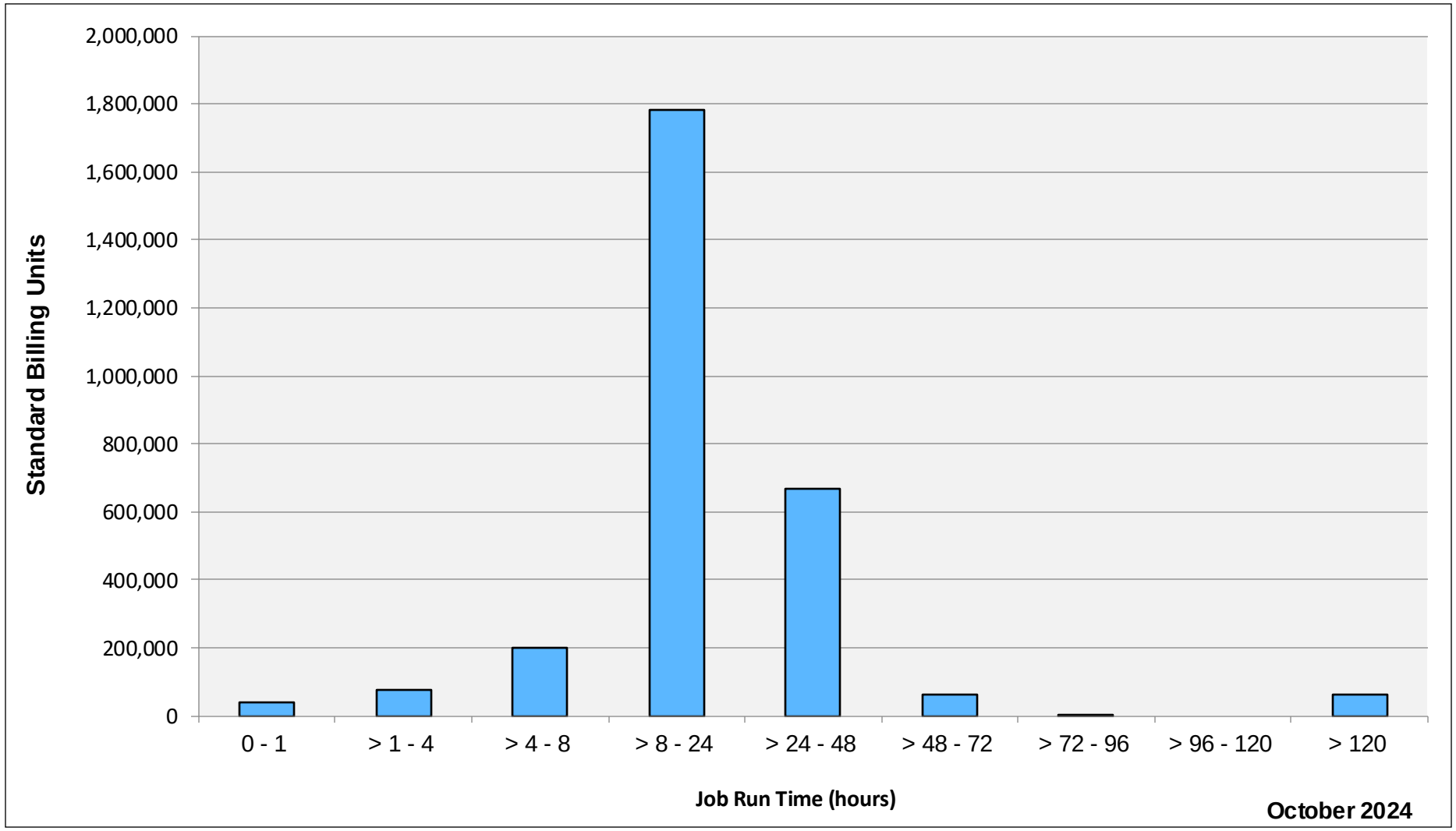
Cabeus: SBUs Reported, Normalized to 30-Day Month



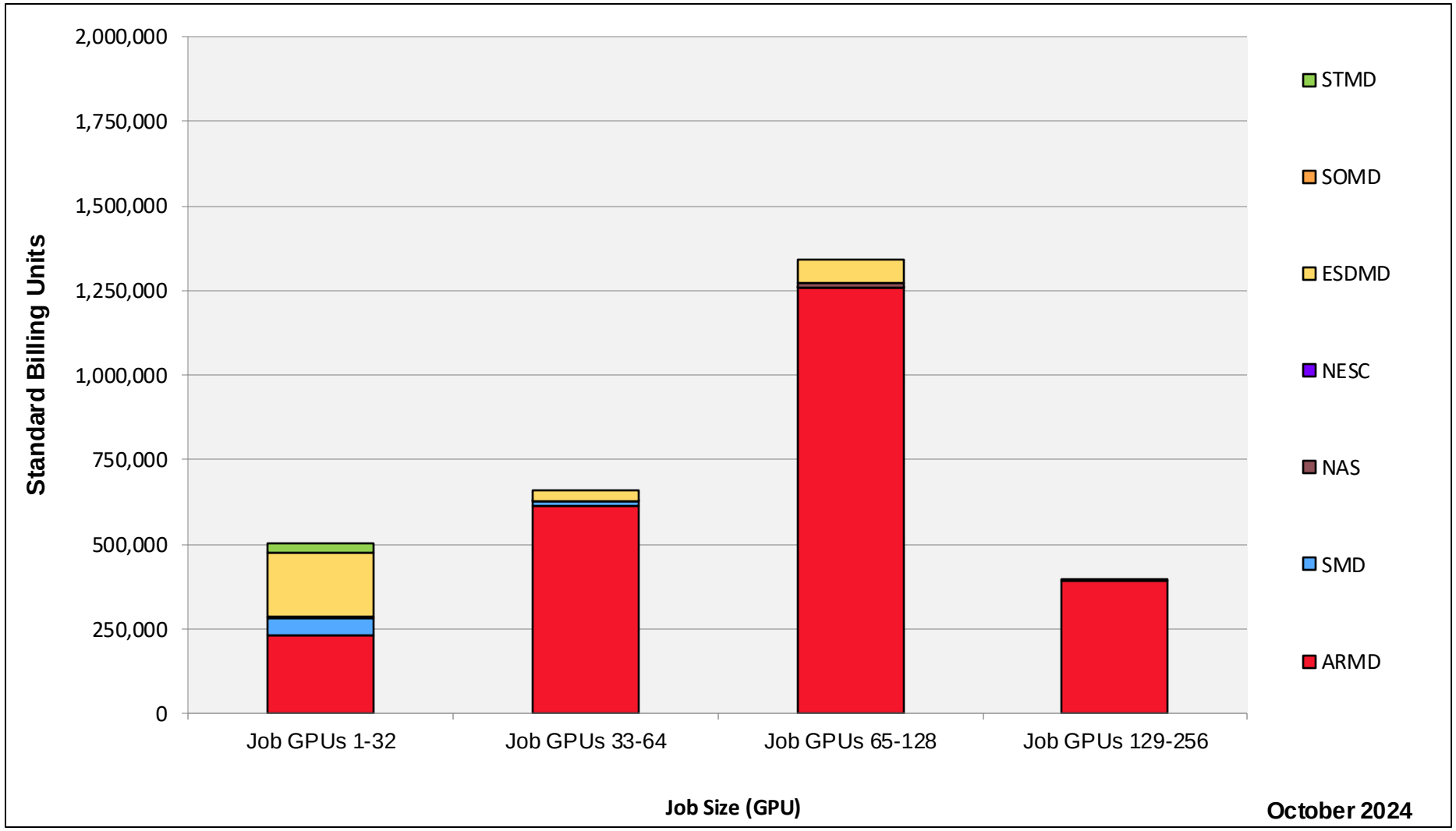
Cabeus: Devel Queue Utilization



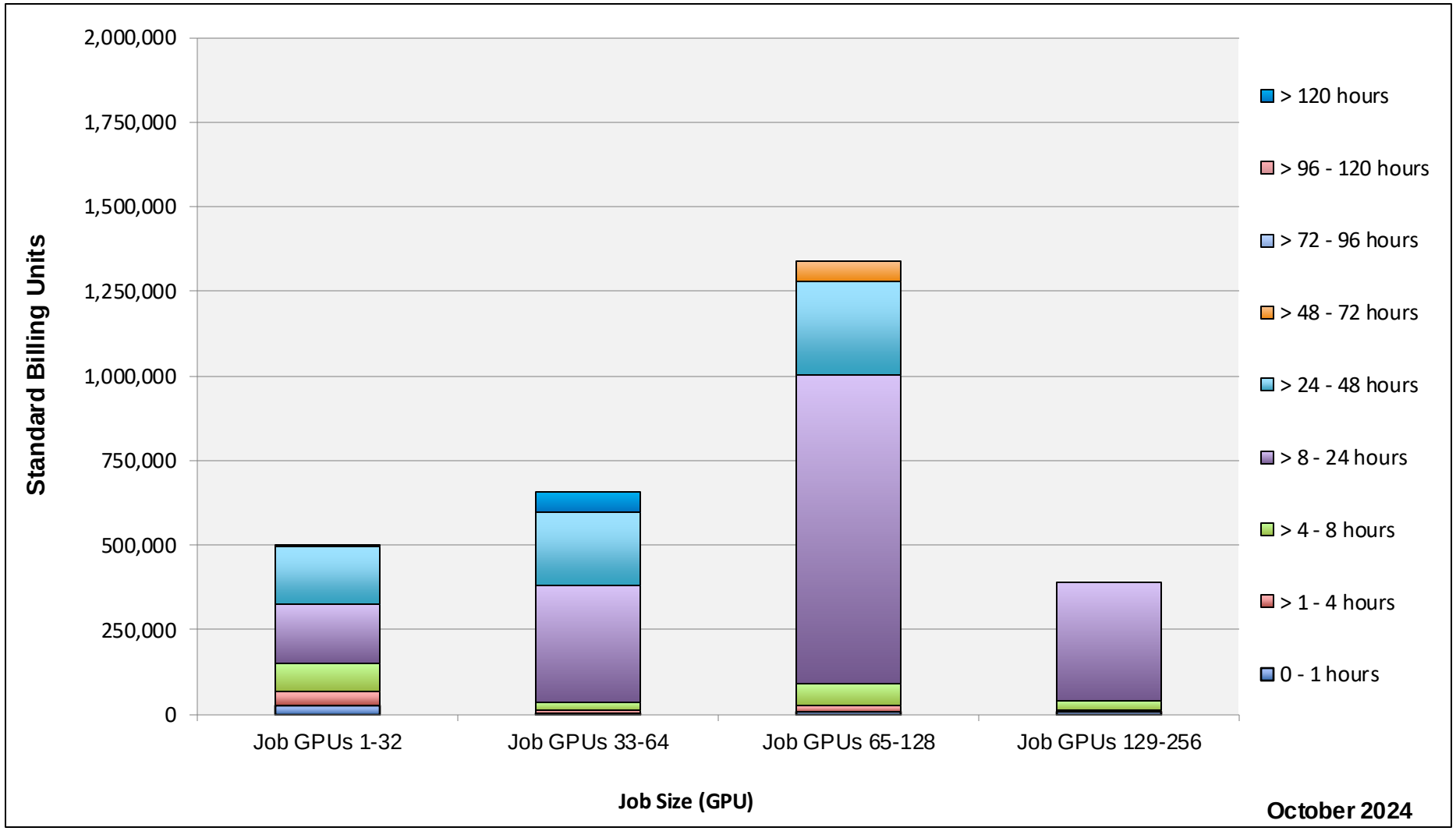
Cabeus: Monthly Utilization by Job Length



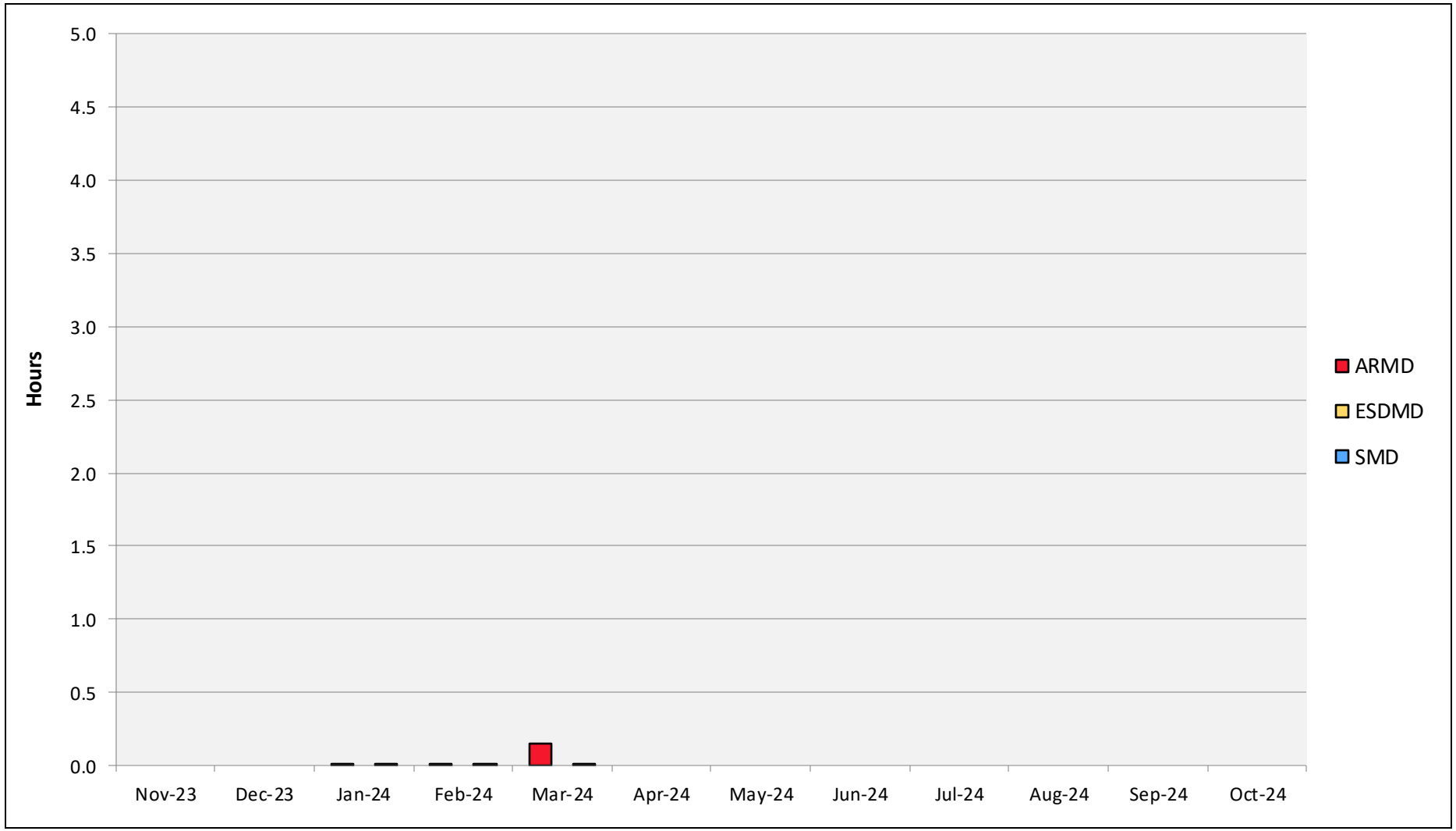
Cabeus: Monthly Utilization by Job Size



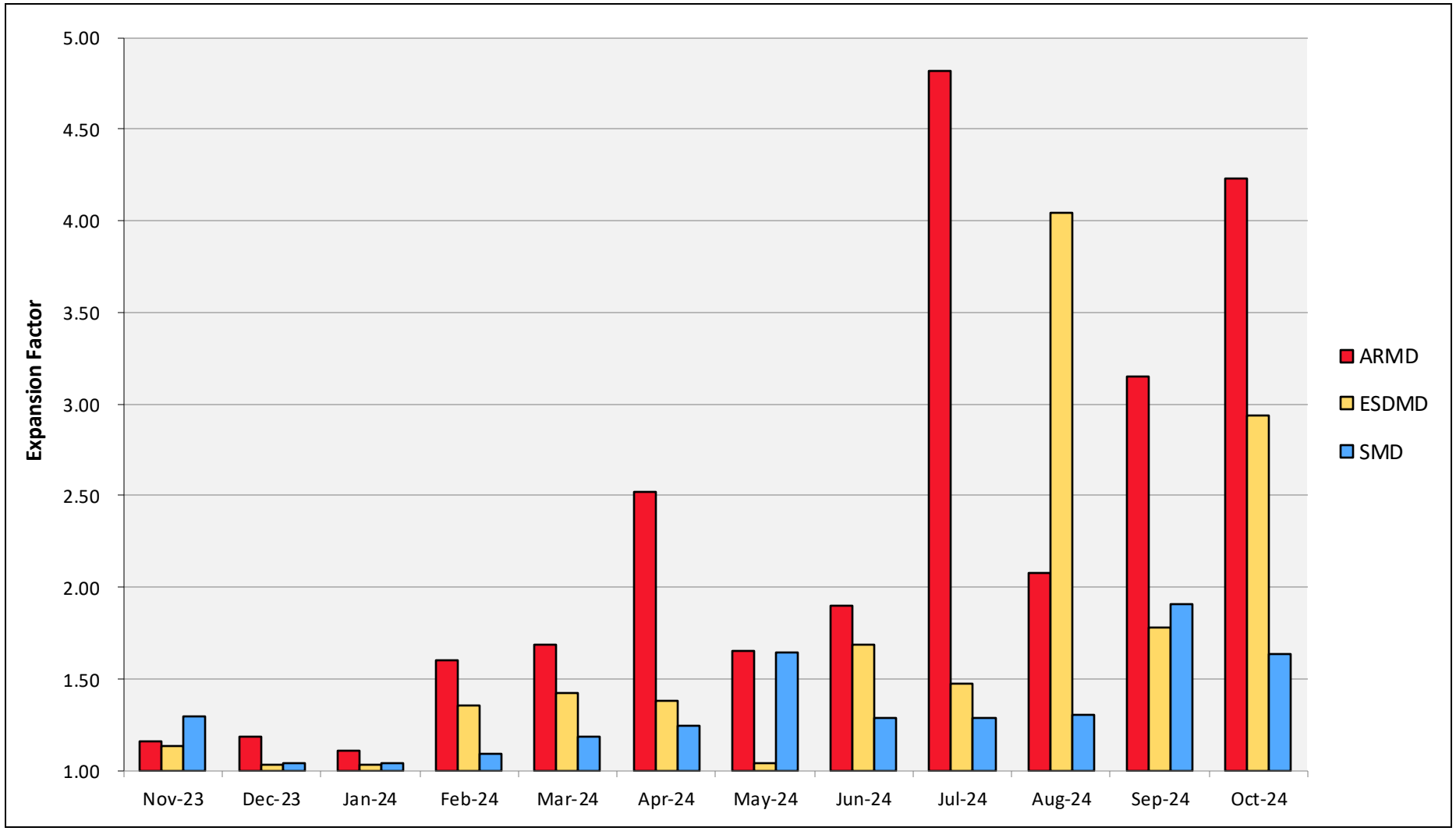
Cabeus: Monthly Utilization by Size and Length



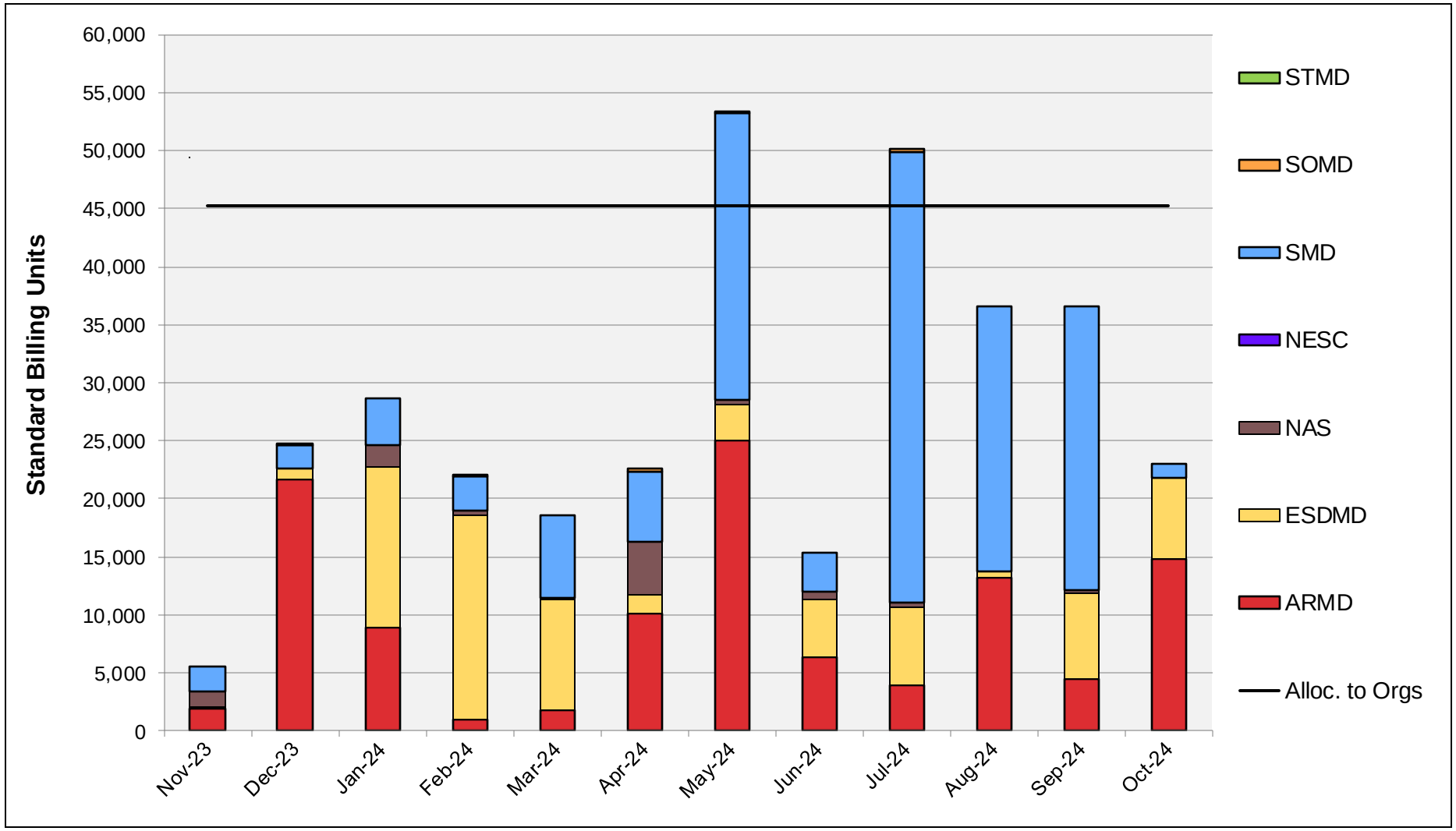
Cabeus: Average Time to Clear All Jobs



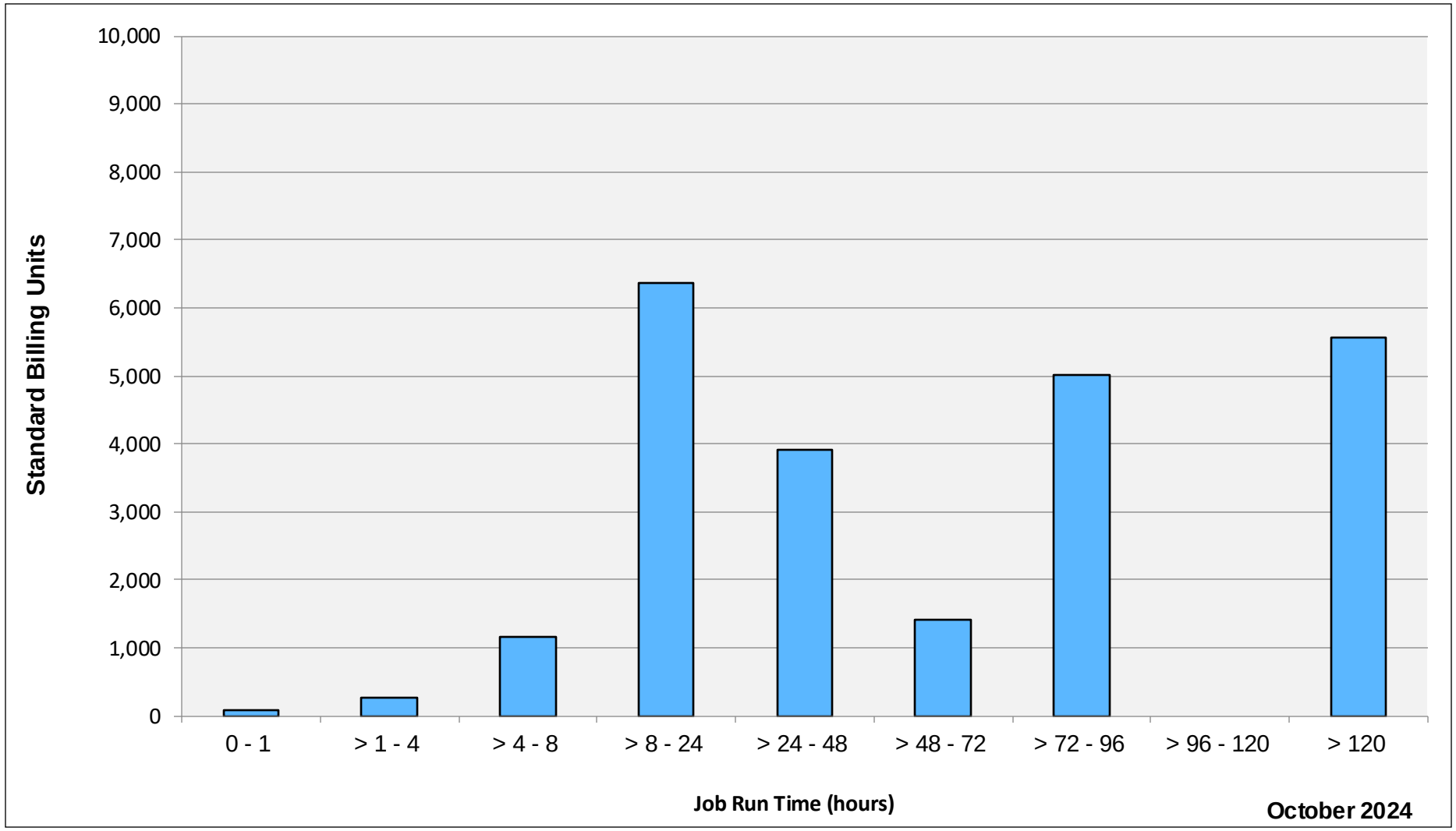
Cabeus: Average Expansion Factor



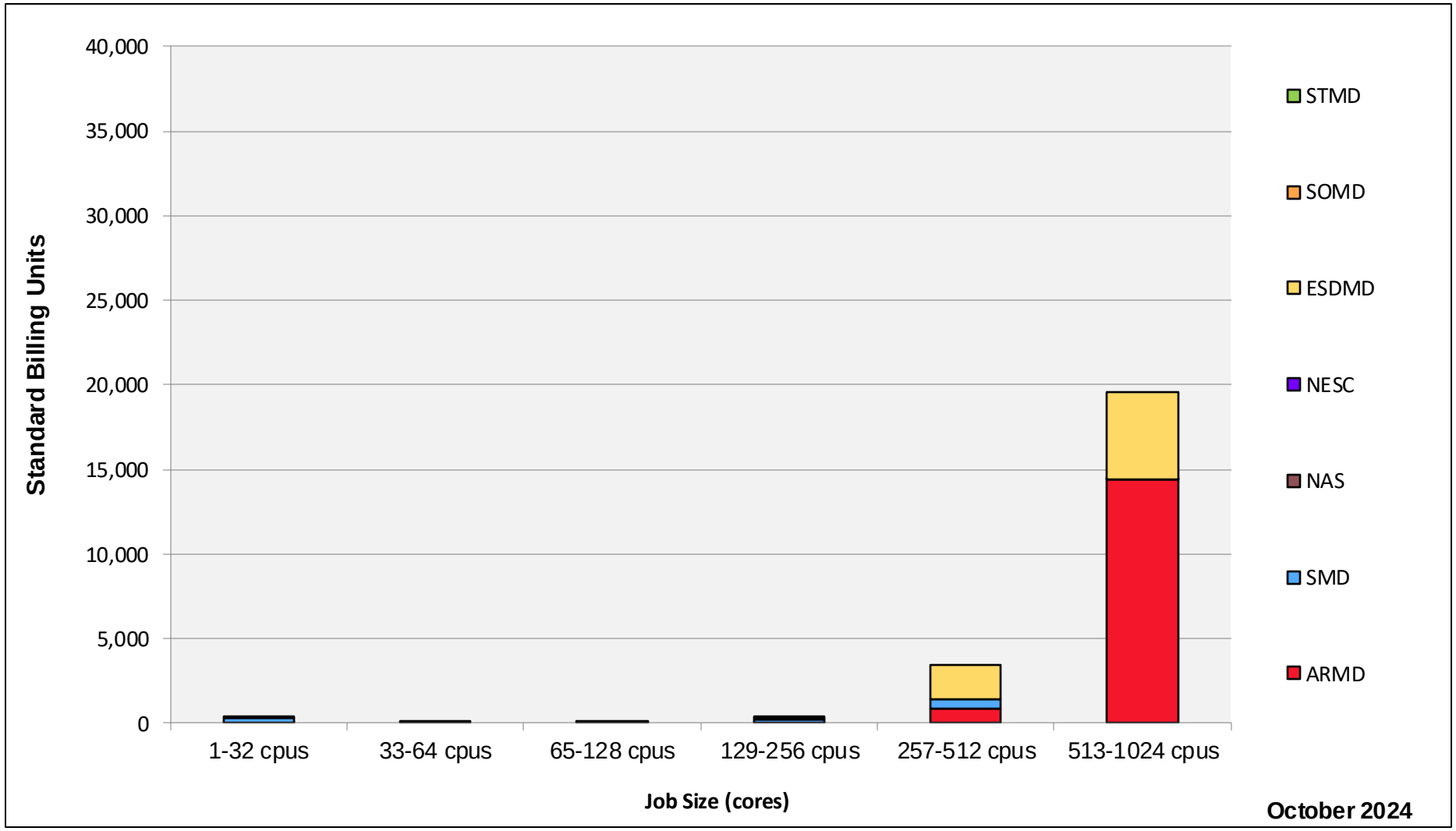
Endeavour: SBUs Reported, Normalized to 30-Day Month



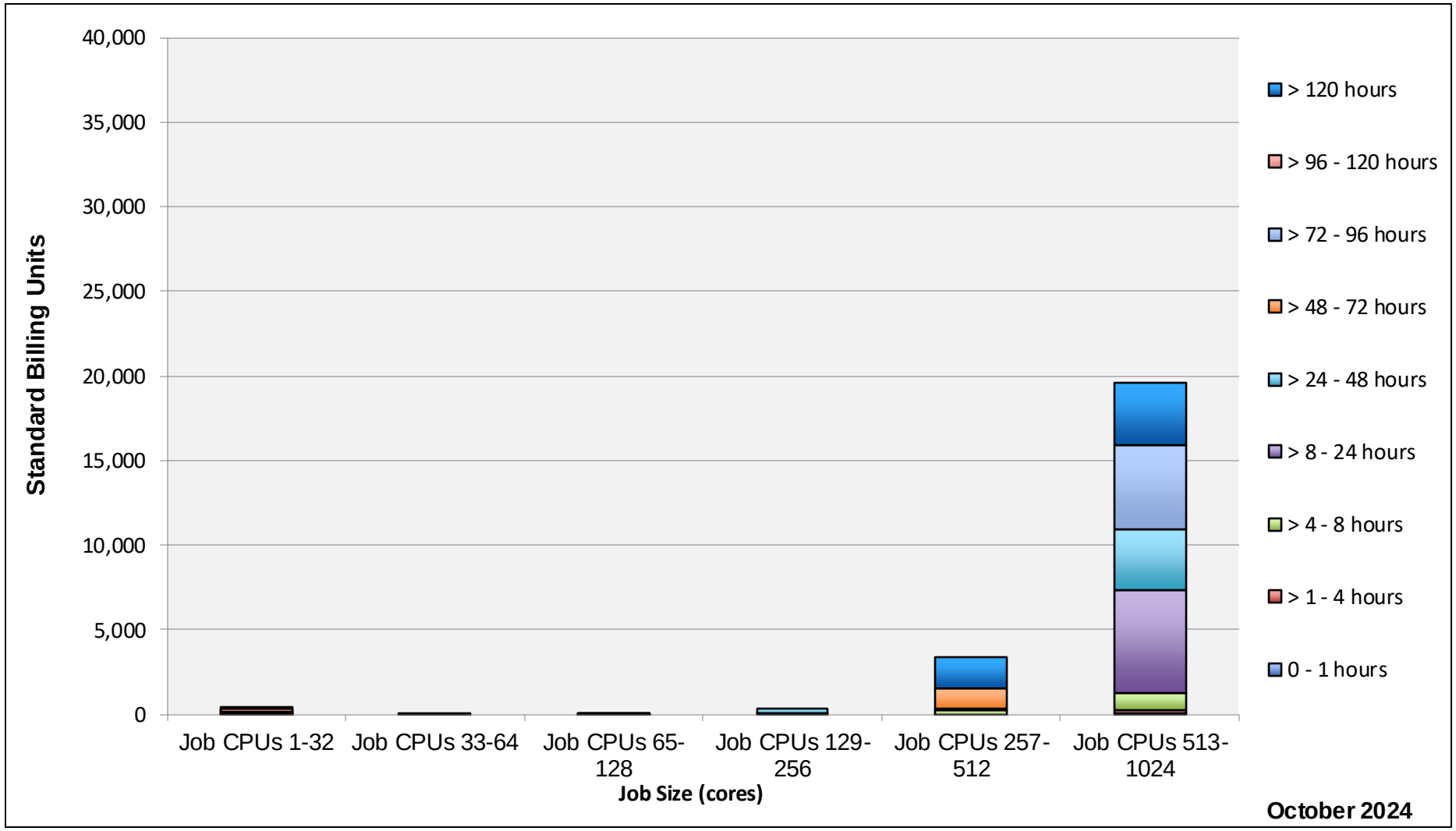
Endeavour: Monthly Utilization by Job Length



Endeavour: Monthly Utilization by Job Size



Endeavour: Monthly Utilization by Size and Length



Endeavour: Average Expansion Factor

