

National Aeronautics and Space Administration

High-End Computing Capability

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Significant Accomplishments: Current & Future

Current

- New Cabeus GPU System Released to Users
- New Aitken DDN InfiniBand Fat-Tree Network
- Control Room Releases Service Catalog
- APP Team Evaluates IBM Power10 E1050 Processor
- HECC Supercomputer Usage Sets New Normalized Record
- HEC Communications Staff Support for AGU23
- Simulating an Iced Wing for Aerodynamic Performance Predictions
- Finding Fireballs Hidden in Satellite Lightning Data

Future

- Compute Module 2 progress
- Shift large transfer performance Improvements
- hyperwall room remodel progress

New Cabeus GPU System Released to Users

- The new Cabeus GPU cluster has been released to users for production computing on December 27, 2023.
  - The cluster has 128 nodes, each node equipped with an AMD Milan processor and 4 NVIDIA A100 GPUs.
  - It adds 5 petaflops of peak performance to HECC's supercomputing capability.
- HECC completed the final testing for Cabeus prior to its production.
  - Testing included verifying functionality as well as performance with users' expected applications.
- Cabeus will provide a lower cost per solution on important NASA applications and will further enable NASA work in the artificial intelligence/machine learning space.
- The new system was announced to users in the NAS Weekly Digest and in a news item on the HECC website. Two new Cabeus-specific articles were added to the Knowledge Base, and three existing articles were updated to include Cabeus information. A new Cabeus system page was added to the top-level HECC Resources menu.

IMPACT: The 512-GPU Cabeus cluster adds a significant GPU-optimized capability to HECC's computing resources.

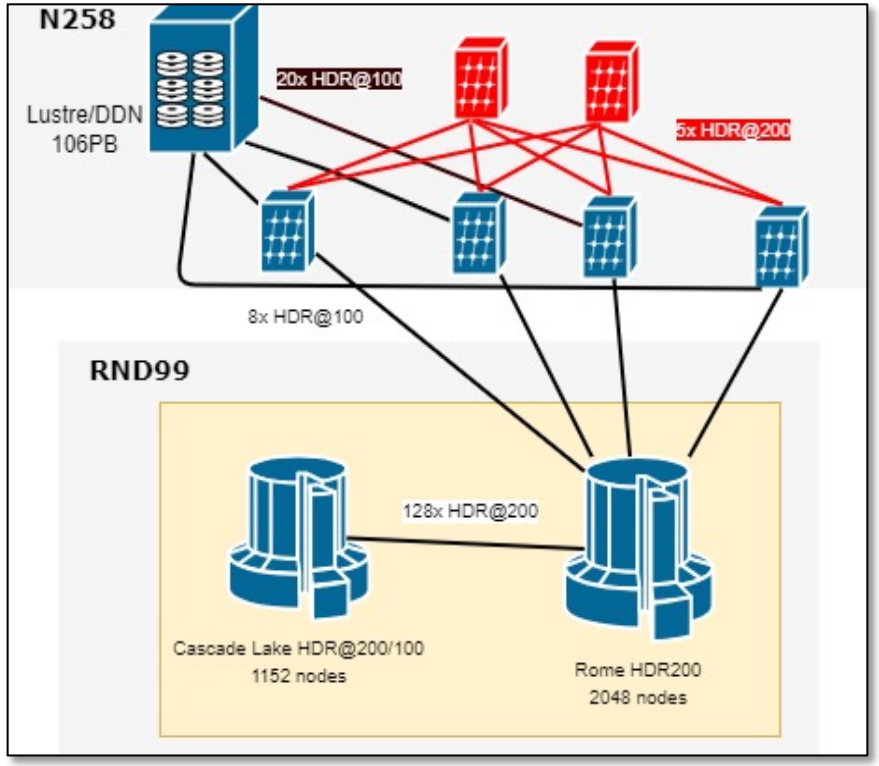


The new Cabeus supercomputer cluster adds 15 racks and 128 nodes to the main floor of the NASA Advanced Supercomputing facility. *Don Story, NASA Ames*

New Aitken DDN InfiniBand Fat-Tree Network

- The HECC Systems team deployed an InfiniBand (IB) fat-tree network topology to connect the Aitken supercomputer to the DDN /nobackup filesystems.
- Comparison of the two configurations:
  - The original configuration consisted of four HDR IB switches connecting DDN/Lustre 'nobackup' file systems in building N258 to Aitken Rome nodes in the MSF via long-haul fiber links. Because the I/O switches were not interconnected to each other, any route chosen by the subnet manager between Cabeus and the filesystems that crosses several I/O switches would traverse route through the long-haul connections multiple times.
  - For the new configuration, the team added two HDR InfiniBand switches as fat-tree spine switches connected by five links to each of the four original switches, which became fat-tree leaf switches.
- Routing chains, used for the first time in the HECC environment, were configured to allow the fat-tree topology to be combined with the Aitken hypercube topology in a single IB subnet.
- Using the IOR benchmark, the new fat-tree configuration, which is required to achieve good Lustre filesystem performance in cluster additions such as Cabeus, was verified not to degrade performance.

IMPACT: Creating an IB fat-tree by adding spine switches to existing switches results in increased I/O performance for new clusters in the HECC environment.

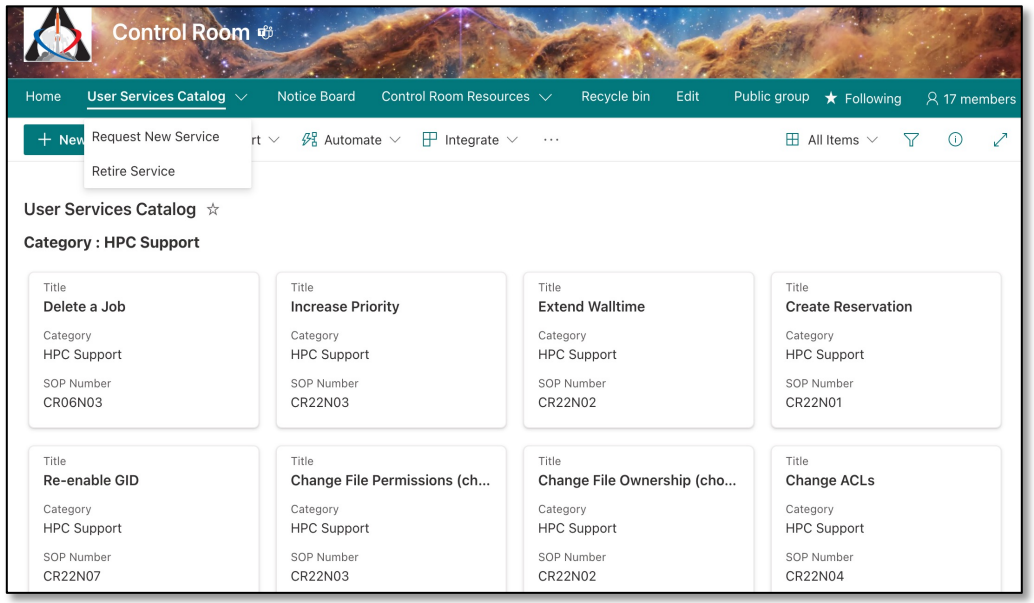


Configuration drawing showing the two new HDR InfiniBand switches, highlighted in red.

Control Room Releases Service Catalog

- Control Room Analysts (CRAs) completed a Service Catalog, performed by the CRAs. using a newly formalized process for transferring work from other NAS groups to the Control Room
- The new service catalog enables:
  - **Standardized Service Delivery:** Standardization through the creation of Standard Operating Procedures (SOPs) included in the Service Catalog ensures consistent and reliable service delivery, reduces the likelihood of errors, and enhances overall service quality.
  - **Improved Communication:** Clearly defined responsibilities within the Service Catalog enhances communication and collaboration among different teams, fostering a cohesive and coordinated approach to service delivery.
  - **Continuous Improvement Culture:** By incorporating feedback mechanisms and regularly reviewing and updating the catalog, HECC teams foster a culture of continuous improvement, ensuring that services evolve to meet the dynamic needs of HECC teams and users.
- The Service Catalog project teams made great strides in documentation, setting roles and responsibilities, and created an infrastructure that can be emulated by other HECC groups.

IMPACT: The new Service Catalog provides standardization of tasks and a formal process for task ownership to be exchanged between the HECC staff and the Control Room.



Screenshot of the new Control Room Service Catalog homepage.

APP Team Evaluates IBM Power10 E1050 Processor

- HECC's Application Performance and Productivity (APP) team is in the process of evaluating a loaner test system with the IBM Power10 processor. The test system contains a single node with:
  - 72 total cores (4 modules with 18 cores each.)
  - Up to 8 threads per core for a maximum of 576 concurrent threads.
  - 2 terabytes of memory (409 gigabytes/second memory bandwidth per socket).
- When evaluating testbed systems, the APP team runs real-world tests that are representative of everyday NAS workloads.
- The IBM Power10 speedup factors below are relative to an equivalent test run on an Aitken Rome node with 128 cores:
  - Aeronautics: FUN3D (~1.4x), OVERFLOW (~2.1x), USM3D (~1.8x), Cart3D (~2x)
  - Weather systems: WRF (~1.7x)
  - Astrophysics: Enzo (~1.16x)
- Cart3D may be seeing a larger speedup because of its ability to take advantage of the high thread count per core. In addition, OVERFLOW may be seeing a larger speedup due to higher memory bandwidth on the testbed relative to an Aitken Rome node.
- If the APP team determines the IBM Power10 performance results merit further study, one or more nodes may be procured.

IMPACT: Reviewing and testing new architectures provides valuable information on their suitability for NASA applications, as well as a better understanding of how these systems can fulfill user needs.



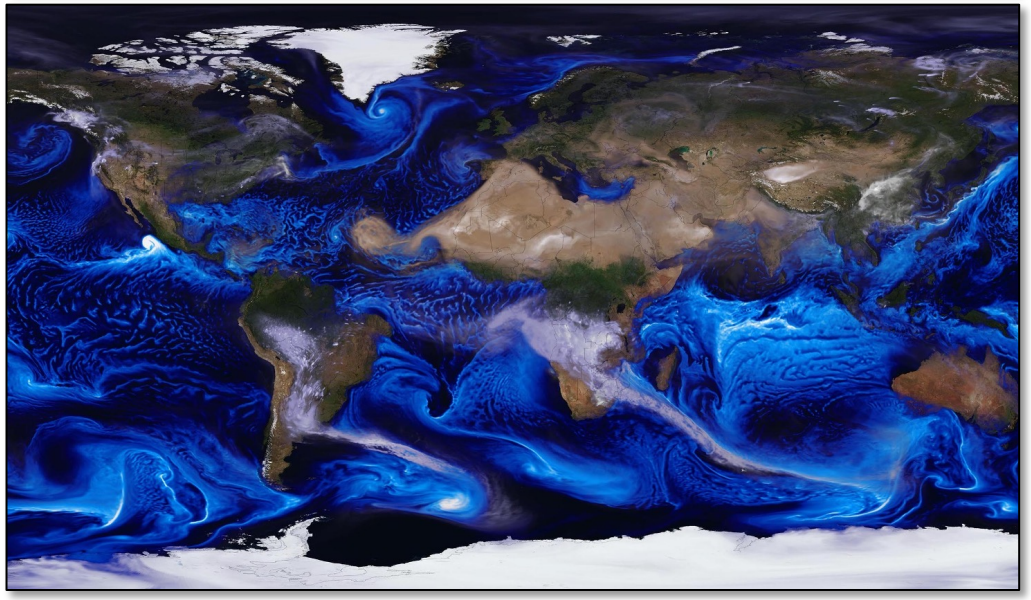
The IBM Power E1050 processor is currently being evaluated for possible use in the HECC environment. *Image courtesy of IBM*

HECC Supercomputer Usage Sets New Normalized Record

- In December, the combined usage of HECC supercomputers set a new normalized record of 14,939,476 Standard Billing Units (SBUs*).
- The usage by 349 of NASA's science and engineering groups exceeded the previous record of 14,896,291 SBUs set in August 2023 by 42,555 SBUs.
- The record was achieved in great part by the Science Mission Directorate supporting many high-resolution simulations with the Goddard Earth Observing System (GEOS) for future model development. These simulations approach 1.5 kilometers global resolution, with focus placed on extreme events and storm-scale processes in these simulations.
- Usage of Aitken, Pleaides, Electra, Endeavour, and Cabeus contributed to this record. The new record is greatly attributed to the Aitken Rome nodes, with 128 cores per node.
- The top 10 projects' usage ranged between 290,184 and 2,570,132 SBUs, and together accounted for over 49% of the total usage.
- Cabeus v100 GPU usage was included this period, adding an additional 483,136 SBUs of usage to achieve this record.
- The HECC project continues to evaluate and plan resources to address the future requirements of NASA's users.

**1 SBU represents the work that can be done in 1 hour on a Pleaides Broadwell 28-core node.*

IMPACT: The increased capacity of HECC systems and expert support to help users optimize their run capacities provide mission directorates with more resources to accomplish their goals and objectives.



Snapshot of forecasted aerosol optical depth from the GEOS model at 12-kilometer horizontal resolution, with blue plumes representing sea salt; white, carbon; and brown, dust. Features visible are dust plumes streaming from the Sahara into the Atlantic, carbon emissions from fires in Africa, and cyclones traced by sea salt in the Pacific.
William Putman, NASA/Goddard

HEC Communications Staff Support for AGU23

- Writers on the HECC Publications and Media team, with HEC colleagues at NASA Goddard and Headquarters, supported the NASA booth at the 2023 American Geophysical Union (AGU) Fall Meeting, held Dec. 11–15 in San Francisco with nearly 27,000 attendees from around the world.
- The writing team provided a script with talking points and a playlist of high-resolution images and videos for a hyperwall talk, “NASA High-End Computing,” presented by NASA Ames’ Ian Brosnan, principal investigator of the NASA Earth Exchange (NEX).
  - The script was developed jointly for HEC Program Manager Tsengdar Lee and Brosnan. The 15-minute presentation gave an overview of supercomputing resources at the NASA Advanced Supercomputing facility and the NASA Center for Climate Simulation and selected science projects enabled by NASA HEC.
  - Four HECC topics were highlighted: Large Asteroid Impacts; Planetary EDL; Total Solar Eclipses; and Finding Signals from Earth-Like Planets.
- HECC’s Michelle Moyer and HEC’s Jarrett Cohen provided in-person support at the “Innovation” table of the NASA booth, engaging with hundreds of attendees on NASA HPC capabilities.
  - Many attendees expressed interest in getting access to HEC supercomputers, and current users voiced their appreciation for our resources and services.
  - Staff interacted with potential NASA staff and interns, answering questions about opportunities and pointing them to QR code signs (developed by staff) and other tables within the NASA booth for more information.

IMPACT: Promoting NASA High-End Computing at AGU provided an opportunity to connect with existing users and inform potential users of the powerful capabilities and tools that can accelerate their scientific endeavors for agency missions and projects.

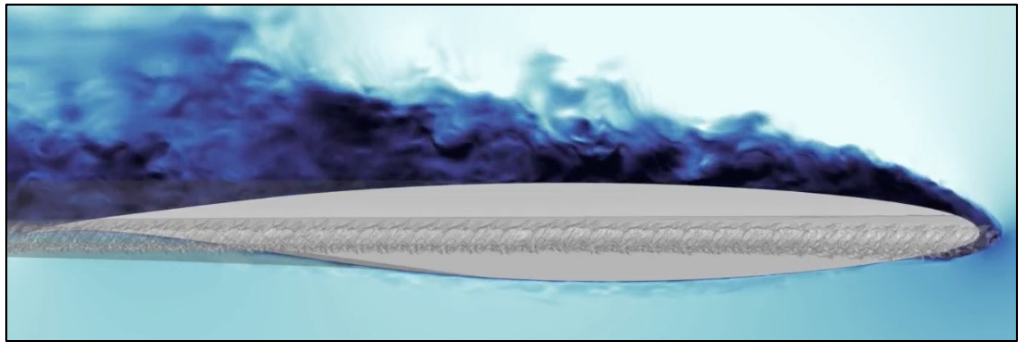


Ian Brosnan, NASA Earth Exchange, presenting “NASA High-End Computing” on the NASA hyperwall at the 2023 AGU Fall Meeting in San Francisco, December 11–15. *Jarrett Cohen, NASA/Goddard*

Simulating an Iced Wing for Aerodynamic Performance Predictions *

- Ice buildup on an aircraft in flight poses a significant safety risk, as it leads to reduced lift and increased drag. To help find ways to reduce the risk, researchers at NASA Ames used HECC systems to explore state-of-the-art computational tools that can provide accurate, cost-effective aerodynamic predictions.
- The team evaluated a scale-resolving simulation approach to determine its ability to predict the highly unsteady and turbulent aerodynamic flow that occurs over an iced aircraft wing and to better understand the fundamental flow physics involved.
  - The large-scale, unsteady, wall-modeled large-eddy simulations (WMLES), were run using the Launch, Ascent, and Vehicle Aerodynamics Curvilinear (LAVA) flow solver. Each simulation required about 400 million grid points and ran on 6,400 Aitken and Electra cores.
  - The hybrid body-fitted/immersed-boundary WMLES approach was found to be an effective way to model the influence of ice on the flow.
- The approach can predict the aerodynamic performance of iced wings with sufficient accuracy to potentially allow these types of predictions to be used for aircraft design and certification.

IMPACT: These simulations demonstrate that state-of-the-art, scale-resolving methods can provide accurate aerodynamic data for iced wings within turnaround times suitable for engineering applications.



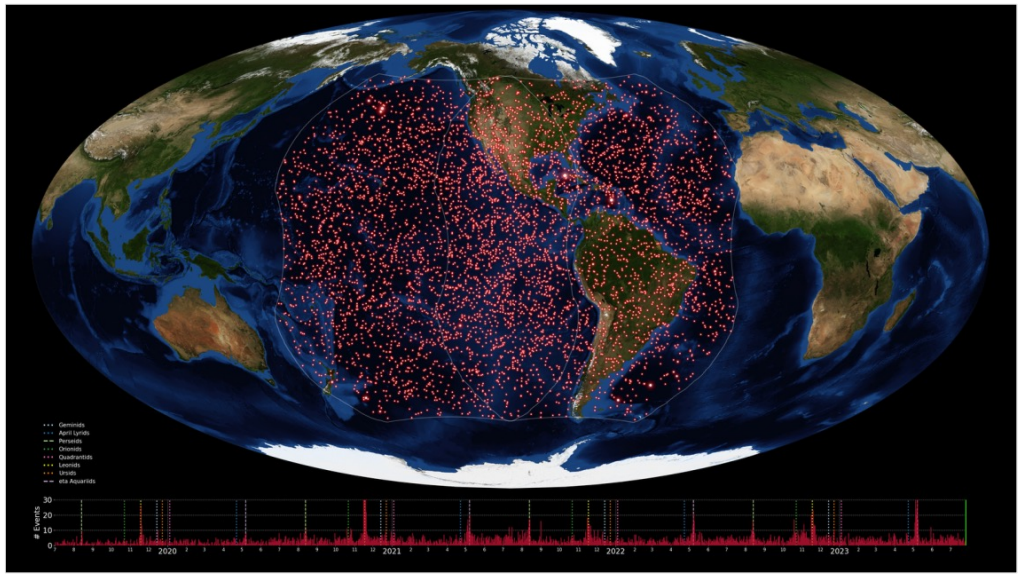
Video of a WMLES simulation of the flow over a scaled Common Research Model wing with high-fidelity leading-edge ice, showing a section slice of streamwise velocity contours normalized by velocity magnitude, where the darker color indicates regions of lower velocity, and lighter indicates higher velocity. *David Craig Penner, Jeffrey Housman, NASA/Ames*

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

Finding Fireballs Hidden in Satellite Lightning Data *

- Researchers at the SETI Institute are utilizing HECC systems to develop an automated pipeline to identify bolides—large exploding meteors—in observational lightning strike data from the NOAA's Geostationary Operational Environmental Satellite's (GOES) Geostationary Lightning Mapper instruments. Their goal is to create a rich, calibrated, and statistically consistent dataset of bolide light curves to inform the planetary defense community of the risks associated with meteoroid and large asteroid impacts.
- Using a custom pipeline with Python-based machine learning tools on the Aitken supercomputer, the team is detecting more than dozens of bolides per day within the GOES lightning strike data, where it was originally believed that they occurred a few times a week.
- After four years of processing, the bolide dataset is now large enough to perform statistical modeling of the distribution of large meteoroid impacts over the Earth.
- Eventually, researchers aim to develop a fully automated pipeline with no human intervention, which would automatically post bolide detections online quickly for the science community.

IMPACT: Funded by NASA's Planetary Defense Coordination Office, this project provides new data and insight into the frequency and distribution of asteroid and meteoroid impacts in Earth's atmosphere.



A 60-second timelapse animation of the detected bolides (exploding meteors) over four years of data collection. Each explosion represents one bolide. The size of the explosion relates to the brightness, and accordingly, the energy of the impact.
Nina McCurdy, NASA/Ames; Jeffrey Smith, SETI Institute

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

Papers

- "**Efficient Estimation of the Number of Clusters for High-Dimensional Data**," S. Kasapis, et al., *The Journal of Defense Modeling and Simulation: Applications, Methodology, Technology*, published online December 6, 2023. *
  https://journals.sagepub.com/doi/full/10.1177/15485129231214569
- "**A Multi-Limiter Method for Simulating Complex Flows on Large Grids**," J. Schoppe, P. Cizmas, *Physics of Fluids*, vol. 35, issue 12, published online December 8, 2023. *
  https://pubs.aip.org/aip/pof/article-abstract/35/12/125115/2928802/A-multi-limiter-method-for-simulating-complex?redirectedFrom=fulltext
- "**TOI-4641b: An Aligned Warm Jupiter Orbiting a Bright (V=7.5) Rapidly Rotating F-Star**," A. Bieryla, et al., *Monthly Notices of the Royal Astronomical Society*, published online December 8, 2023. *
  https://academic.oup.com/mnras/advance-article/doi/10.1093/mnras/stad3785/7464053
- "**Modelling Time-Dependent Convective Penetration in 1D Stellar Evolution**," C. Johnston, et al., arXiv:2312.08315 [astro-ph.SR}, December 13, 2023. *
  https://arxiv.org/abs/2312.08315
- "**NEOMOD 2: An Updated Model of Near-Earth Objects from a Decade of Catalina Sky Survey Observations**," D. Nesvorny, et al., *Icarus*, vol. 411, published online December 13, 2023. *
  https://www.sciencedirect.com/science/article/abs/pii/S0019103523005018
- "**Six Consecutive Seasons of High-Resolution Mountain Snow Depth Maps from Satellite Stereo Imagery**," J. M. Hu, et al., *Geophysical Research Letters*, vol. 50, issue 24, published online December 19, 2023. *
  https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2023GL104871

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

Papers (cont.)

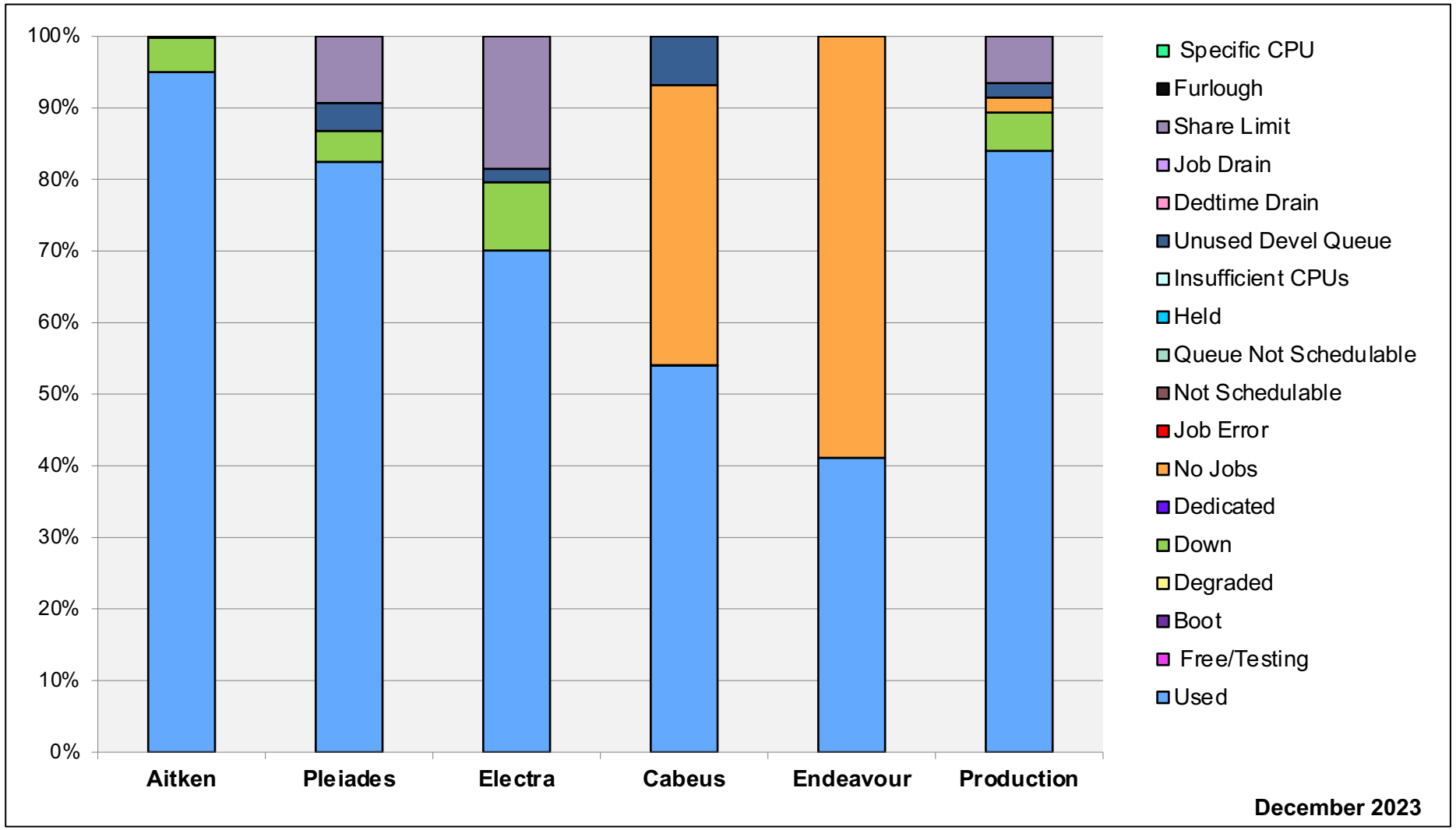
- "**Inertial Waves in a Nonlinear Simulation of the Sun's Convective Zone and Radiative Interior**," C. Blume, et al., arXiv:2312.14270 [astro-ph.SR], December 21, 2023. *
  https://arxiv.org/abs/2312.14270
- "**Solar Eruptions Triggered by Flux Emergence Below or Near a Coronal Flux Rope**," T. Török, et al., arXiv:2312.14092 [astro-ph.SR], December 21, 2023. *
  https://arxiv.org/abs/2312.14092
- "**Impact of Time-Dependent Data Assimilation on Ice Flow Model Initialization and Projections: A Case Study of Kjer Glacier, Greenland**," Y. Choi, et al., *The Cryosphere*, vol. 17, issue 12, published online December 22, 2023. *
  https://tc.copernicus.org/articles/17/5499/2023/

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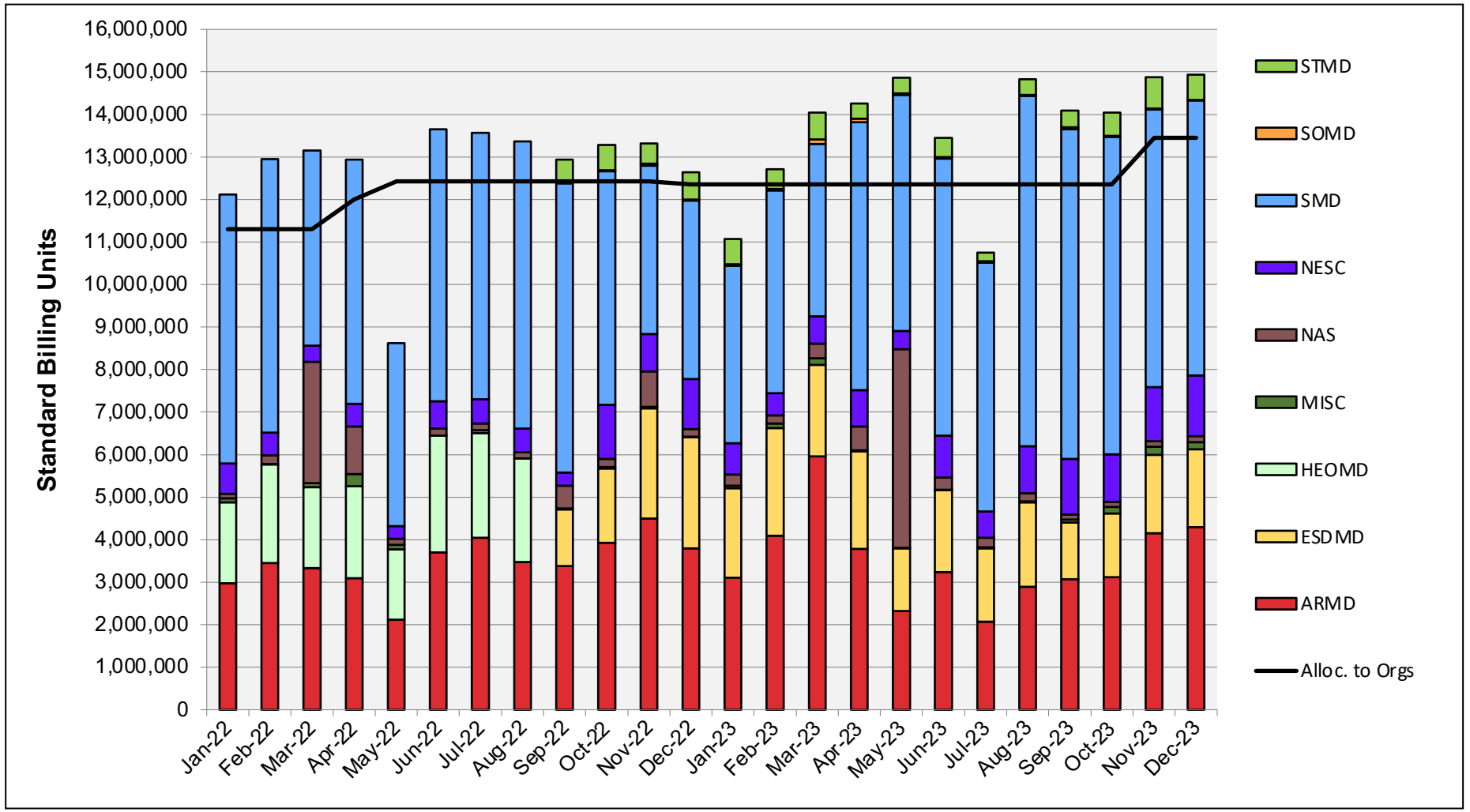
News and Events

- **2023 in Review: Highlights from NASA in Silicon Valley**, *NASA Ames Research Center*, December 13, 2023—Review of some of the science, engineering and innovation achievements at NASA Ames in 2023, including aeronautics modeling and simulation performed at the NASA Advanced Supercomputing facility.
  https://www.nasa.gov/centers-and-facilities/ames/2023-nasa-silicon-valley/
- **NAS Science Gives the Gift of Insight in 2023**, *NASA Advanced Supercomputing Division*, December 27, 2023—The year's highlights from several projects led by NAS scientists and engineers supporting missions across the agency.
  https://www.nas.nasa.gov/pubs/stories/2023/feature_NAS_science_gives_the_gift_of_insight_in_2023.html

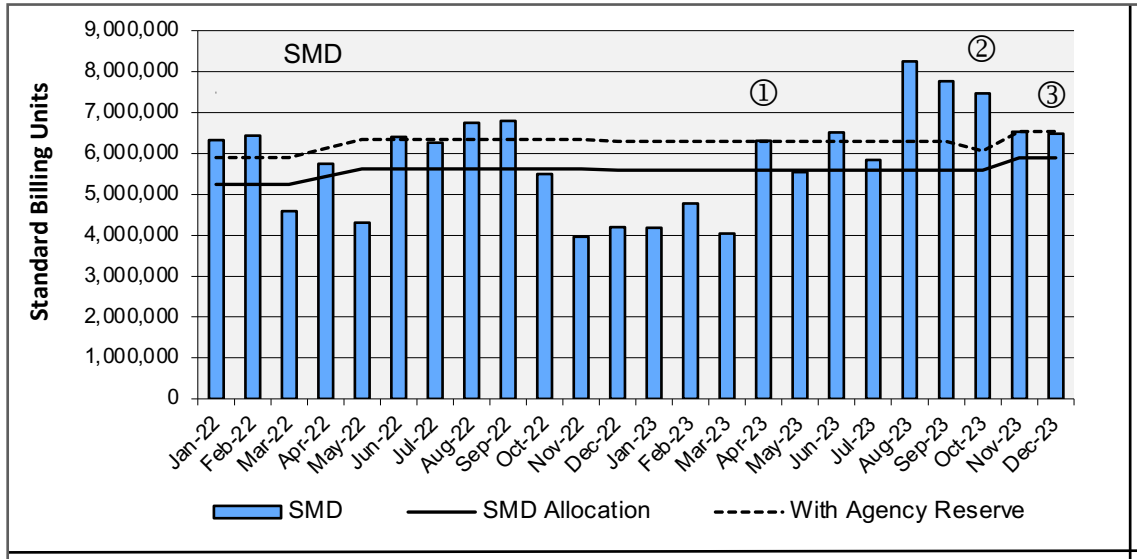
HECC Utilization

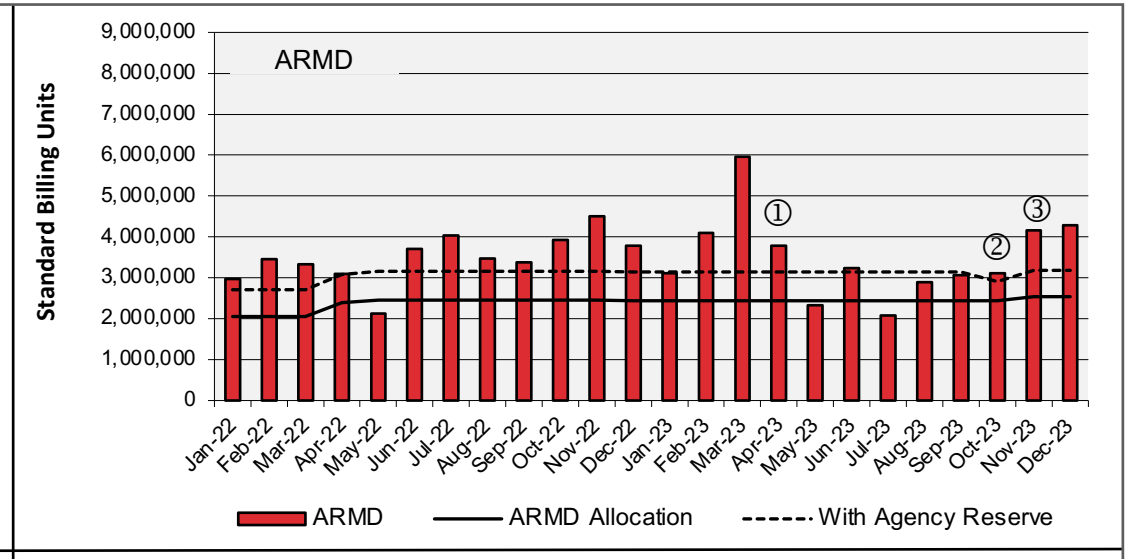


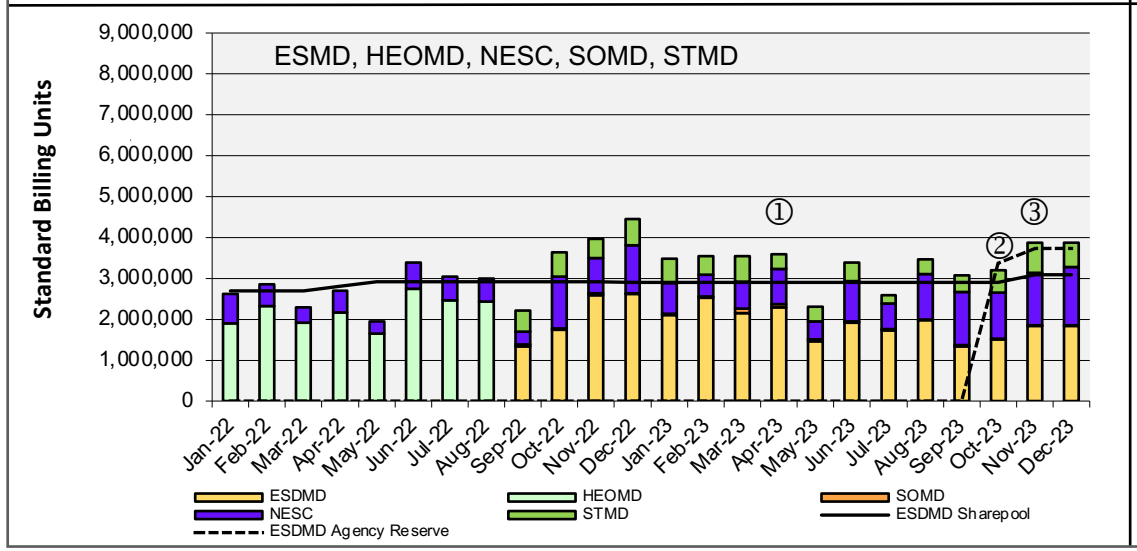
HECC Utilization Normalized to 30-Day Month



HECC Utilization Normalized to 30-Day Month





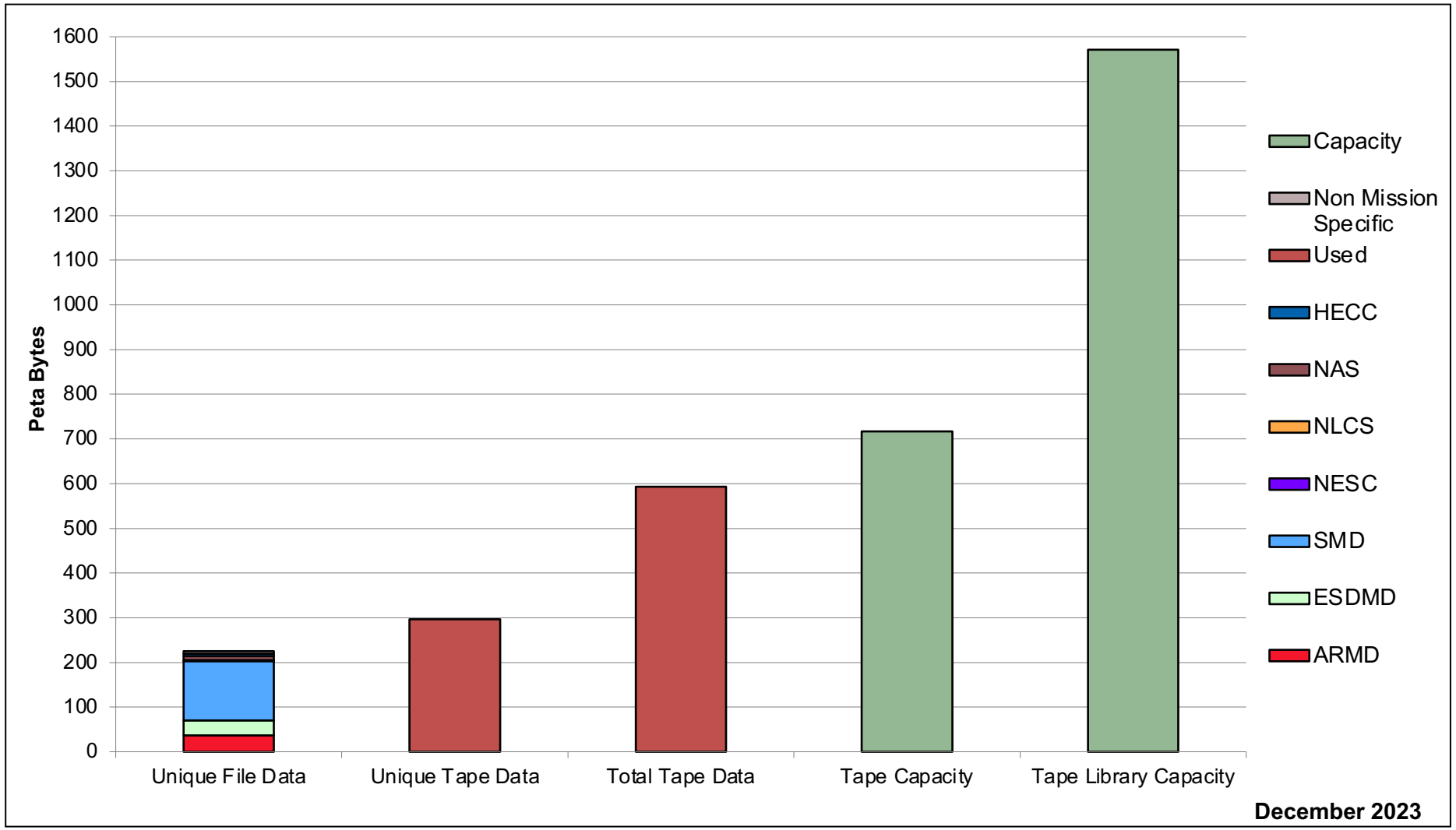


① 4 Rome Apollo Racks added to Aitken

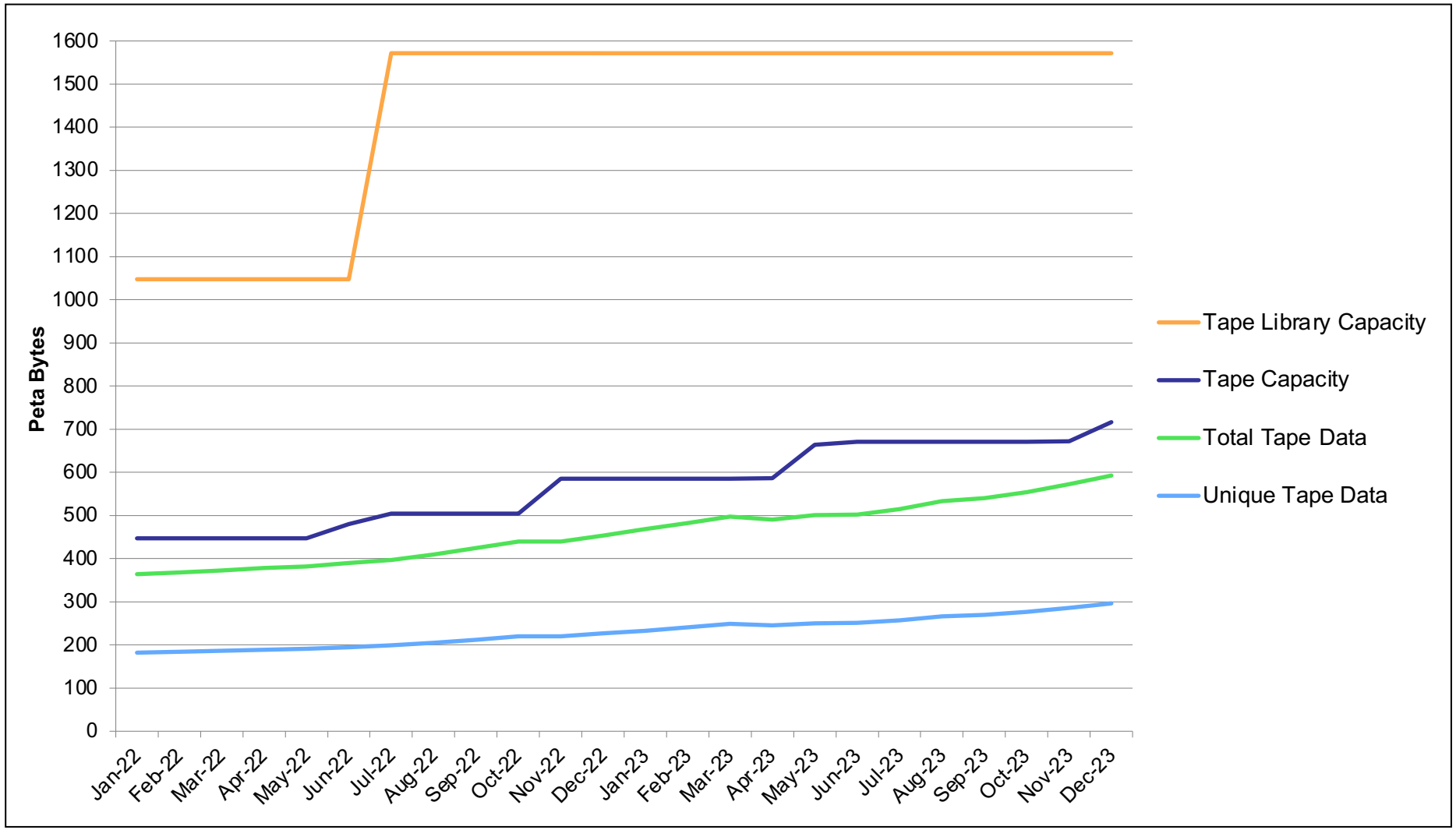
② 4 Rome Apollo Racks added to Aitken

③ Cabeus v100 nodes added

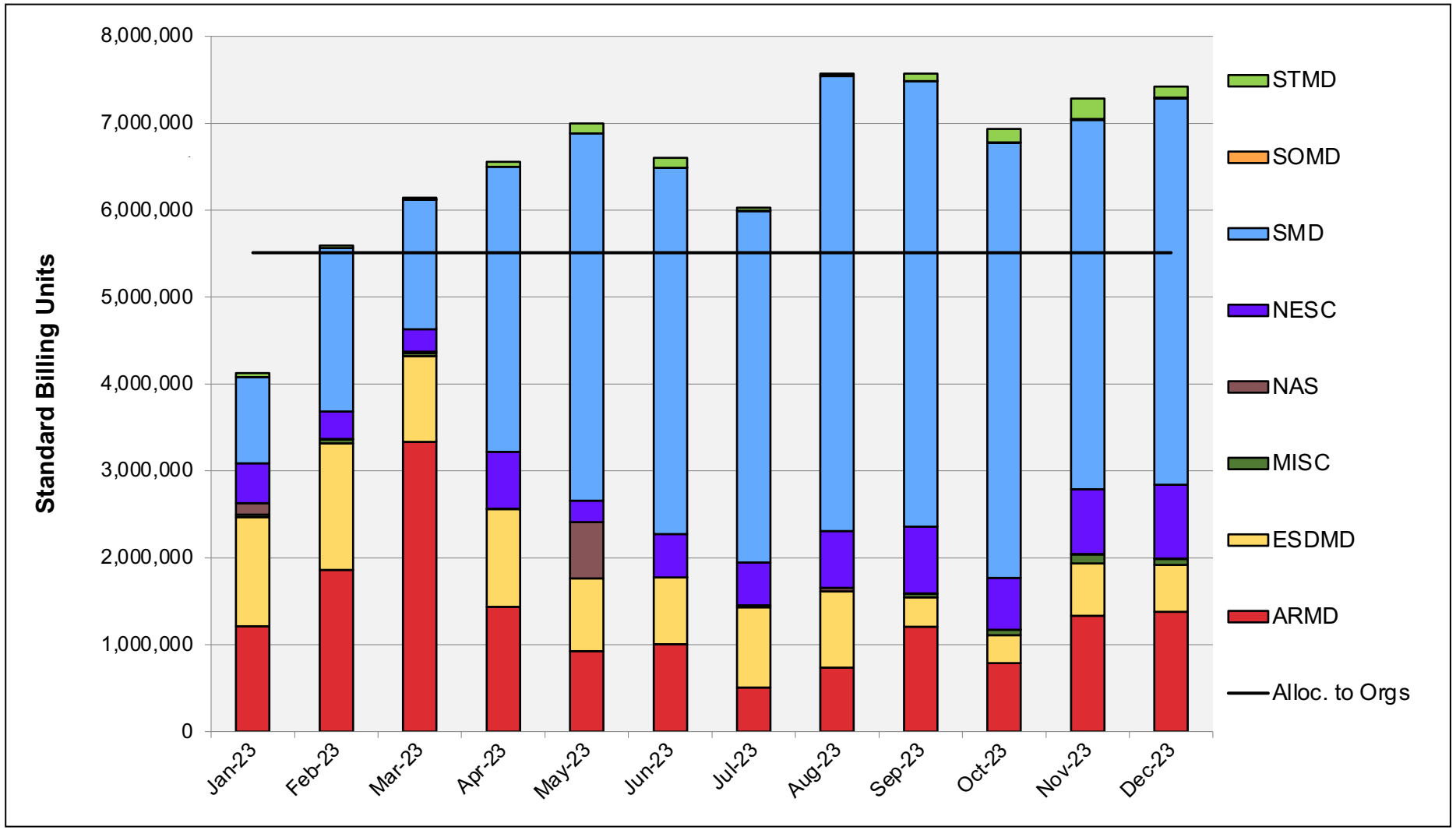
Tape Archive Status



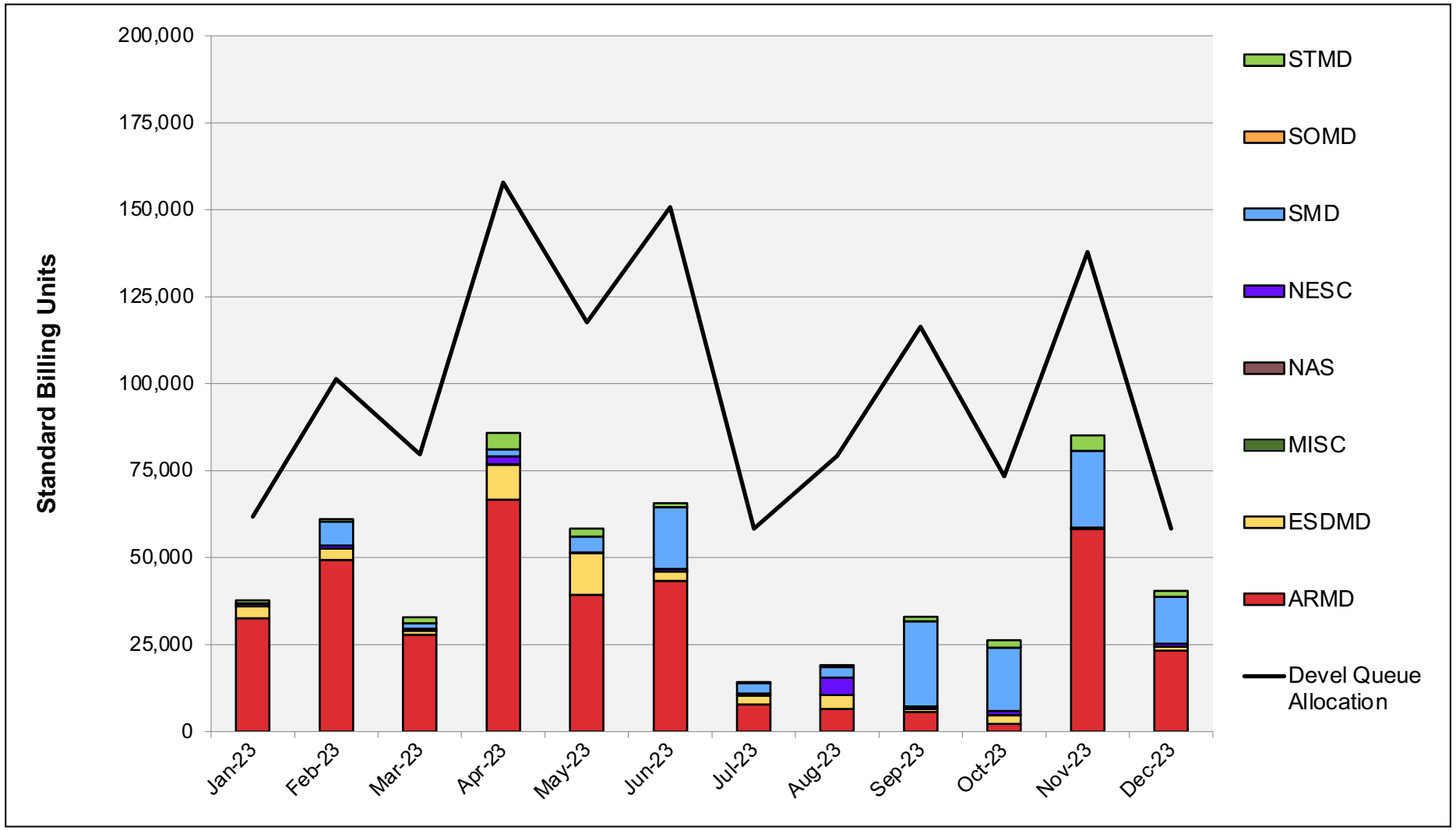
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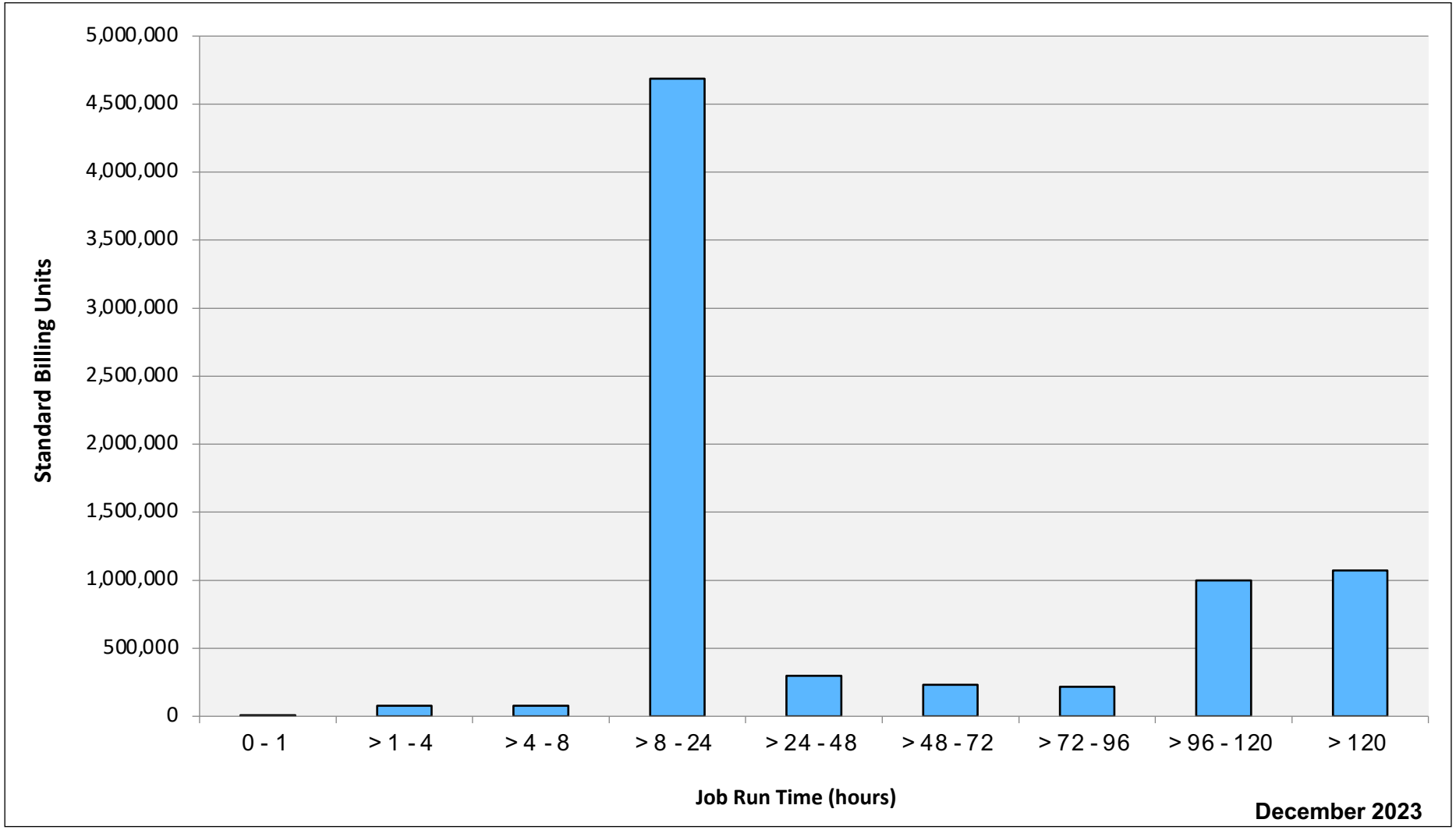
Aitken: SBUs Reported, Normalized to 30-Day Month



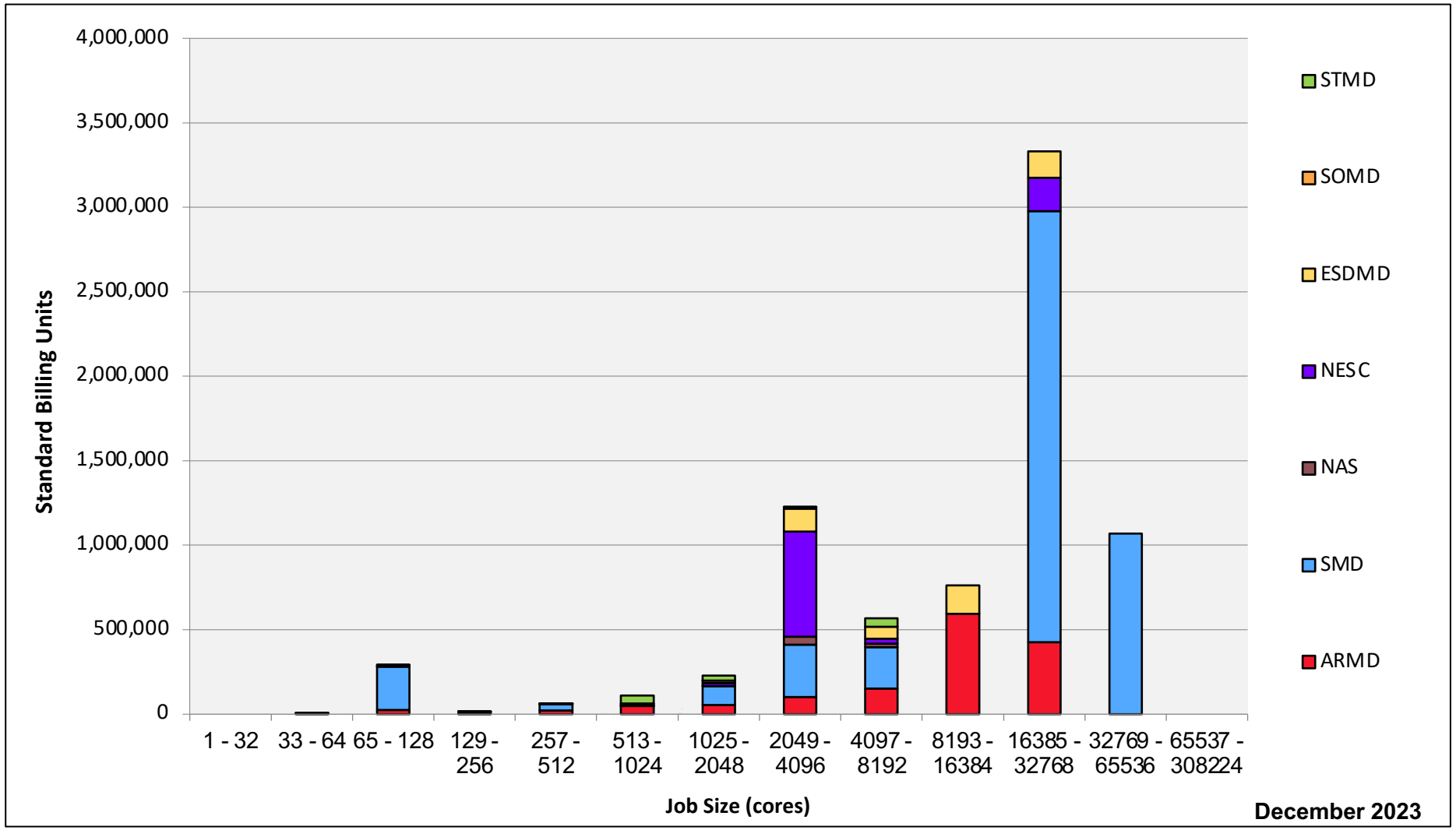
Aitken: Devel Queue Utilization



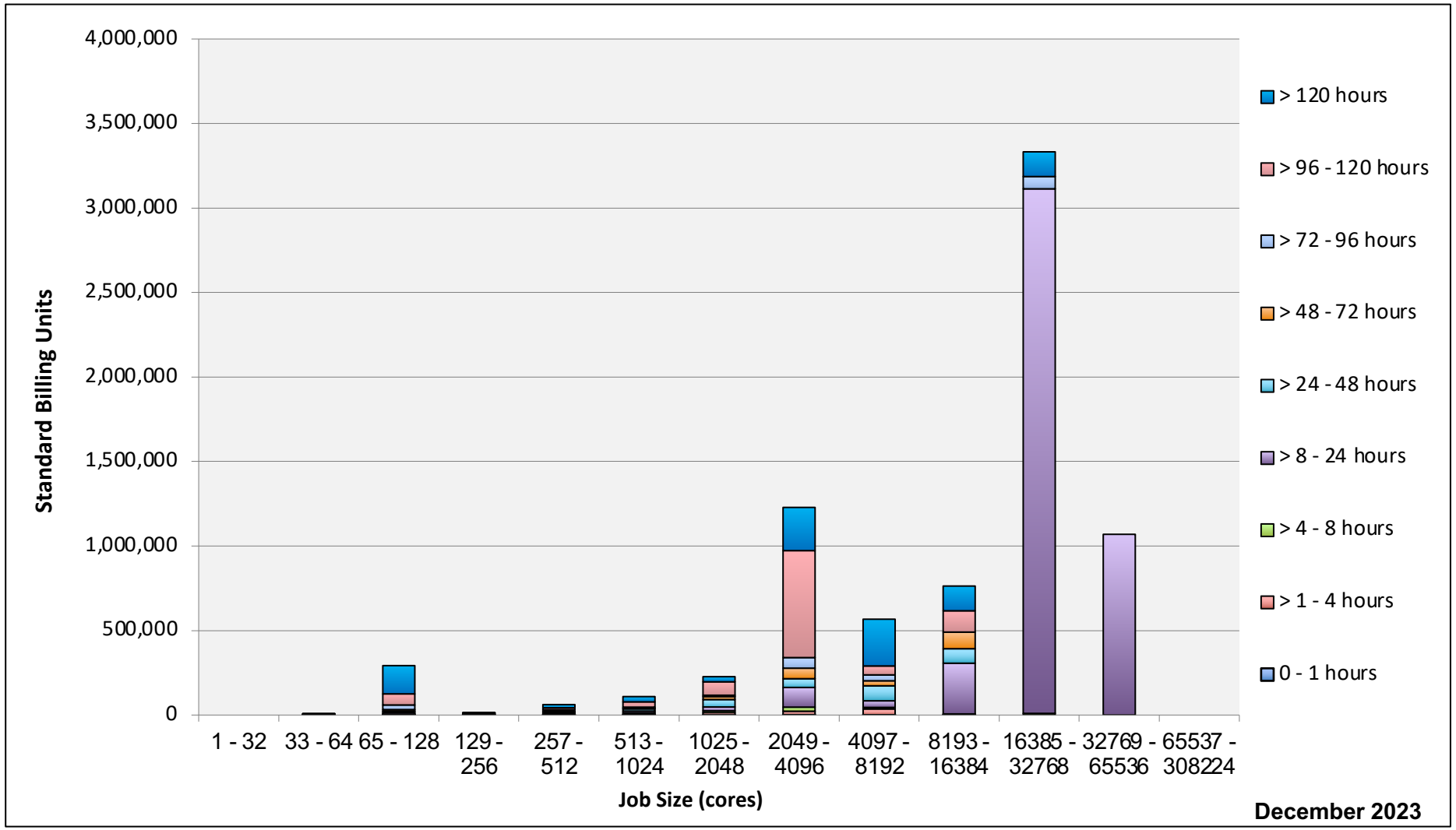
Aitken: Monthly Utilization by Job Length



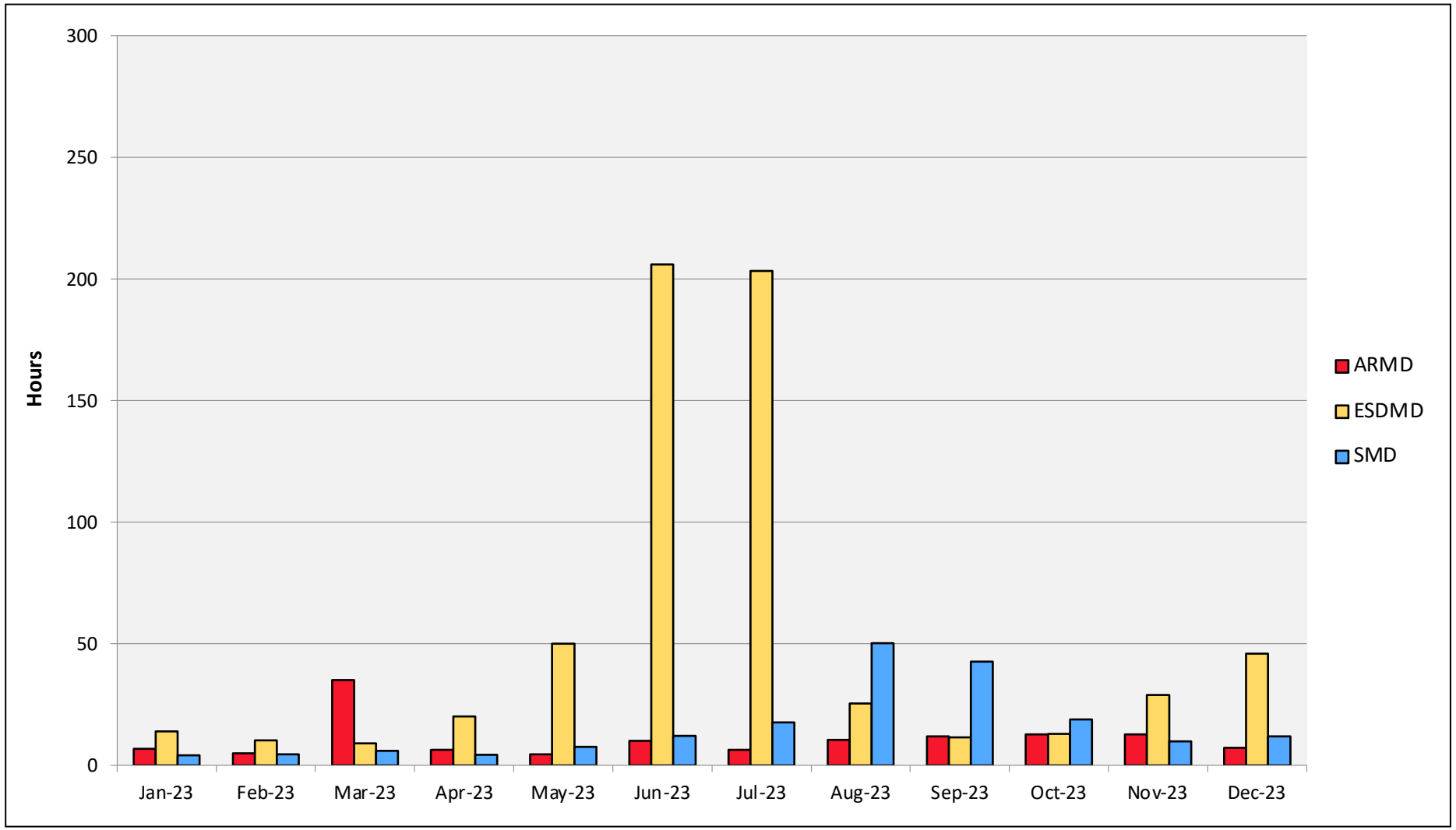
Aitken: Monthly Utilization by Job Size



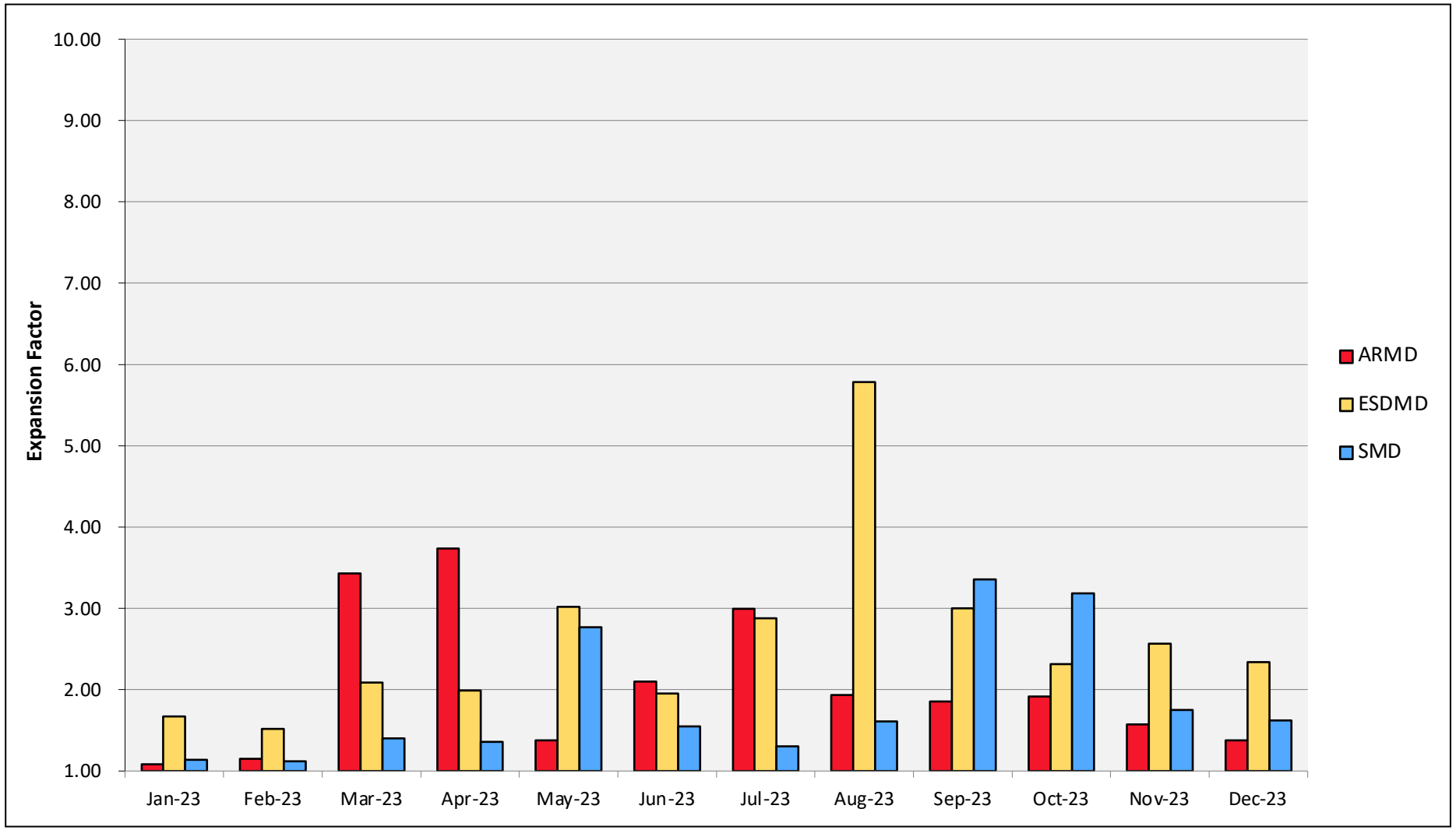
Aitken: Monthly Utilization by Size and Length



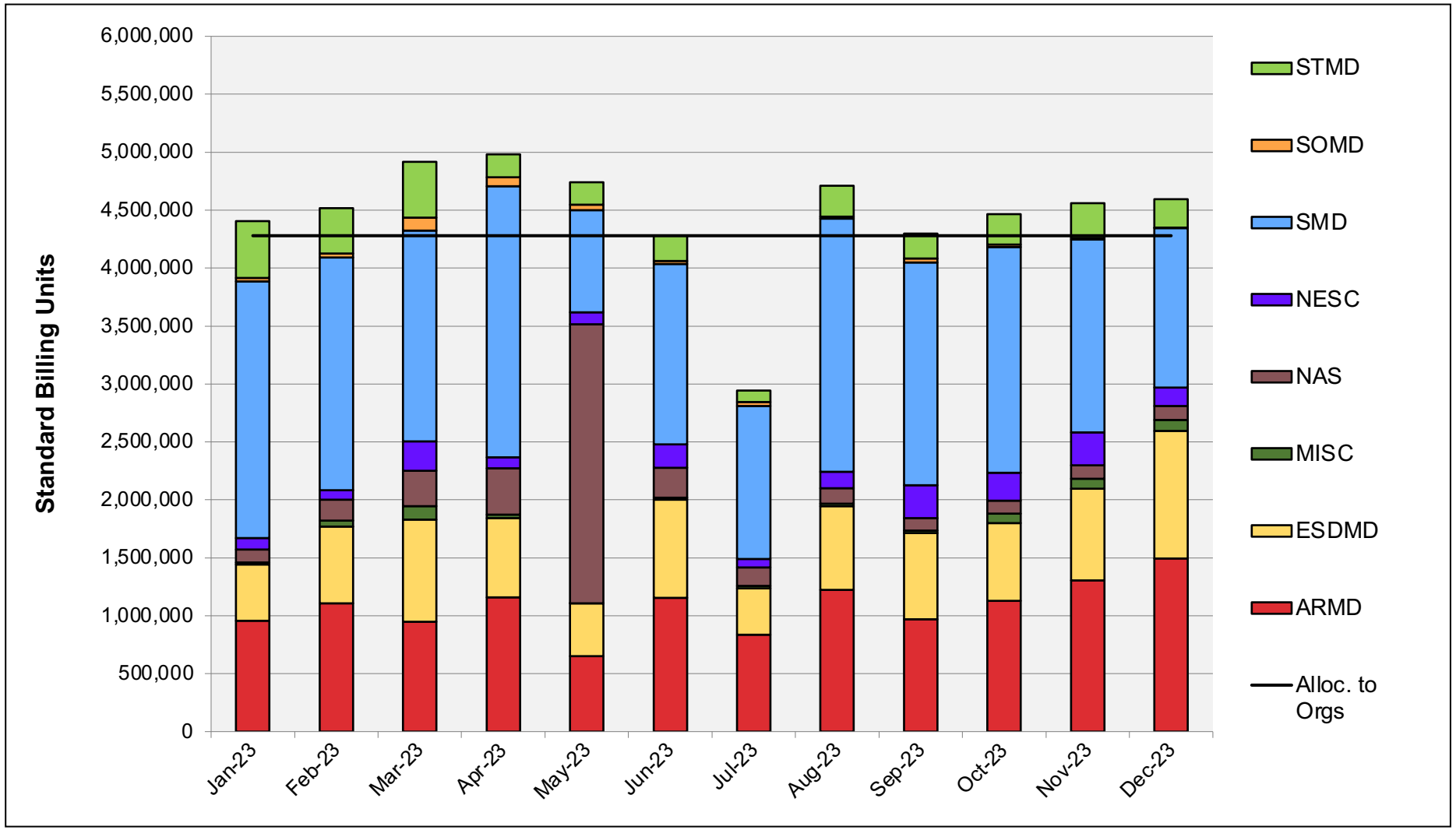
Aitken: Average Time to Clear All Jobs



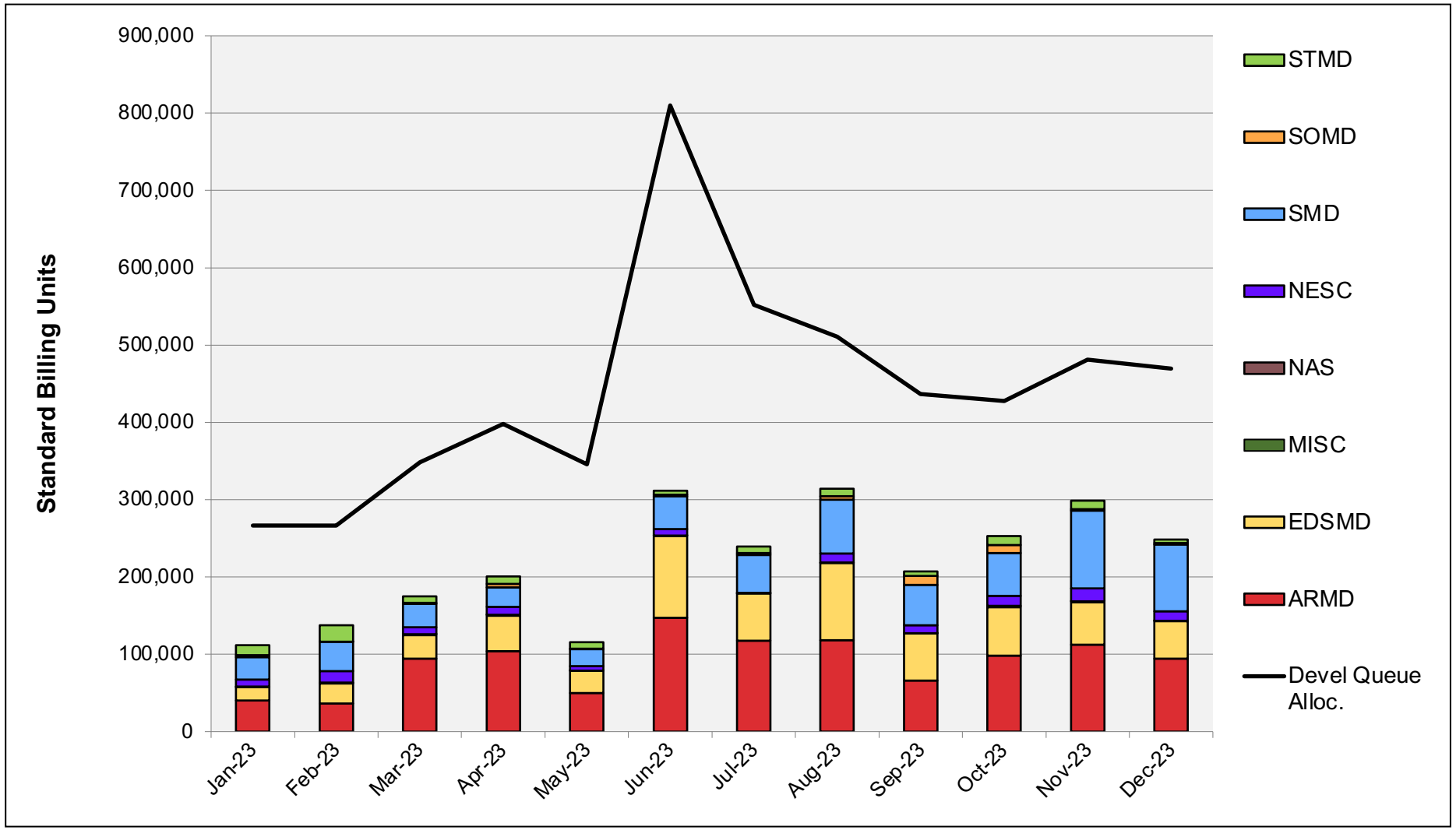
Aitken: Average Expansion Factor



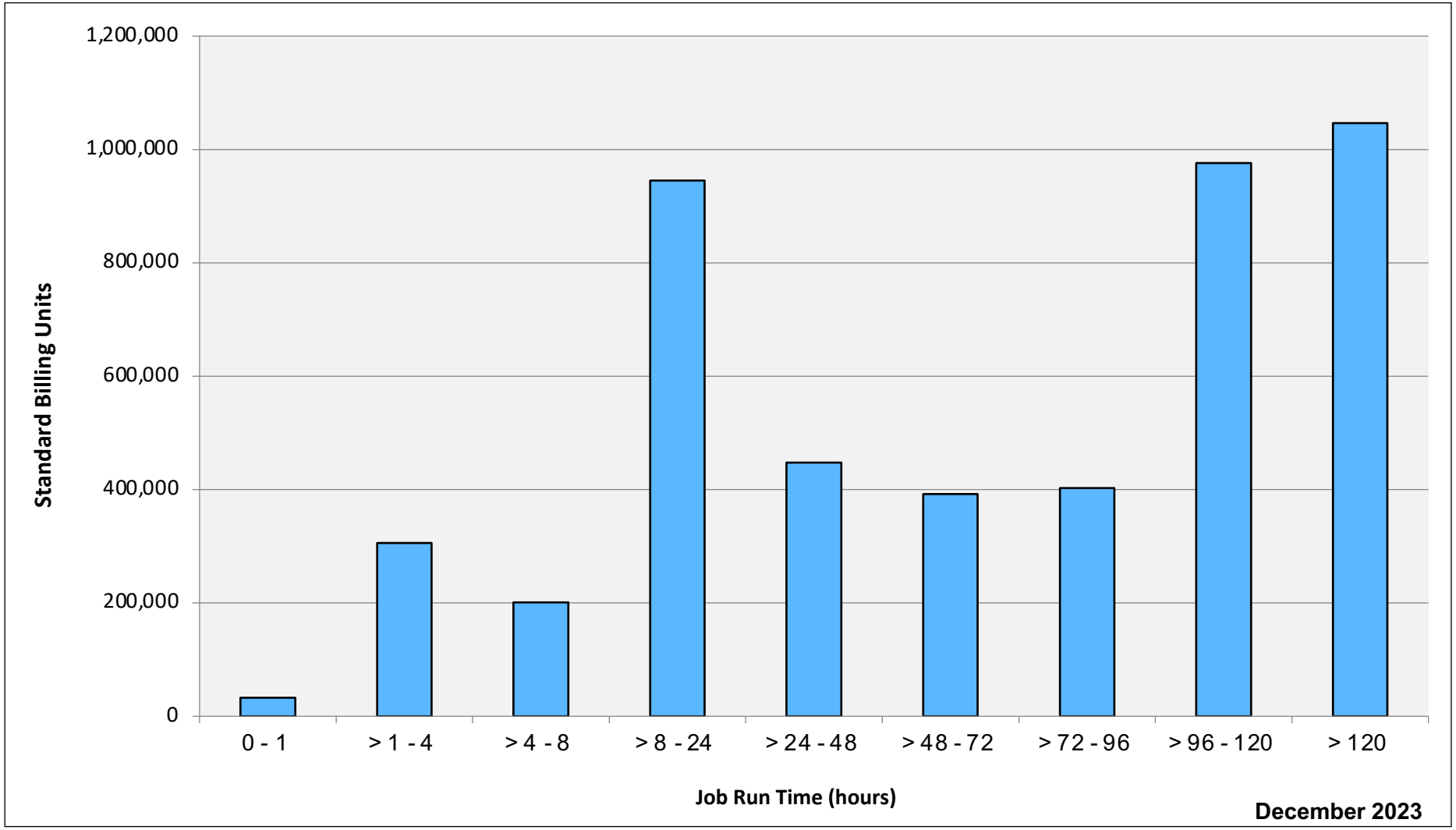
Pleiades: SBUs Reported, Normalized to 30-Day Month



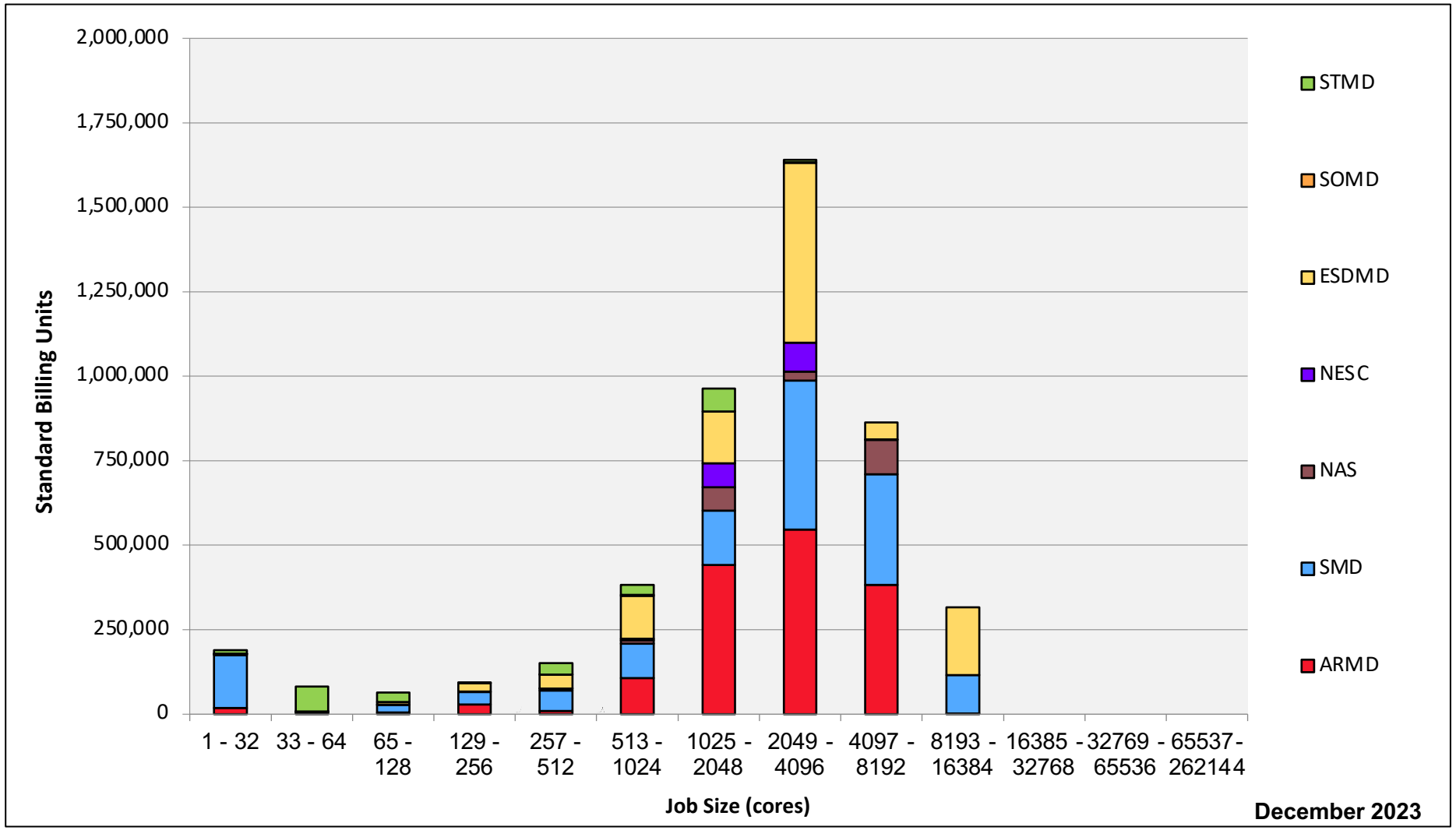
Pleiades: Devel Queue Utilization



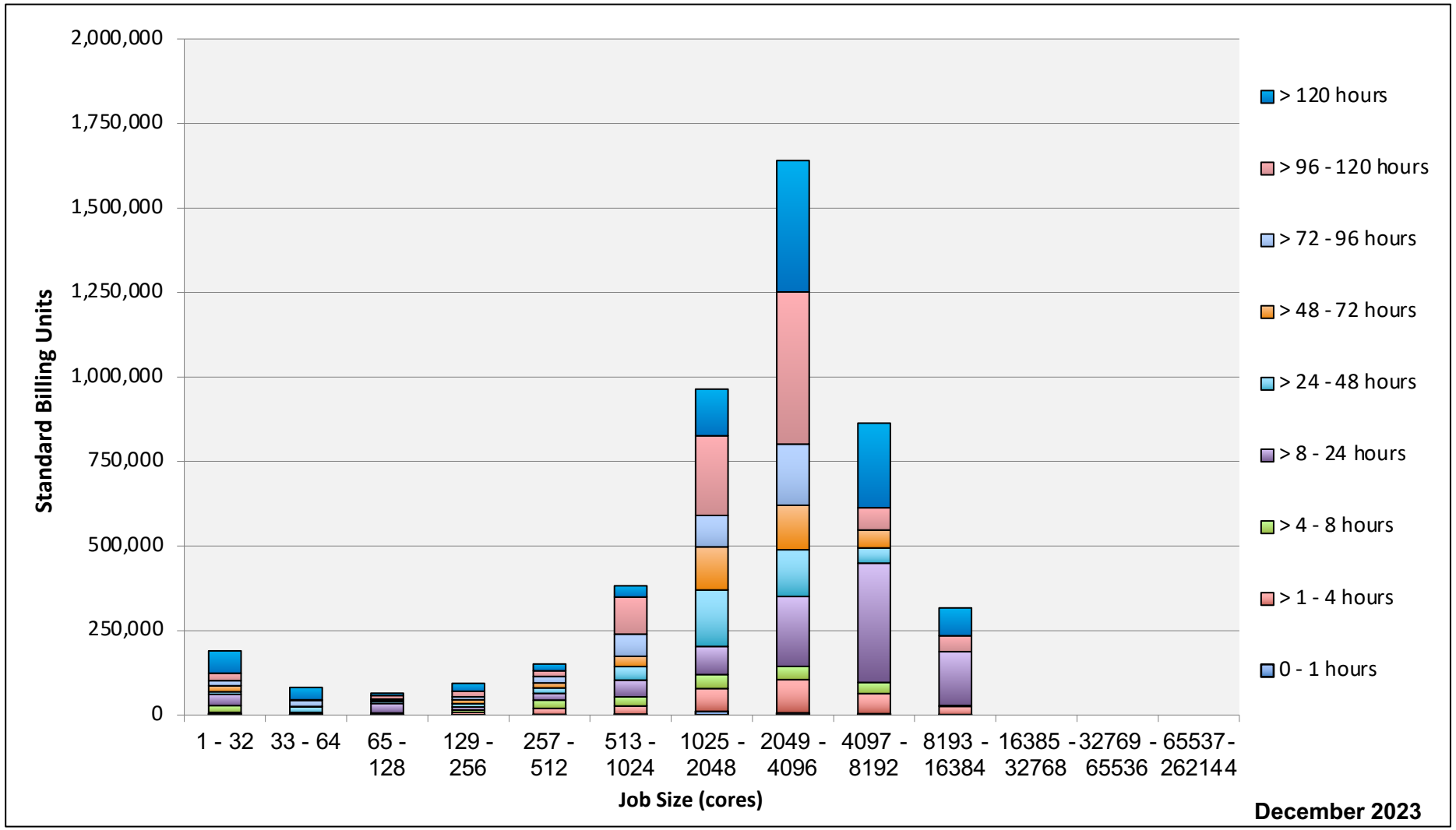
Pleiades: Monthly Utilization by Job Length



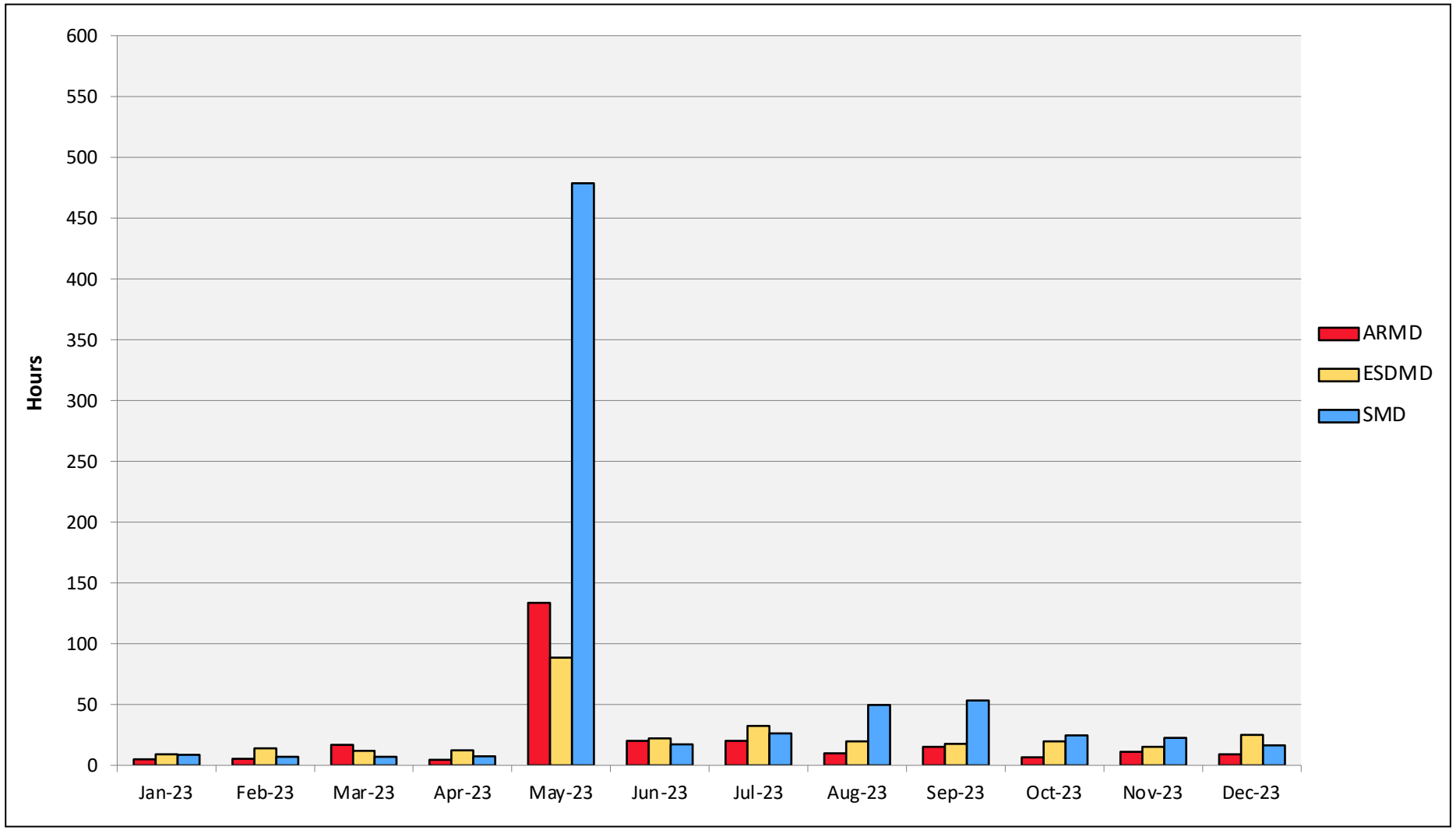
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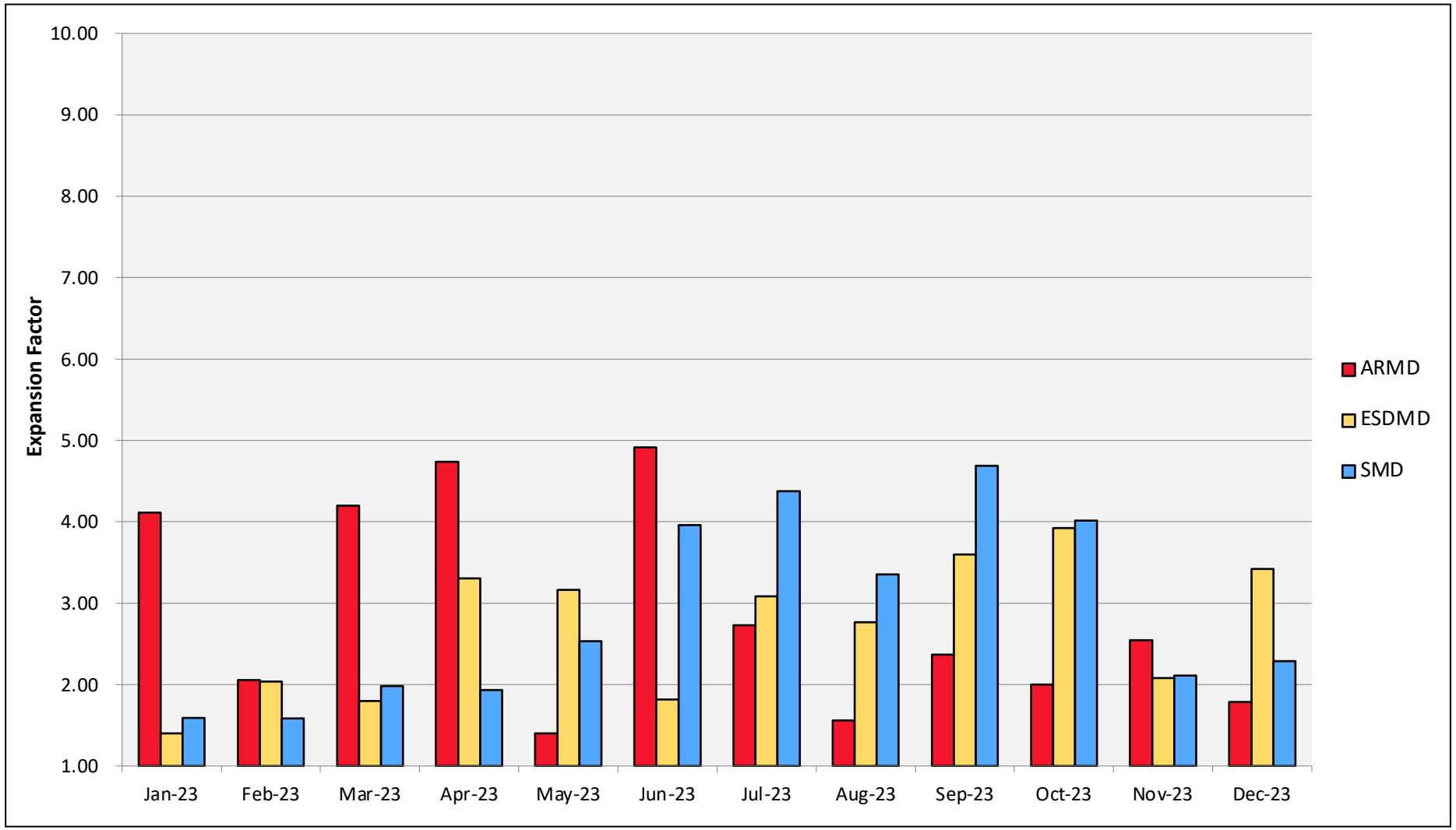
Pleiades: Monthly Utilization by Size and Length



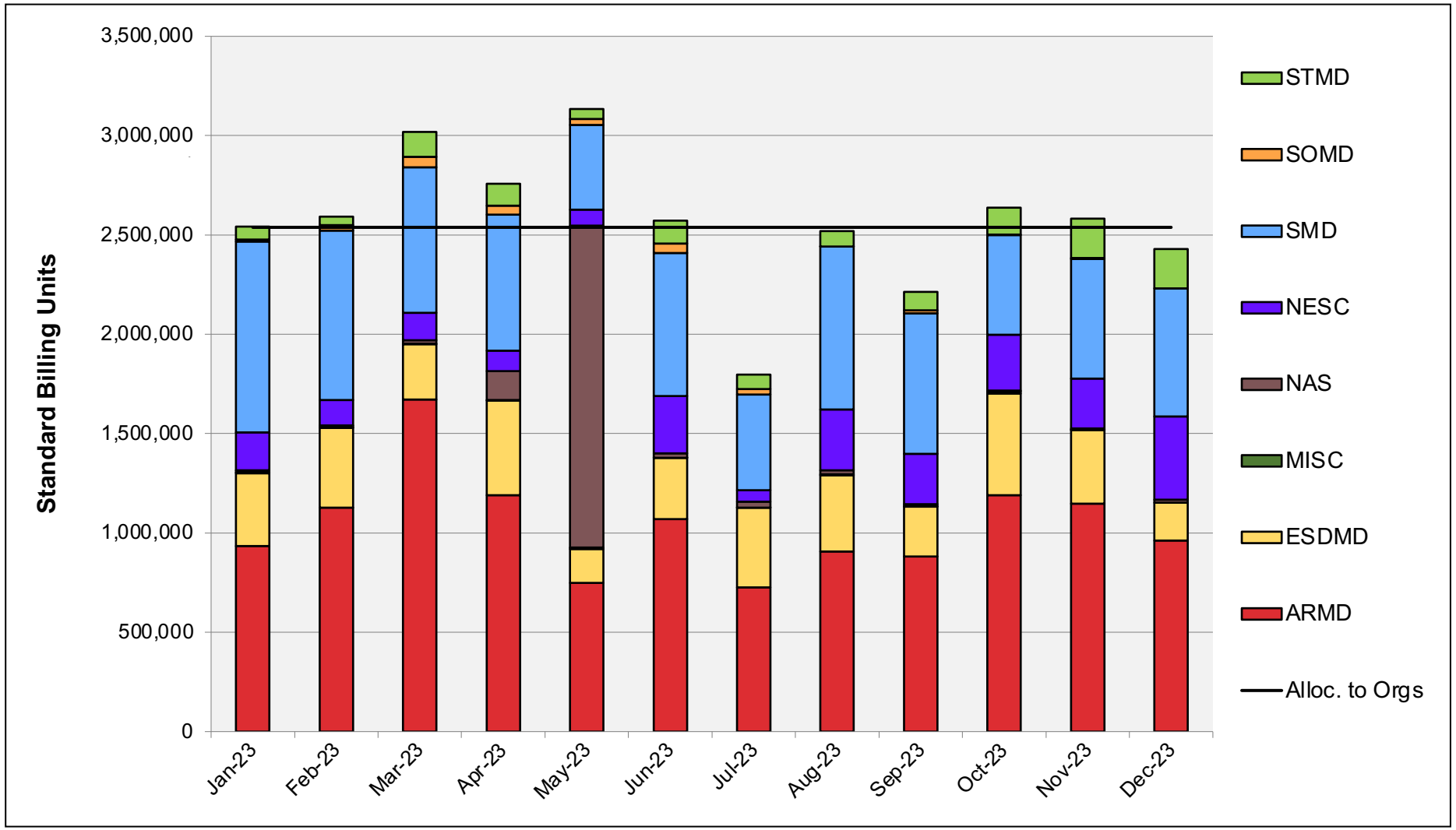
Pleiades: Average Time to Clear All Jobs



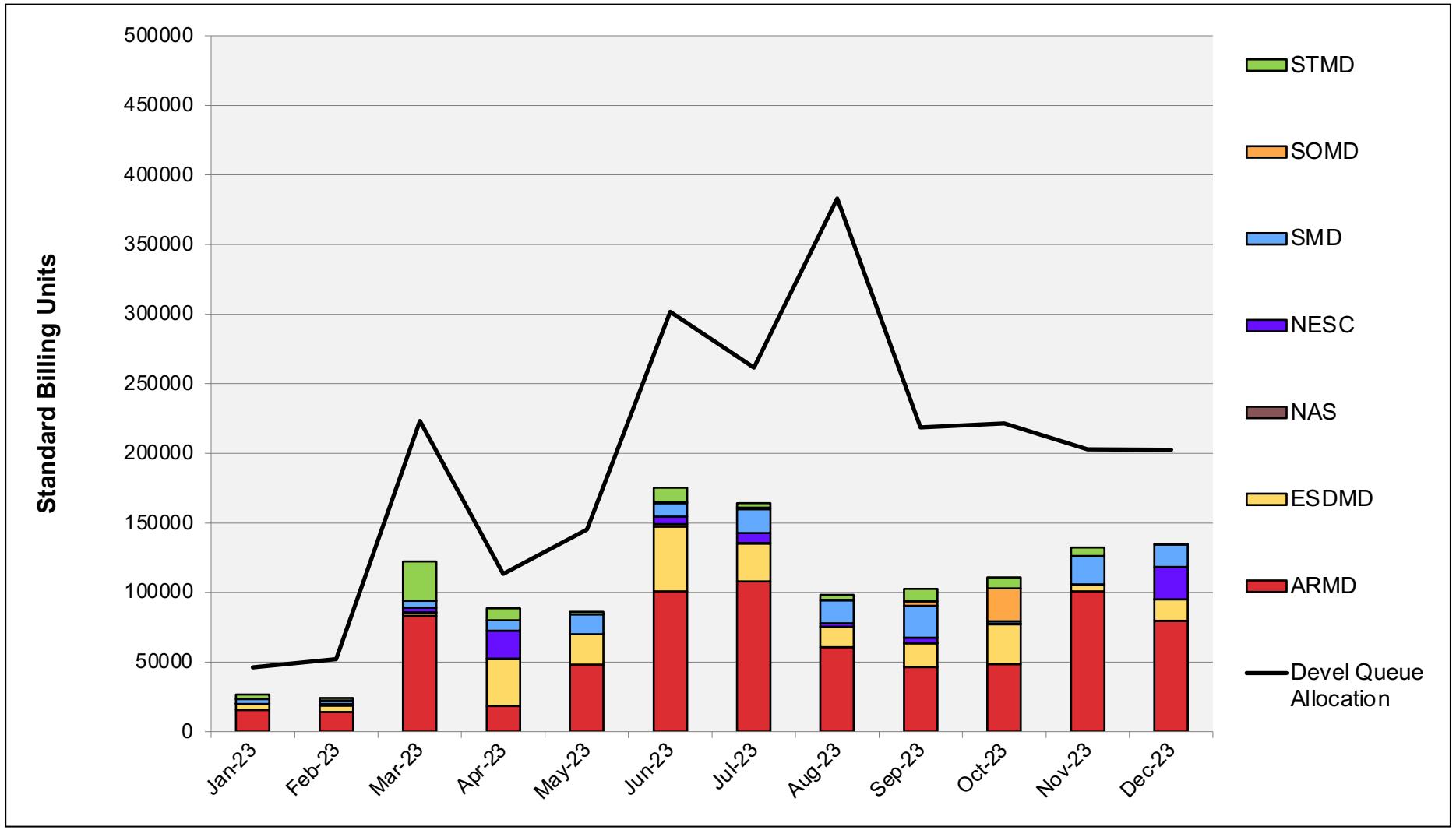
Pleiades: Average Expansion Factor



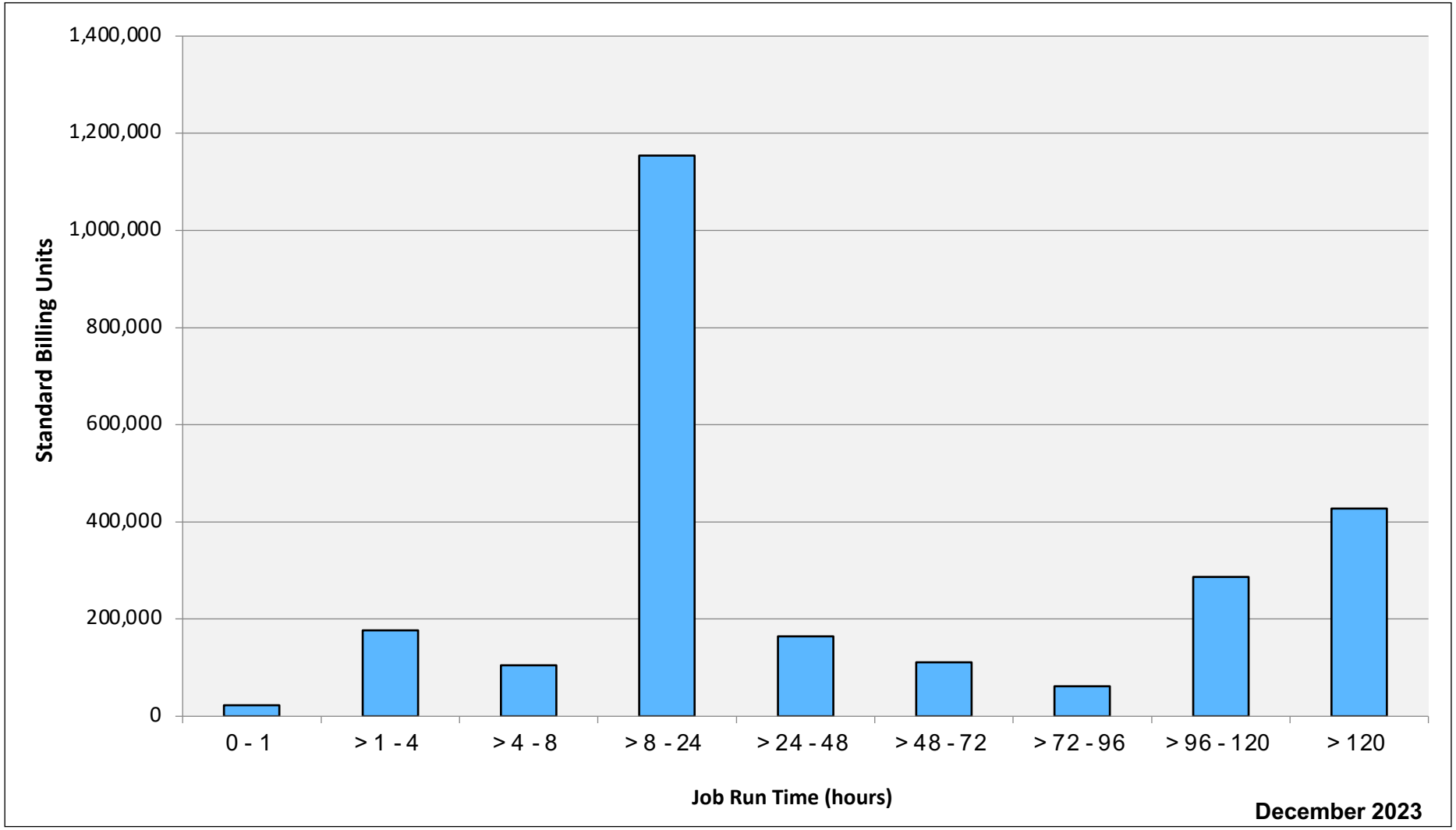
Electra: SBUs Reported, Normalized to 30-Day Month



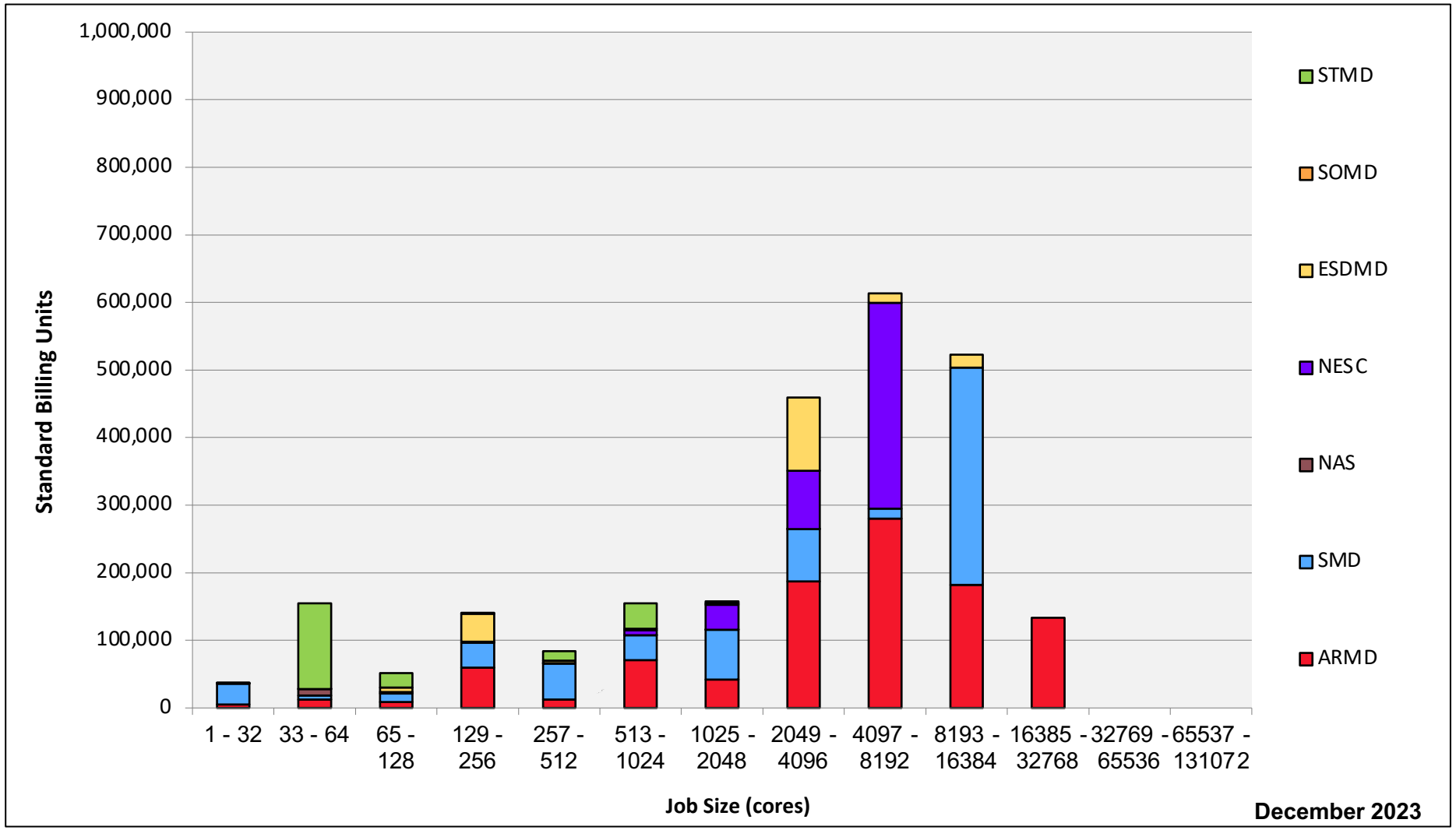
Electra: Devel Queue Utilization



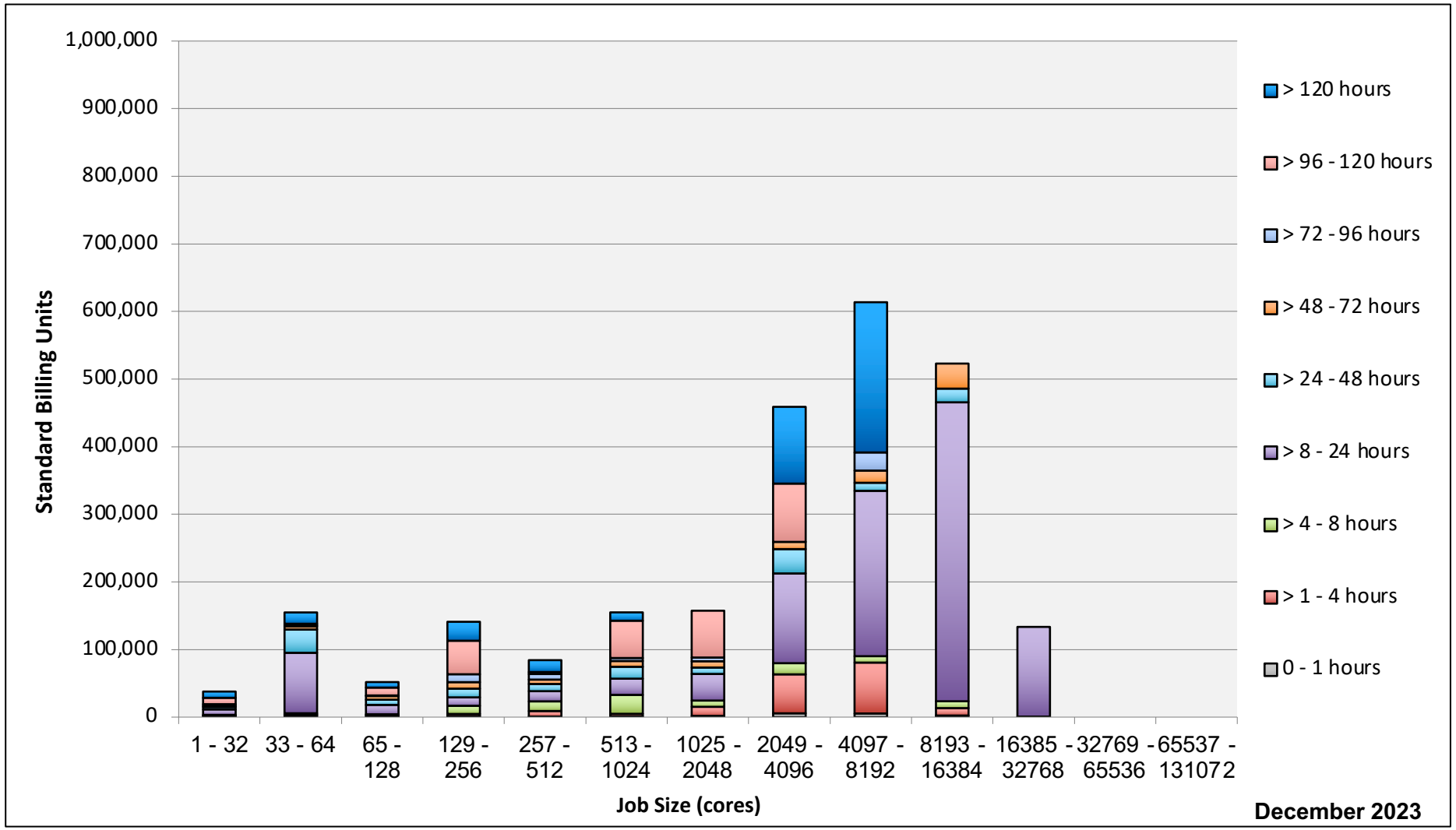
Electra: Monthly Utilization by Job Length



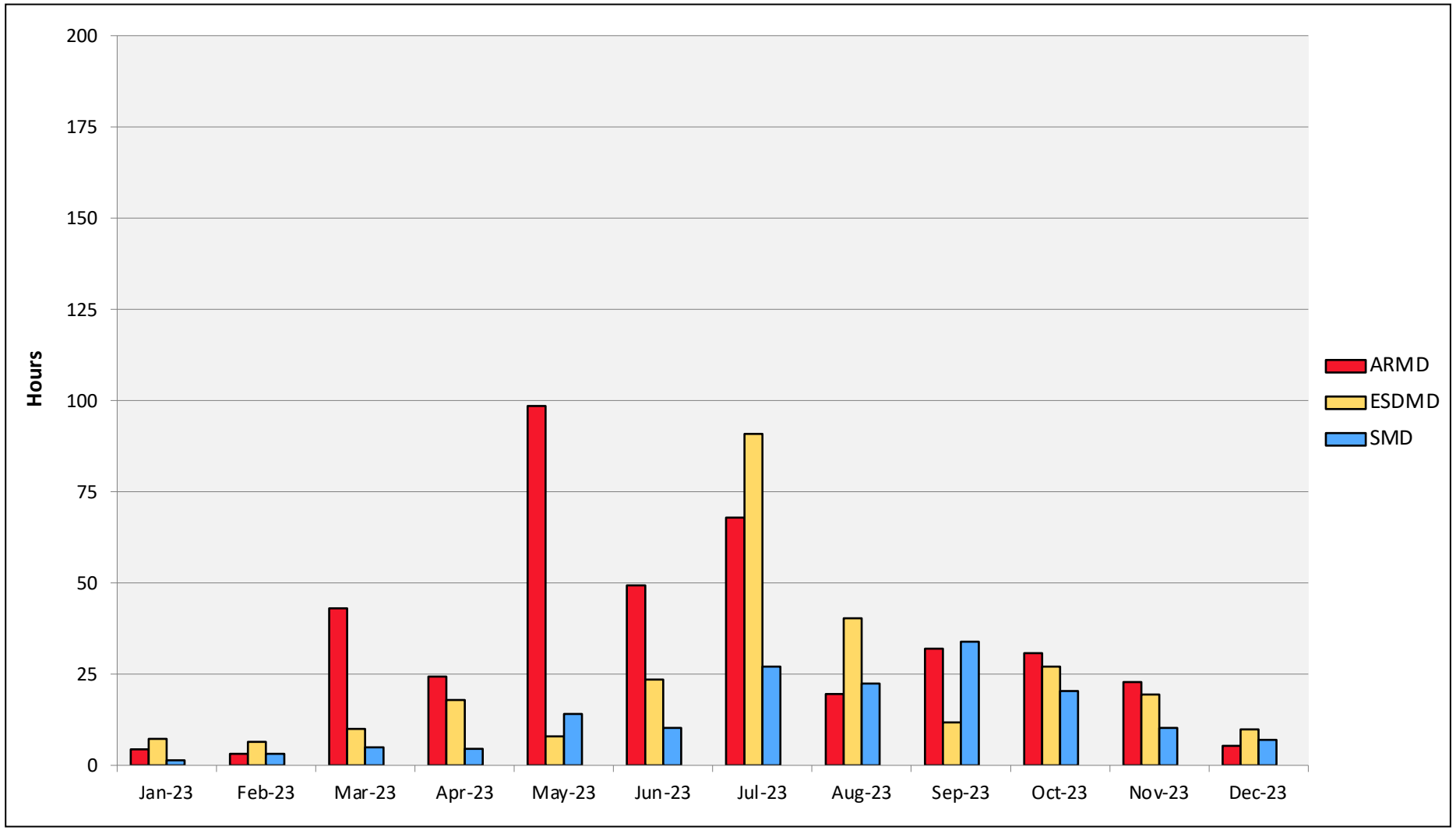
Electra: Monthly Utilization by Job Size



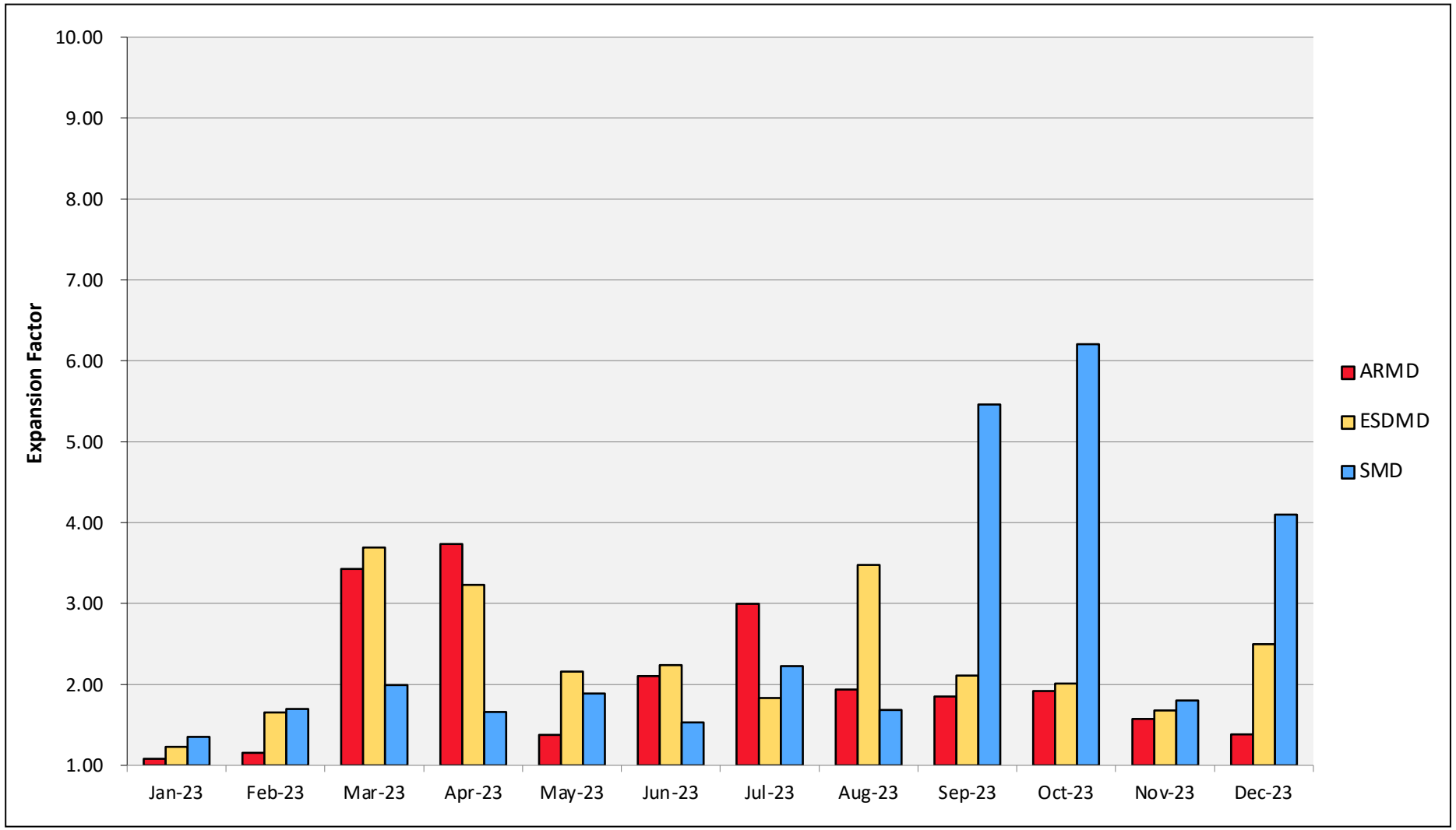
Electra: Monthly Utilization by Size and Length



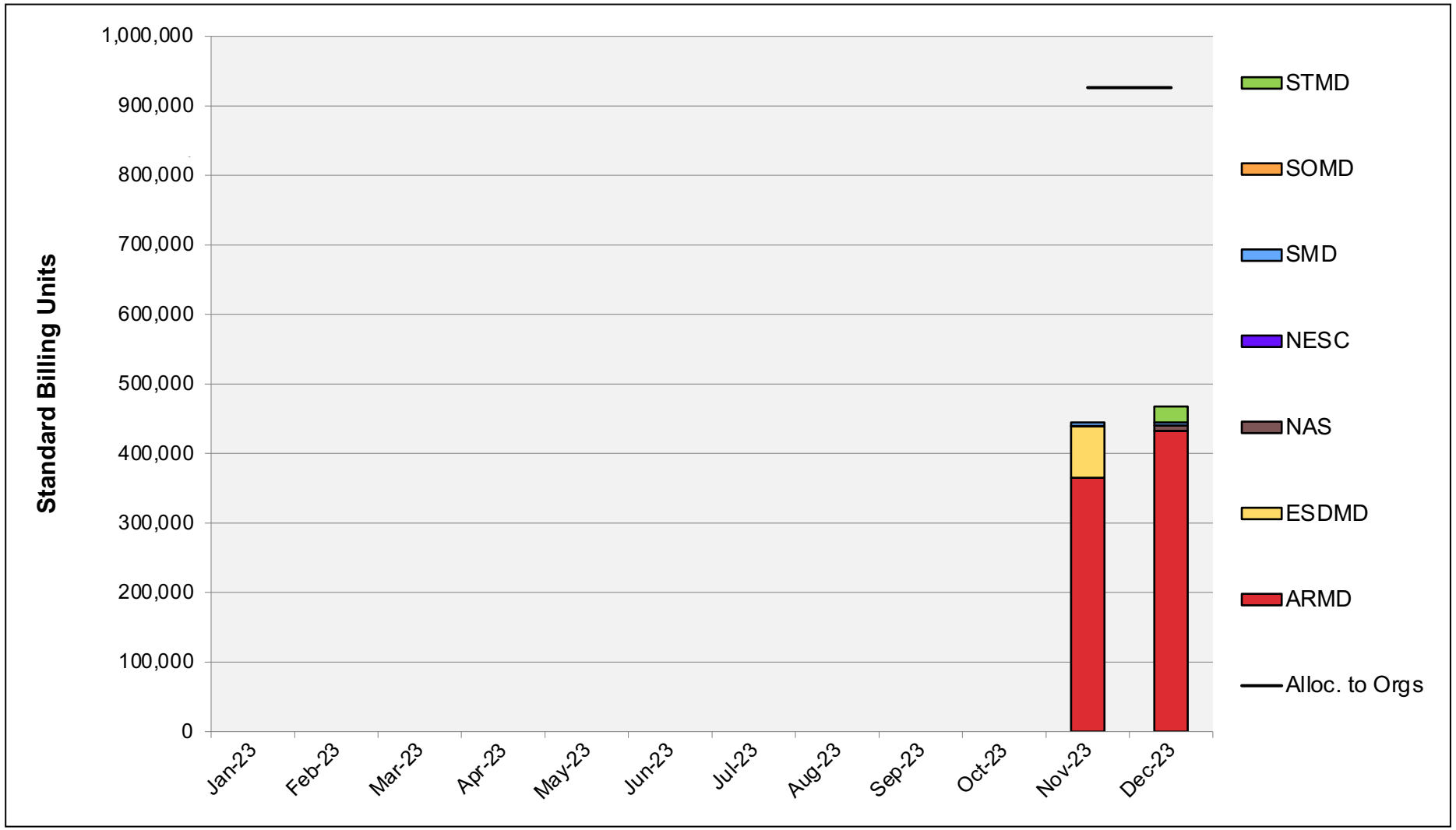
Electra: Average Time to Clear All Jobs



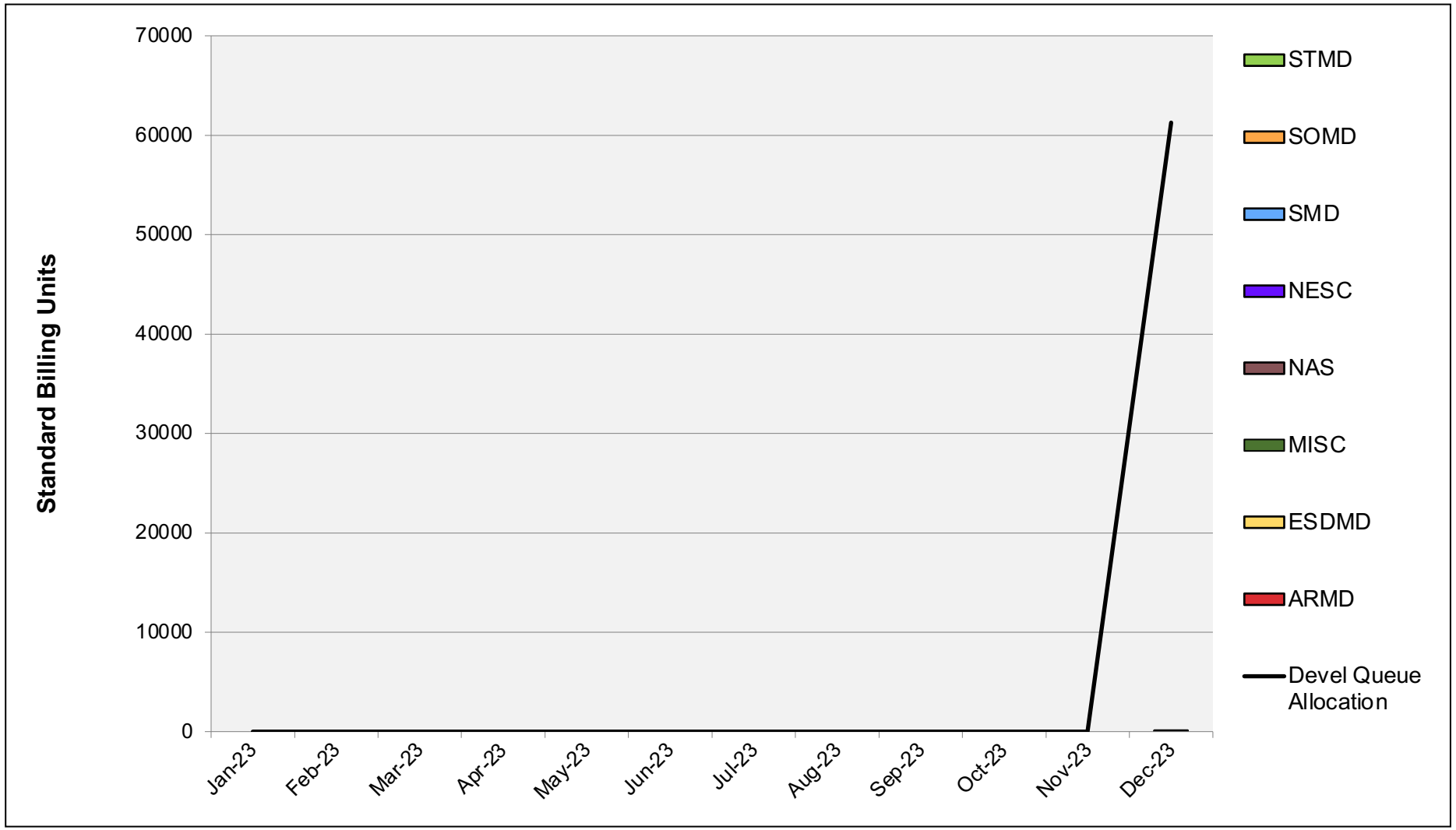
Electra: Average Expansion Factor



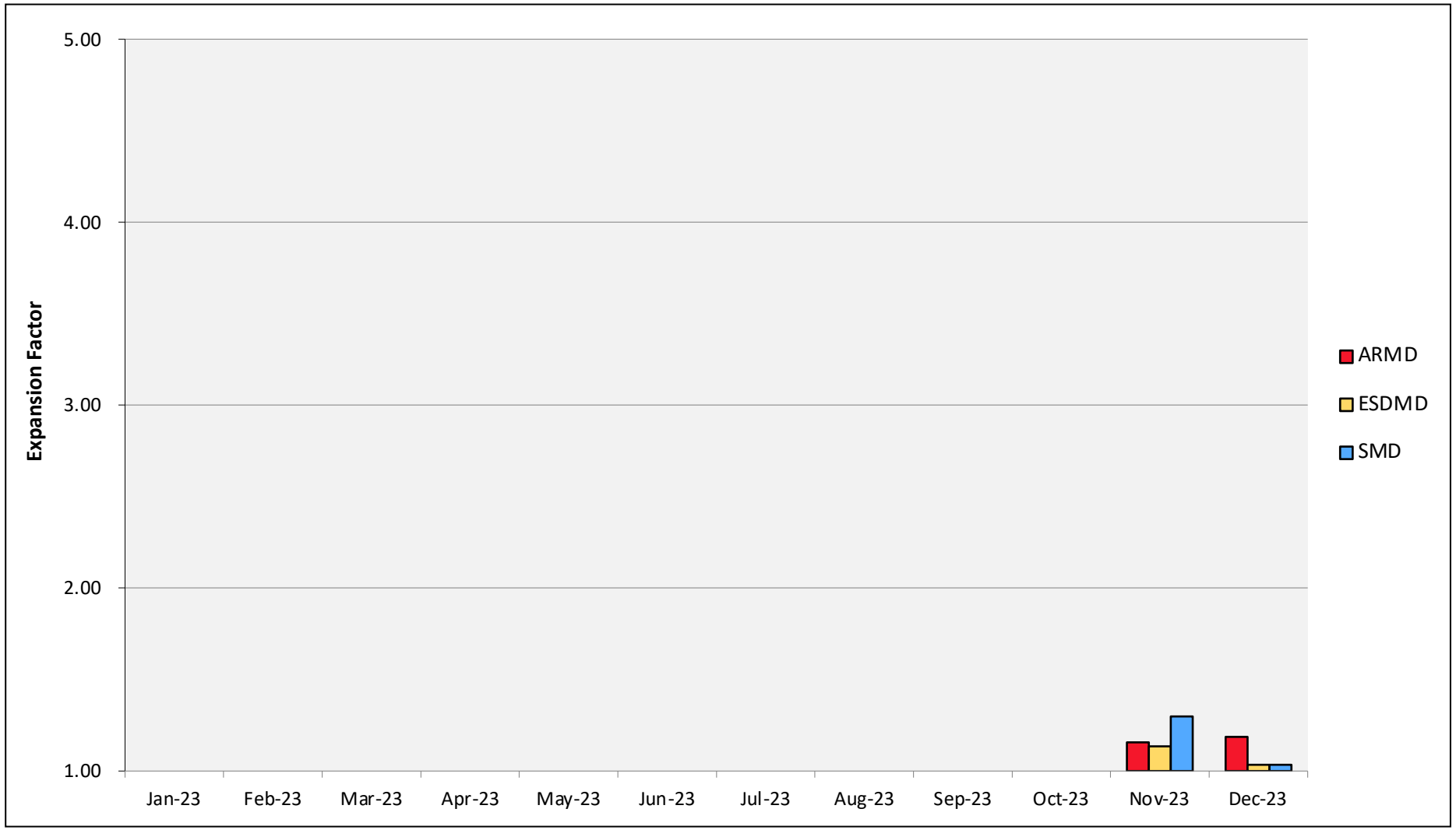
Cabeus: SBUs Reported, Normalized to 30-Day Month



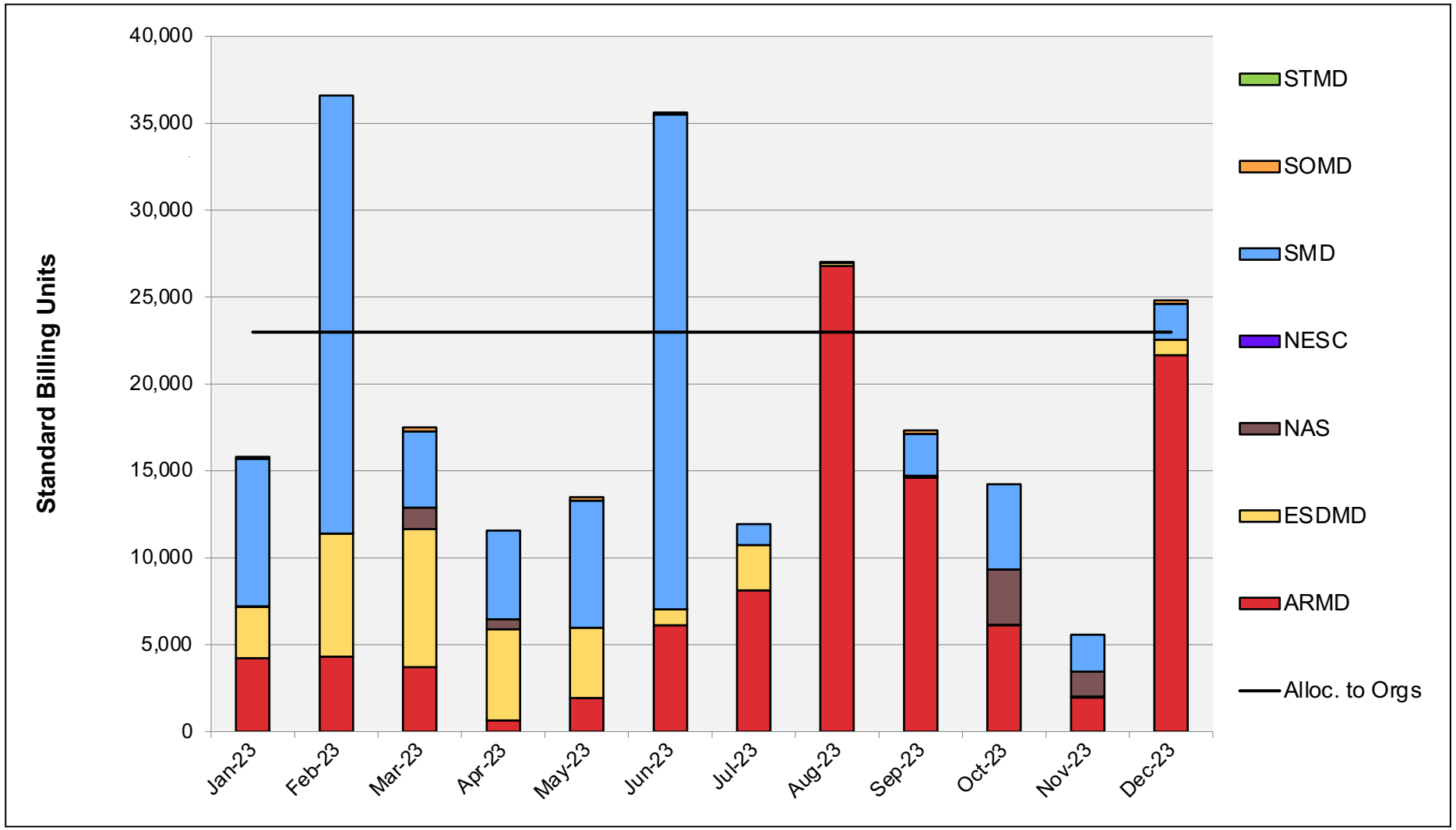
Cabeus: Monthly Utilization by Job Length



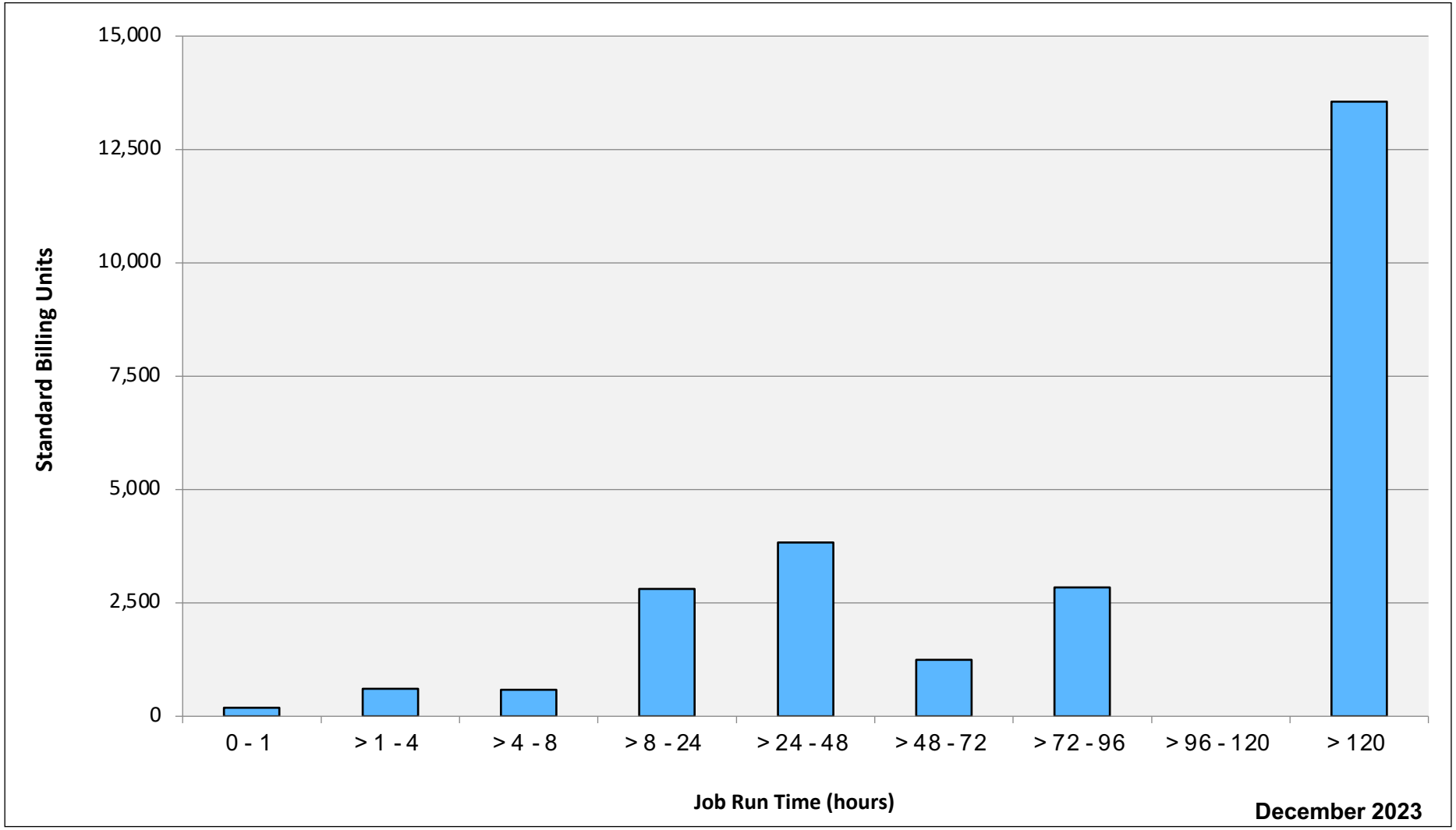
Cabeus: Average Expansion Factor



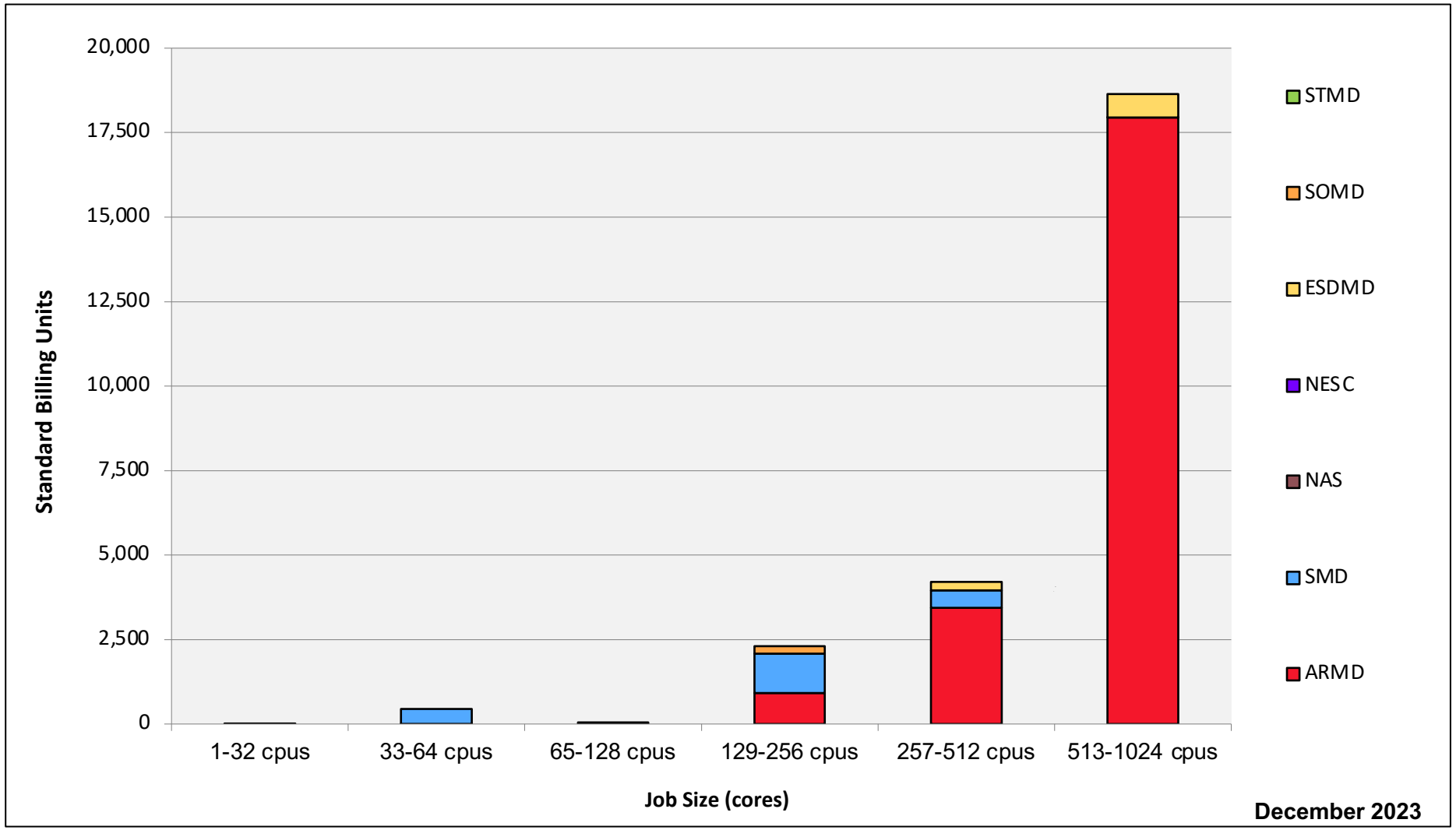
Endeavour: SBUs Reported, Normalized to 30-Day Month



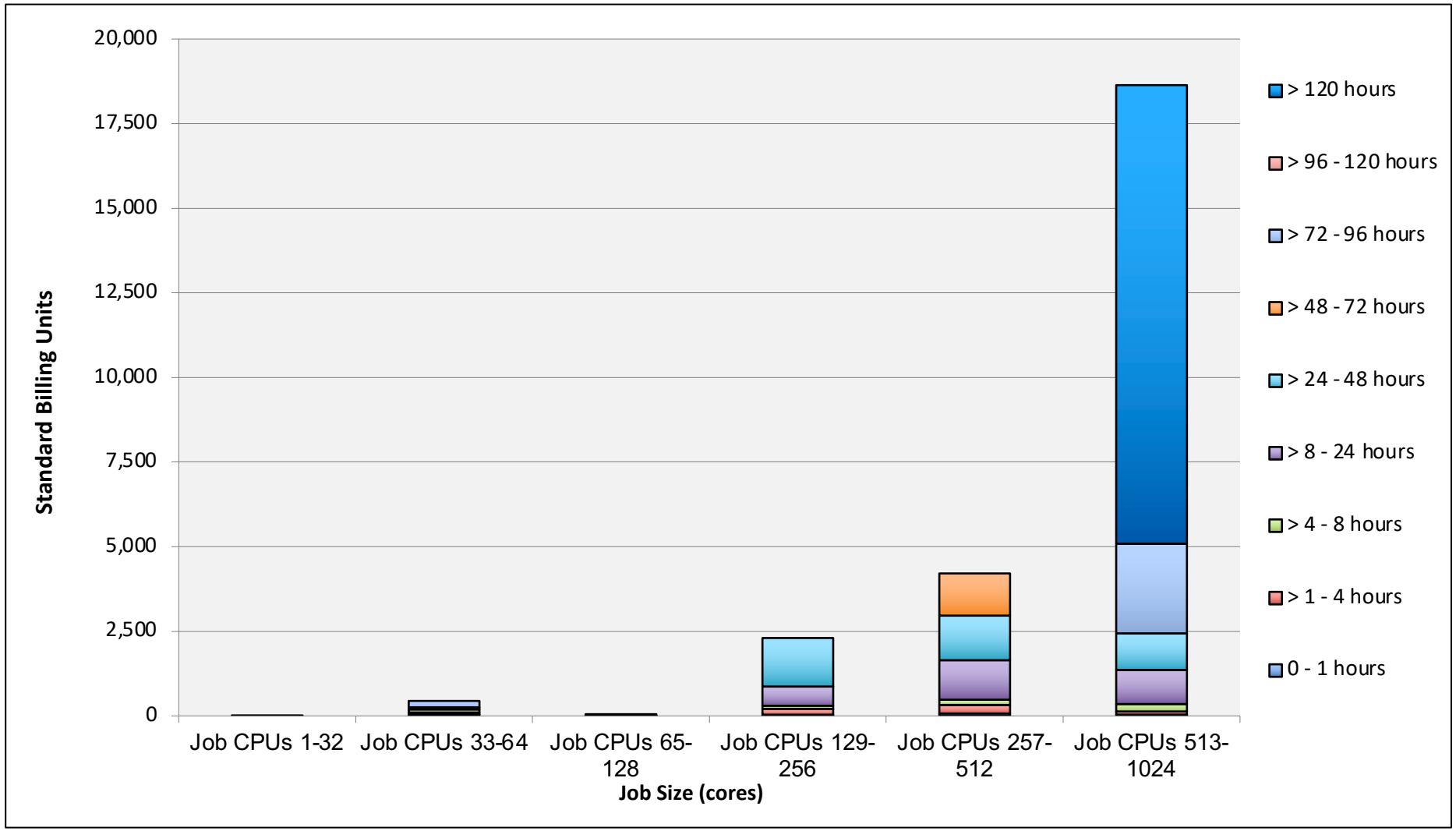
Endeavour: Monthly Utilization by Job Length



Endeavour: Monthly Utilization by Job Size



Endeavour: Monthly Utilization by Size and Length



Endeavour: Average Expansion Factor

