

National Aeronautics and
Space Administration

High-End Computing Capability

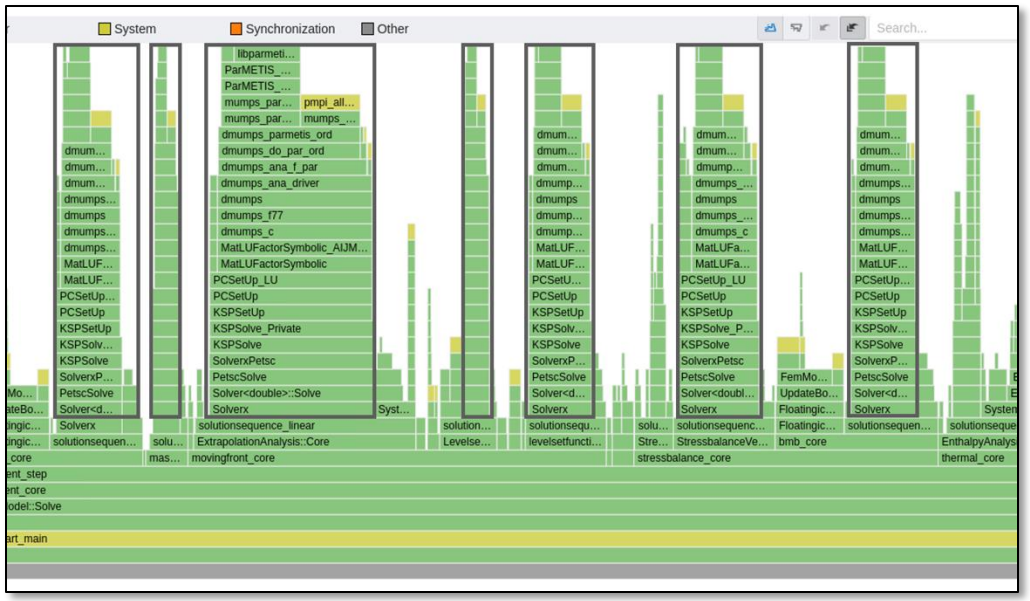
William Thigpen
HECC Component Manager
william.w.thigpen@nasa.gov

January 10, 2025

Applications Experts Profile ISSM Code

- The Ice-Sheet and Sea-level System Model (ISSM) code is used by NASA scientists to model the flow of polar ice caps and corresponding sea level changes.
- The HECC Application Performance and Productivity (APP) team used mpiprof and vtune to analyze the performance of ISSM. Results include:
  - mpiprof revealed that 60% of the time is spent in computation and 39% in communication, with 27% of total wall time in MPI_Allreduce, which is from the Petsc MUMPs solver.
  - vtune revealed a significant amount of computation involved in MUMPS, which uses mostly parmetis, metis, and MPI_Allreduce. The next most CPU-intensive code is in FemModel::DistanceToFieldValue, with a loop that does not vectorize
- The following recommendations and improvements to the ISSM workflow were made:
  - Use Krylov subspace solvers discussed in published article by Habbal, et al., Geosci. Model Dev., 2017.
  - Use Embree, restructuring, or threads to speed up the DistanceToFieldValue and related subroutines that compute the distance to triangular gridded surfaces.
  - User Josh Cuzzone (NASA Jet Propulsion Lab) reported a 30% speed up by using the Block Conjugate Gradient Solver.
- After the code is optimized with the user's solver of choice, the APP team will re-evaluate performance.

IMPACT: Increasing the efficiency of the ISSM code allows more timely and accurate sea-level predictions, which are important as expected climate change causes sea level rise and enables more efficient use of HECC systems.



Flame graph analysis of ISSM shows CPU time on the horizontal axis for each function in the call stack, which extends vertically. The MUMPS solver from Petsc is highlighted by the rectangular black frames. These account for at least half of the run time. *Gary Kedziora, NASA/Ames*

Open-Source Hugging Face Models Now Available

- Hugging Face is a platform for Machine Learning comprised of multiple Python packages that can help train, deploy, and host open-source and licensed machine learning models and datasets.
- Thirteen open-source machine learning models are available to use on HECC systems through the Data Analytics Conda environments with Hugging Face.
  - Models for masked language modeling, translation, text generation, and speech recognition are available to users.
- The Conda environments provide access to users for large open-source models like Llama 3 and GPT-2 locally without users having to download the models to their home directories. Conda:
  - Acts as a central repository for common open-source models.
  - Allows for on-prem training and inference with hosted models.
  - Adds new models on user request.
- The local Hugging Face repository can allow for easy model sharing between users.
- Models can take advantage of multiple GPUs, allowing users to run inference and training across multiple GPUs.

IMPACT: Having open-source pretrained models for users to access allows for faster development and testing of machine learning community use cases. These models are the basis for NASA AI foundation models.



Hugging Face

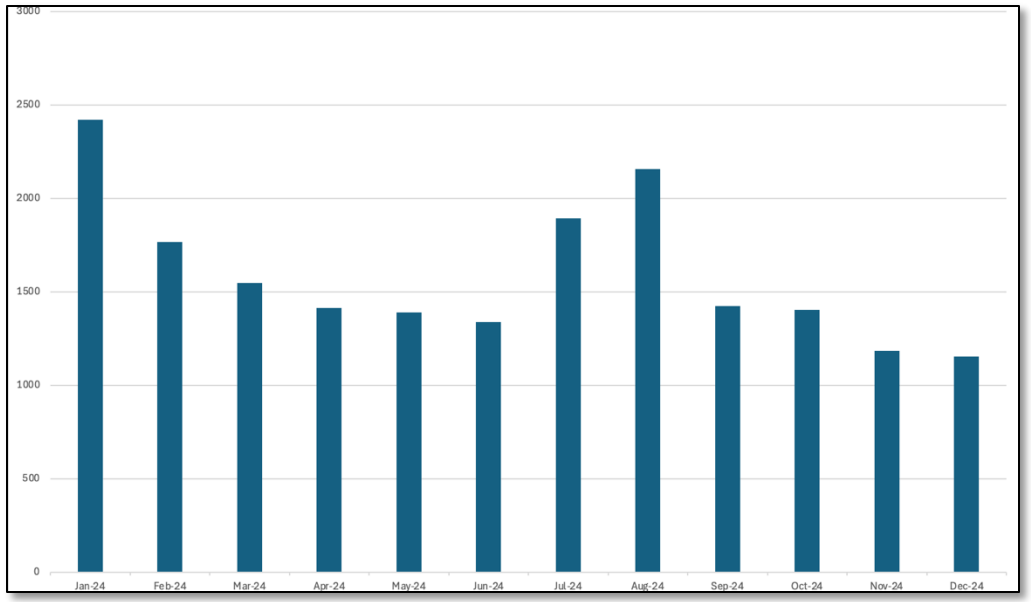
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Masked Language Modelling	google-bert/bert-base-uncased google-bert/bert-base-cased FacebookAI/roberta-base microsoft/deberta-v3-base distilbert/distilbert-base-uncased distilbert/distilbert-base-cased
Translation	google-t5/t5-base
Text Generation	openai-community/gpt2 meta-llama/Meta-Llama-3-8B meta-llama/Meta-Llama-3-70B meta-llama/Meta-Llama-3-70B-Instruct google/gemma-7b
Speech Recognition	openai/whisper-large-v3

Chart showing Language Models locally hosted on HECC systems.

Control Room Staff Continued Excellent Service to Users in 2024

- In 2024, HECC Control Room staff provided support to more than 1,800 users from all of NASA's technical mission directorates.
- Control Room staff processed, tracked, and resolved over 19,000 tickets for the 12 months from January 1, 2024, through December 31, 2024.
- Tickets covered a wide range of support activities—from automated notifications of system issues to resolving a variety of issues for users calling for help:
  - Answered inquiries about accounts, failed jobs, and status of systems.
  - Extended run-times of already-queued or running jobs.
  - Created complex reservations for mission critical projects
  - Modified allocations and account expiration dates.
  - Explained file transfer tools and processes.
  - Debugged job failures and identified execution bottlenecks.
  - Developed automation tools for archiving and triaging of nodes
- A major initiative completed by Control Room staff was the implementation of Arbiter, a tool that automatically terminates jobs on the Pleiades front-end (PFE) nodes identified as misusing the nodes; this led to greater stability of the PFEs and user satisfaction on being able to access the nodes.

IMPACT: The 24x7 support services provided by HECC experts resolve system problems and users' technical issues and enable users to focus on their critical mission projects.



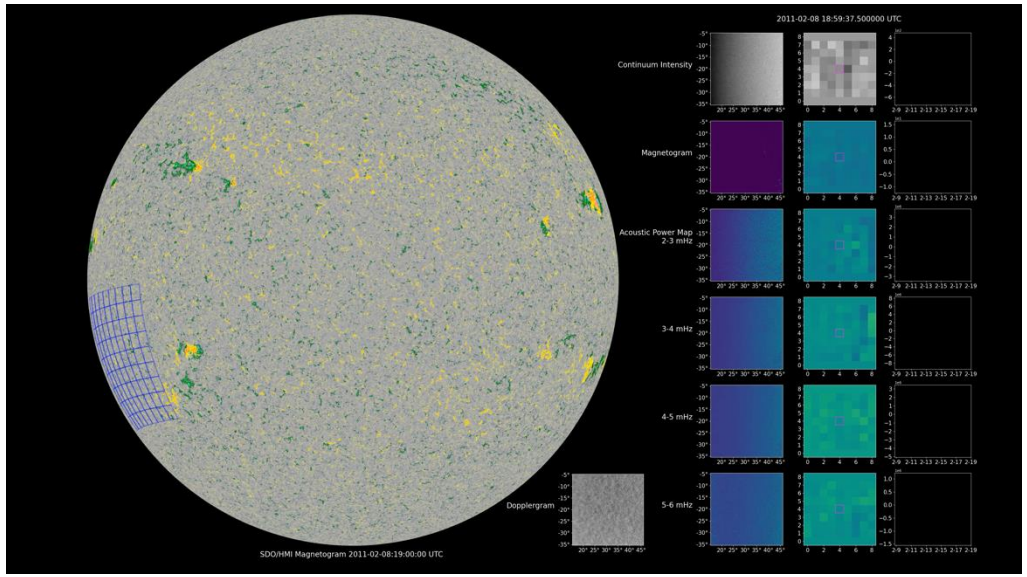
HECC Control Room staff resolved on average over 1,590 Remedy tickets per month in 2024—just over 19,000 tickets total.

Forecasting Space Weather Using Machine Learning*

- The ability to forecast space weather phenomena, like solar flares, is critical to helping protect technologies like satellites, power grids, and communication systems from potential disruptions—and astronauts in space from harmful doses of radiation.
- To help forecast geoeffective flaring activity, scientists at the NAS facility developed a machine learning (ML) model to predict the emergence of large sunspots on the solar surface.
  - ML models have proven capable of capturing changes in solar photospheric dynamics that signal the emergence and evolution of magnetic flux, which can lead to eruptive activity.
  - The science team significantly accelerated the training of ML models that are critical for processing large datasets using the HECC facilities
- The scientists aim to provide ML-driven technology that will aid with processing large amounts of historical data from NASA's Solar and Heliospheric Observatory (SoHO) and Solar Dynamics Observatory (SDO) satellites to forecast Solar Energetic Particle (SEP) events.
- The datasets created for ML model training, along with the models, will be made publicly available, allowing for the investigation of various solar phenomena. Products of this work will aid with the community's understanding of how various space weather phenomena are connected.

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

IMPACT: Using HECC's NVIDIA A100 GPU nodes, researchers were able to significantly accelerate the training of machine learning models that are critical for processing large datasets and building more reliable solar flare forecast modules.



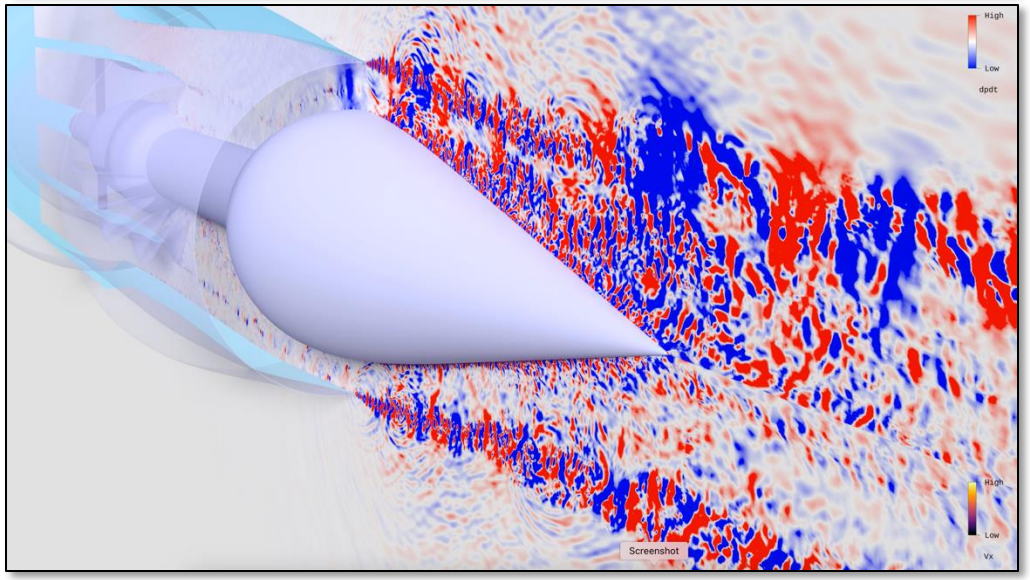
This video tracks the magnetic evolution of sunspot AR11158 using observations from NASA's Solar Dynamics Observatory (SDO) Helioseismic and Magnetic Imager (HMI).
Spiridon Kasapis and Nina McCurdy, NASA/Ames

Scale-Resolving Simulations for Jet Noise Prediction*

- As part of NASA's Commercial Supersonic Transport (CST) Project, a research team at Ames Research Center are using the Launch, Ascent, and Vehicle Analysis (LAVA) computational fluid dynamics software to predict jet noise during landing and takeoff (LTO) conditions.
  - The CST Project's mission is to develop new tools, technologies, and knowledge to build propulsion systems that exceed Federal Aviation Administration (FAA) regulatory expectations and eliminate barriers to supersonic transport.
  - One key goal of the project is to evaluate and reduce noise levels during the LTO phases—crucial for achieving public support of the commercial supersonic market, ensuring the safety of ground crew, and informing FAA guidelines for LTO operation.
- The Ames researchers study the acoustic impact of different nozzle geometries and operating conditions to inform future design decisions. The simulation results are also used to develop better understanding of the limitations and uncertainties in the software as they relate to far-field noise predictions.
- Using 100 AMD Rome nodes on the Aitken supercomputer and the LAVA solver, the research team enhanced jet noise predictions by an order of magnitude.
  - They efficiently used modern hardware, employed load balancing for scaling, and improved algorithms, enabling the generation of a first-of-its-kind database for jet noise simulations of supersonic configurations.

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

IMPACT: Data from this project is used to help inform noise certification guidelines for future supersonic aircraft. Comparison with experimental measurements is also used to establish best practices for jet noise simulations and quantify uncertainties and sensitivities in the results.



Pressure fluctuations for nozzle configurations with an internal lobed mixer (bottom half of domain) and axisymmetric splitter (upper half of domain). Tracer particles are seeded inside the nozzle and advected downstream.
Timothy A. Sandstrom and Gerrit-Daniel Stich, NASA/Ames

Papers

- "**Discovery and Characterization of an Eccentric, Warm Saturn Transiting the Solar Analog TOI-4994**," R. Rodriguez Martinez, et al., arXiv:2412.02769 [astro-ph.EP], December 3, 2024. *
  https://arxiv.org/abs/2412.02769
- "**A Joint Effort to Discover and Characterize Two Resonant Mini Neptunes Around TOI-1803 with TESS, HARPS-N, and CHEOPS**," T. Zingales, et al., arXiv:2412.05423 [astro-ph.EP], December 6, 2024. *
  https://arxiv.org/abs/2412.05423
- "**The Impacts of Thermospheric Circulation and Exospheric Transport on the Coupled System**," S. Luettgen, E. Sutton, J. Thayer, *Journal of Geophysical Research: Space Physics*, vol. 129, issue 12, published online December 7, 2024. *
  https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2024JA033116
- "**Conditions for Super-Eddington Accretion onto the First Black Holes**," S. Gordon, et al., arXiv:2412.06888 [astro-ph.GA], December 9, 2024. *
  https://arxiv.org/abs/2412.06888
- "**Interfacial Characteristics of Ice-Supporting Substrates via Molecular Dynamics Simulations**," E. Skountzos, et al., *Langmuir*, vol. 40, issue 51, published online December 9, 2024. *
  https://pubs.acs.org/doi/abs/10.1021/acs.langmuir.4c03106
- "**HD 60435: The Star that Stopped Pulsating**," D. Kurtz, et al., *Monthly Notices of the Royal Astronomical Society*, vol. 535, issue 3, published online December 10, 2024. *
  https://academic.oup.com/mnras/article/536/3/2103/7920801

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

Papers (cont.)

- "**Physics-Based Simulation of the 2013 April 11 SEP Event**," W. Liu, et al., arXiv:2412.07581 [astro-ph.SR], December 10, 2024. * https://arxiv.org/abs/2412.07581
- "**Confirmation of Four Hot Jupiters Detected by TESS Using Follow-up Spectroscopy from MaHPS at Wendelstein Together with NEID and TRES**," J. Ehrhardt, et al., *Astronomy & Astrophysics*, vol. 692, published online December 13, 2024. * https://www.aanda.org/articles/aa/abs/2024/12/aa51404-24/aa51404-24.html
- "**Transport and Distribution of Sodium Ions in Mercury's Magnetosphere: Results from Multi-Fluid MHD Simulations**," Y. Chen, C. Dong, W. Sun, *Geophysical Research Letters*, vol. 51, issue 24, published online December 13, 2024. * https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2024GL110301
- "**Vibrational and Electronic Spectroscopy of 2-Cyanoindene Cations**," T. Douglas-Walker, et al., *ASC Earth and Space Chemistry*, published online December 16, 2024. * https://pubs.acs.org/doi/full/10.1021/acsearthspacechem.4c00270
- "**Application of a New Nonlinear Subgrid-Scale Model to a Gaussian Bump Flow**," A. Uzun, M. Malik, *AIAA Journal of Aeronautics & Astrophysics*, published online December 17, 2024. * https://arc.aiaa.org/doi/full/10.2514/1.J064103
- "**A First-Principles Investigation on the Enthalpy Landscape for the Hibonite Solid Solution: Implications for a Nebular Barometer**," P.-M. Zanetta, et al., *American Mineralogist*, published online December 18, 2024. * https://pubs.geoscienceworld.org/msa/ammin/article-abstract/doi/10.2138/am-2024-9449/650696/A-first-principles-investigation-on-the-enthalpy

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Papers (cont.)

- "**NASA Earth Exchange Downscaled Climate Projections 30 Arcseconds CMIP6**," B. Thrasher, et al., *Scientific Data* (Nature), published online December 18, 2024. *
  https://www.nature.com/articles/s41597-024-04188-x
- "**Characterization of TOI-406 as a Showcase of the THIRSTEE Program**," G. Lacedelli, et al., *Astronomy & Astrophysics*, vol. 692, published online December 18, 2024. *
  https://www.aanda.org/articles/aa/full_html/2024/12/aa52244-24/aa52244-24.html
- "**Evolutionary Dynamics of Counterhelical Magnetic Flux Ropes**," Y.-D. Jia, et al., *The Astrophysical Journal*, vol. 977, no. 2, published online December 19, 2024. *
  https://iopscience.iop.org/article/10.3847/1538-4357/ad93d9/meta
- "**Observation of Deep Convective Cloud-Top Height and Vertical Temperature Structure of Hurricane Using Hyperspectral Infrared Sounder and Its Single-Field-View Retrieval Products**," X. Xiong, et al., *Proceedings Volume 13266, Multispectral, Hyperspectral, and Ultraspectral Remote Sensing Technology, Techniques, and Applications VIII*, published online December 20, 2024. *
  https://www.spiedigitallibrary.org/conference-proceedings-of-spie/13266/1326609/Observation-of-deep-convective-cloud-top-height-and-vertical-temperature/10.1117/12.3039281.full
- "**Two Earth-size Planets and an Earth-size Candidate Transiting the Nearby Star HD 101581**," M. Kunimoto, et al., *The Astronomical Journal*, vol. 169, no. 1, published online December 20, 2024. *
  https://iopscience.iop.org/article/10.3847/1538-3881/ad9266/meta

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Papers (cont.)

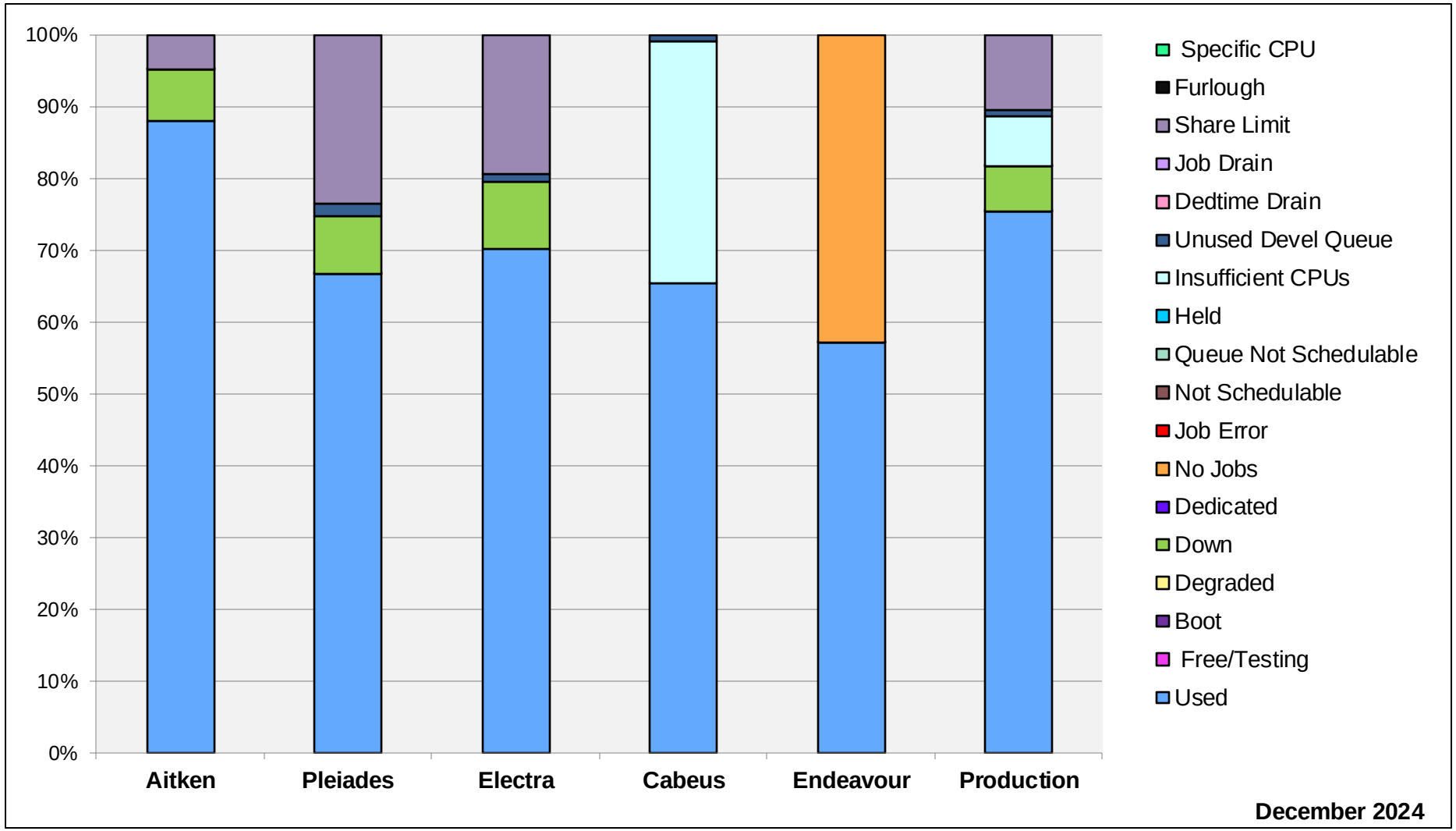
- "**A Sub-Earth-Mass Planet Orbiting Barnard's Star**," A. Stefanov, et al., *Astronomy & Astrophysics*, vol. 693, published online December 23, 2024. *
  https://www.aanda.org/articles/aa/full_html/2025/01/aa52450-24/aa52450-24.html
- "**Instabilities Along the Axis of the Heliospheric Jets**," X. Ma, et al., *The Astrophysical Journal*, vol. 978, no. 1, published online December 24, 2024. *
  https://iopscience.iop.org/article/10.3847/1538-4357/ad93a5/meta
- "**The GAPS Programme at TNG, LXV: Precise Density Measurement of TOI-1430 b, a Young Planet with an Evaporating Atmosphere**," D. Nardiello, et al., *Astronomy & Astrophysics*, vol. 693, published online December 24, 2024. *
  https://www.aanda.org/articles/aa/full_html/2025/01/aa52236-24/aa52236-24.html
- "**Young Stellar Object Jets Magnetiocentrifugally Driven by Reconnecting Atmospheric Avalanche Accretion Streams Above Inner Circumstellar Disks**," Y. Tu, et al., *The Astrophysical Journal*, vol. 978, no. 1, published online December 26, 2024. *
  https://iopscience.iop.org/article/10.3847/1538-4357/ad927b/meta

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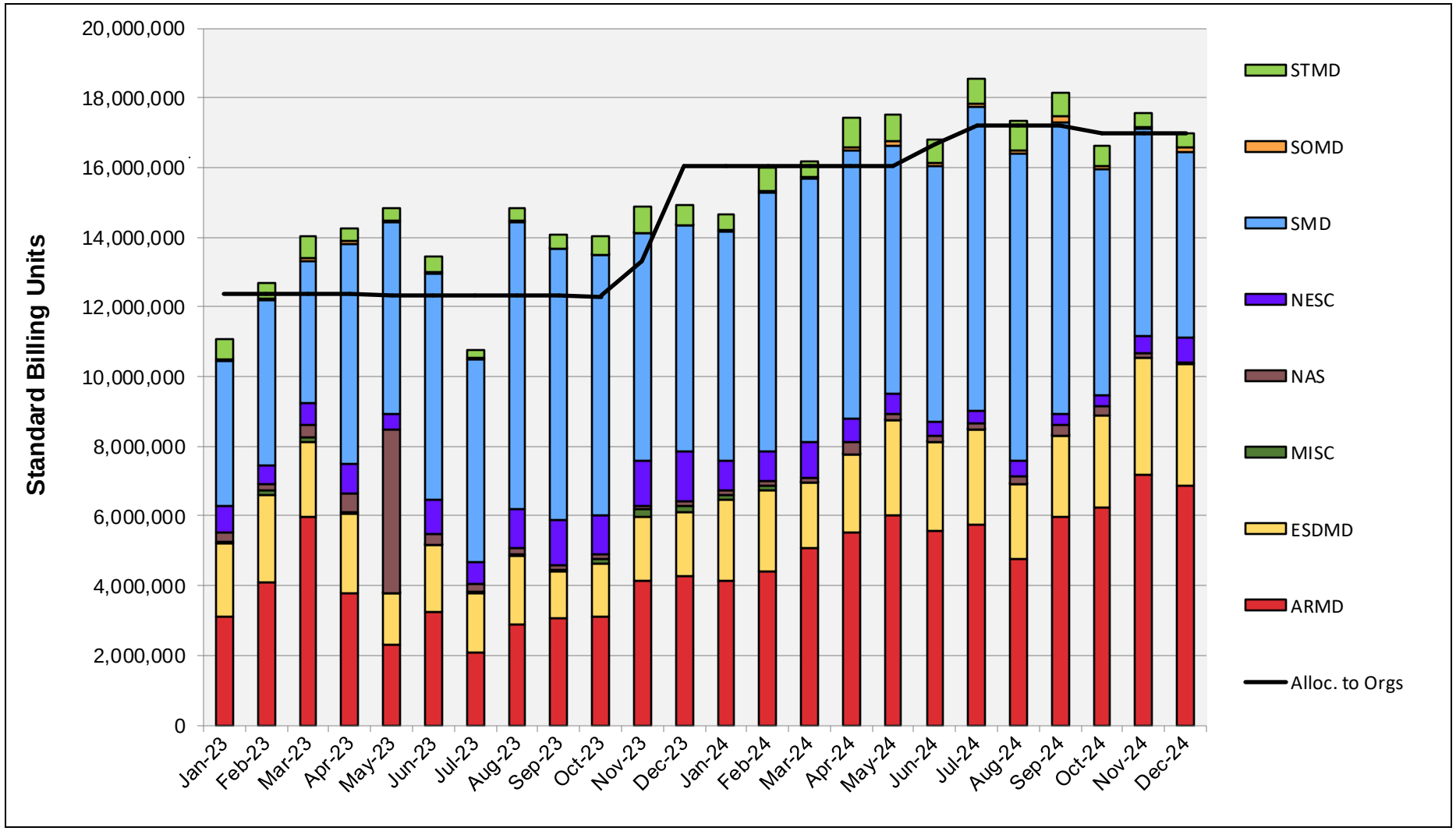
News and Events

- **2024 in Review: Highlights from NASA in Silicon Valley**, *NASA Ames Research Center*, December 17, 2024—As Ames Research Center in Silicon Valley enters its 85th year, the center looks back on some of the science, engineering, research, and innovation from its staff in 2024—including major upgrades to the hyperwall visualization system at the NASA Advanced Supercomputing facility. https://www.nasa.gov/general/2024-in-review-highlights-from-nasa-in-silicon-valley/

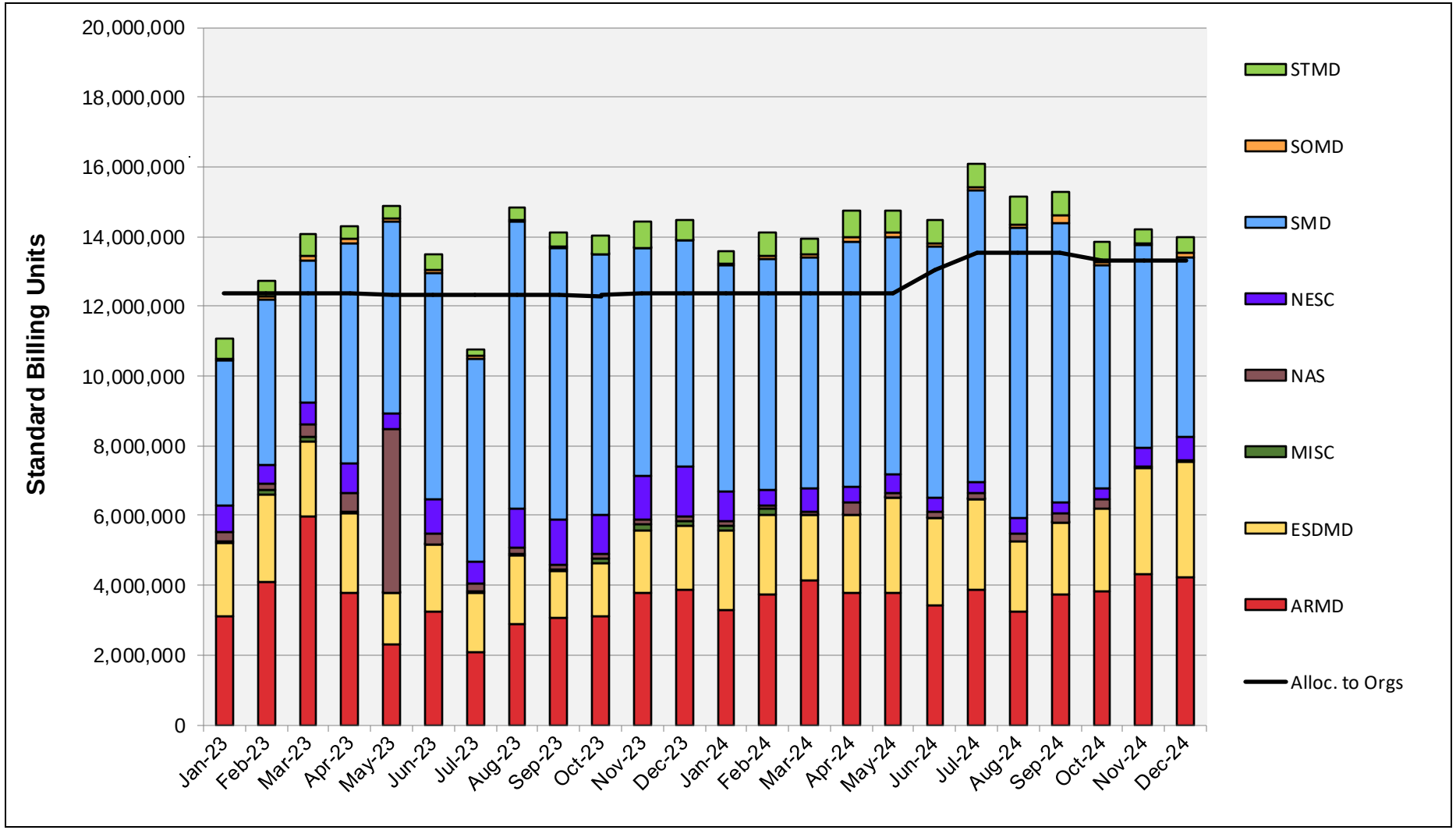
HECC Utilization



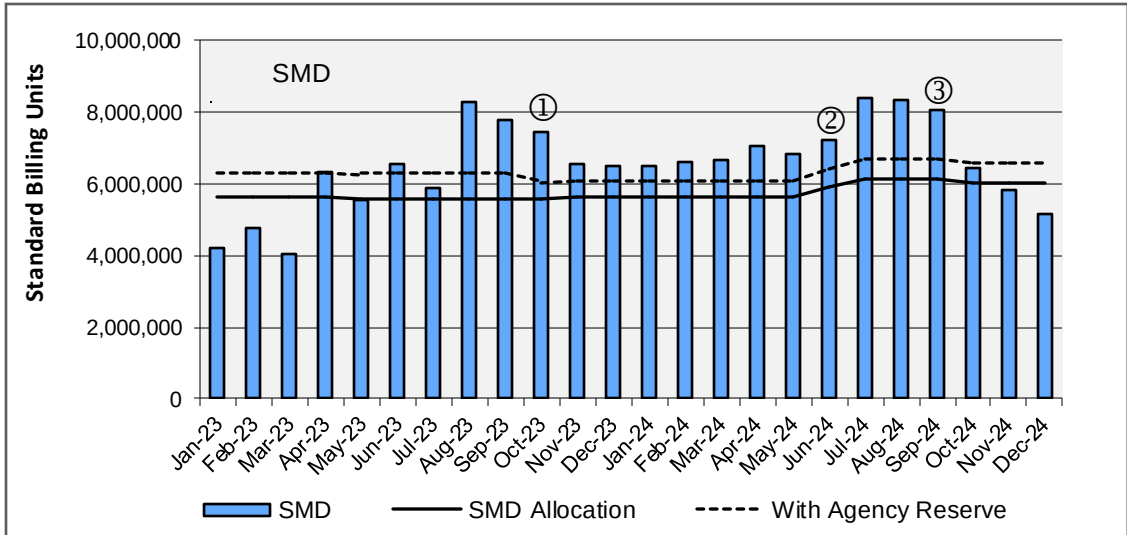
HECC Utilization Normalized to 30-Day Month

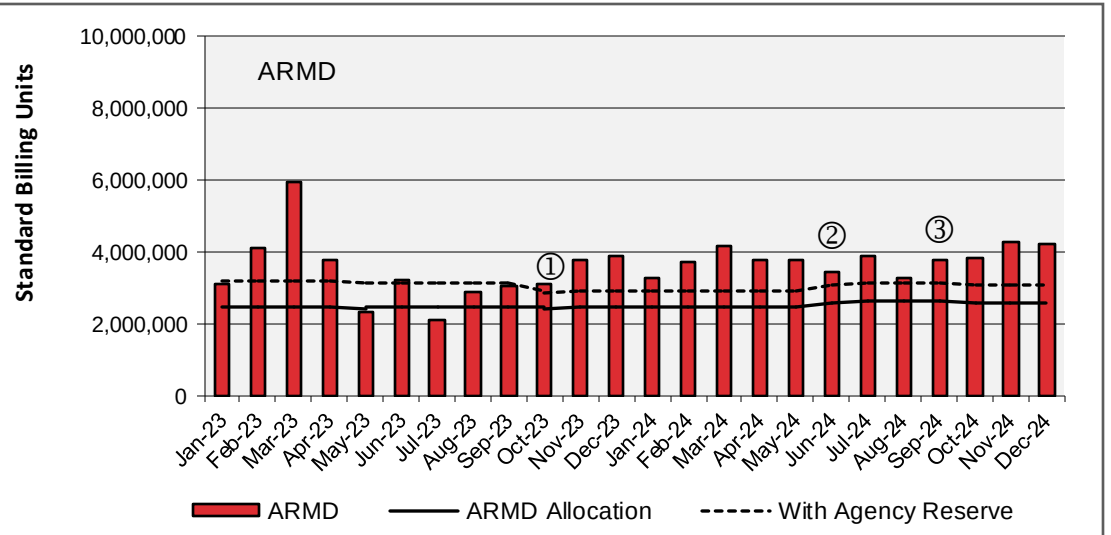


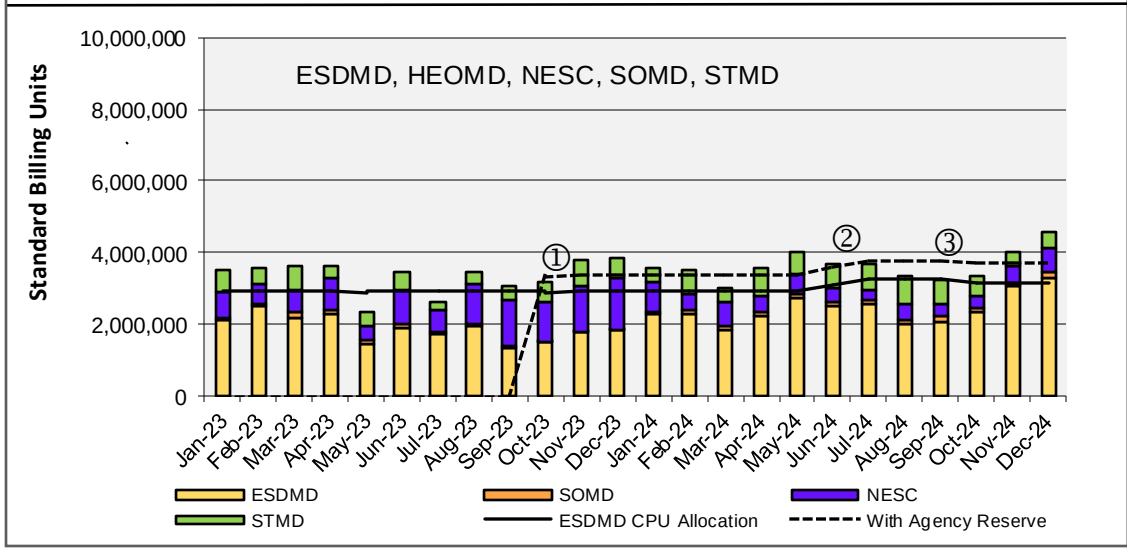
CPU Only Normalized Data



CPU Only by Mission Directorate





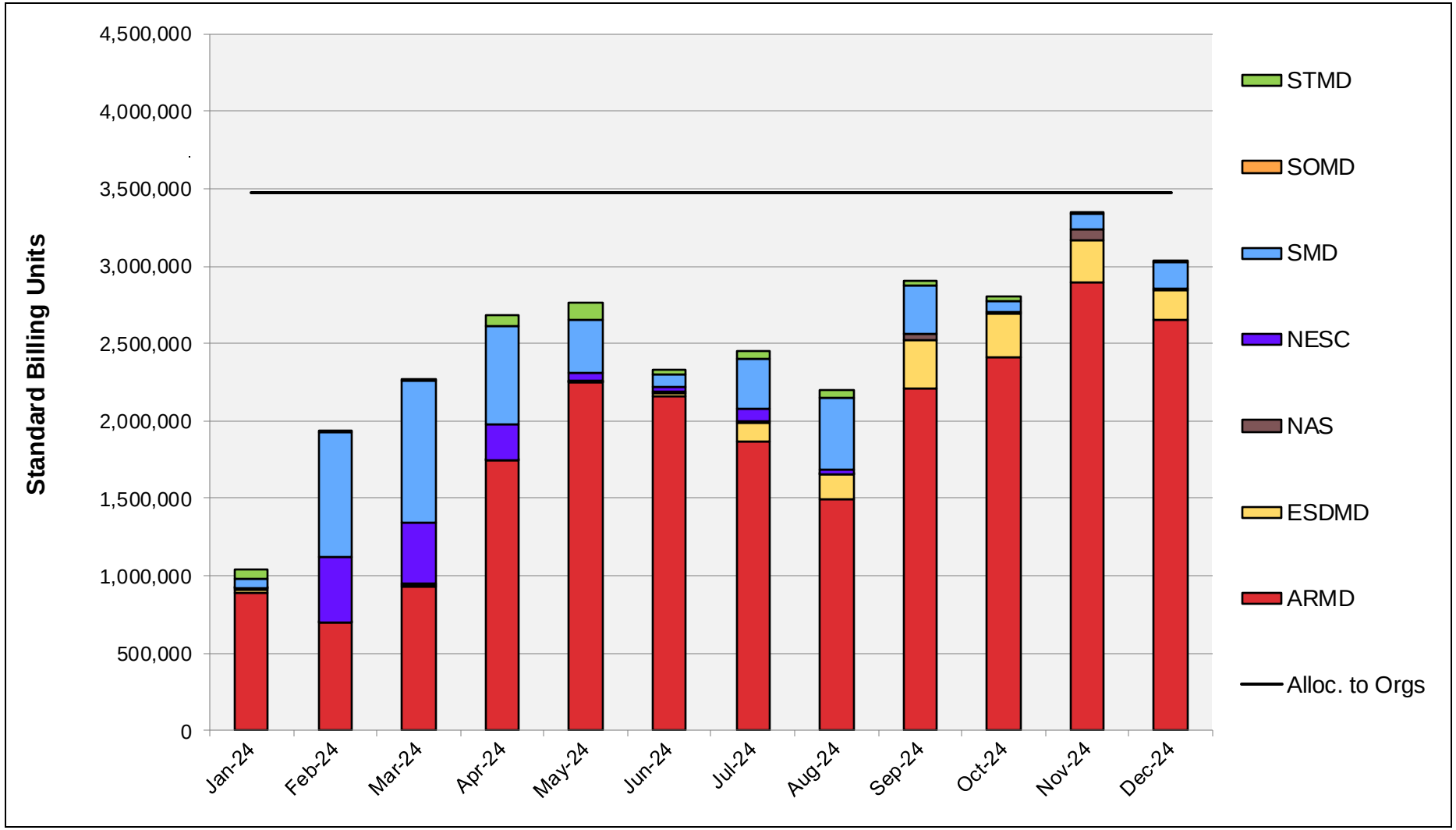


① 4 Rome Apollo Racks added to Aitken

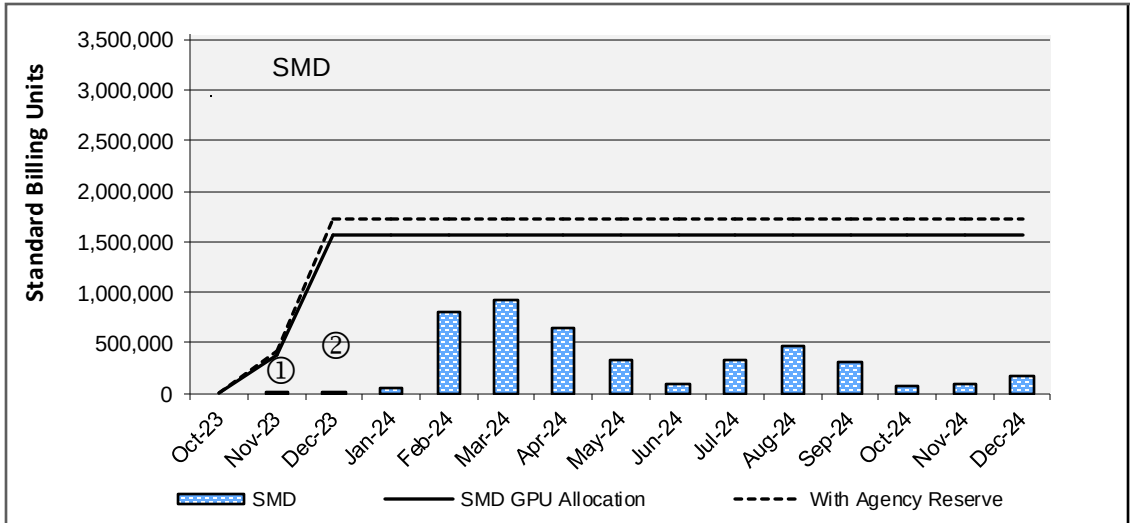
② Aitken Milan nodes added

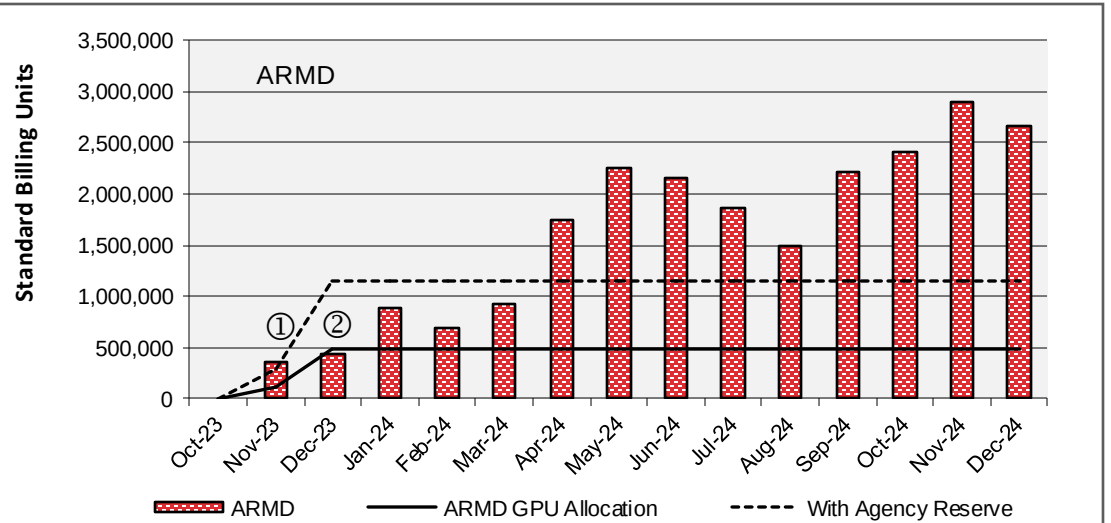
③ Sandy Bridge temporarily removed

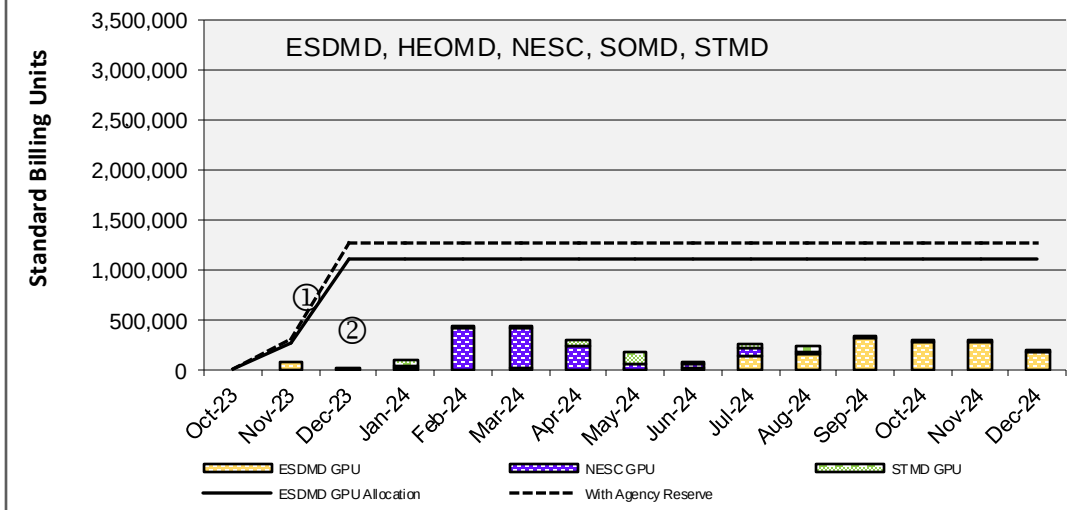
GPU Only Normalized Data



GPU Only Normalized Data



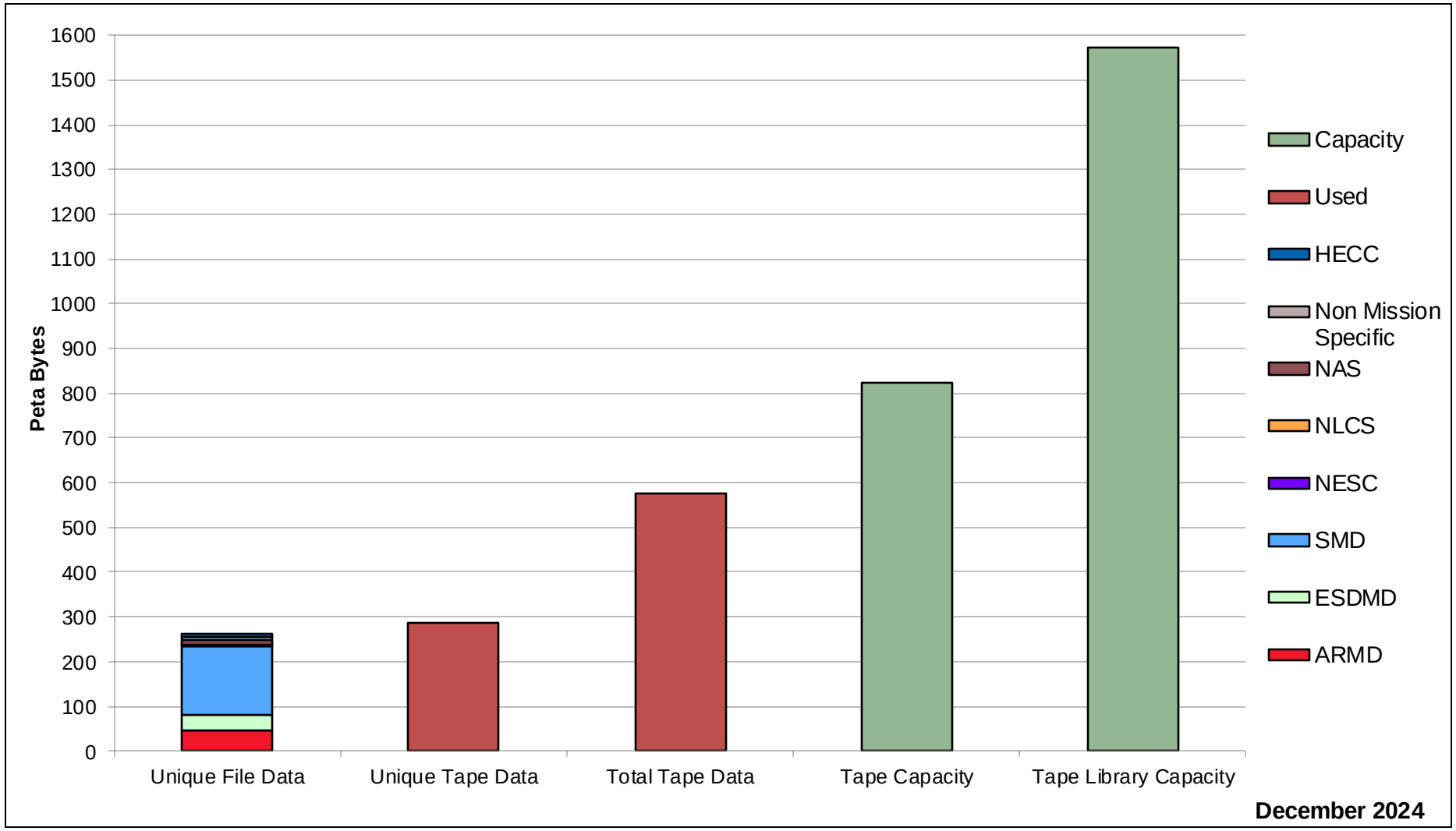




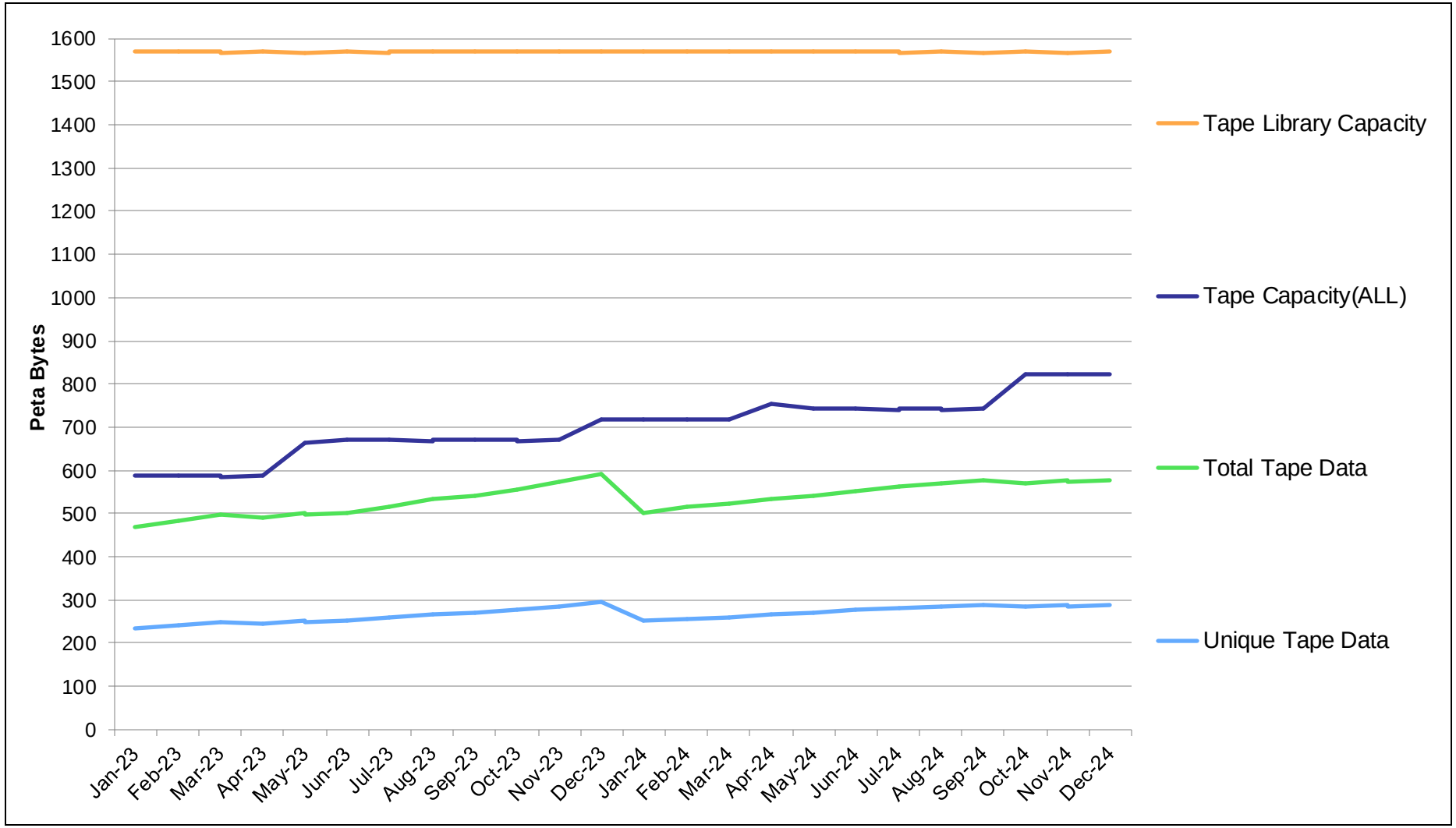
① Cabeus v100 nodes added

② Cabeus a100 nodes added

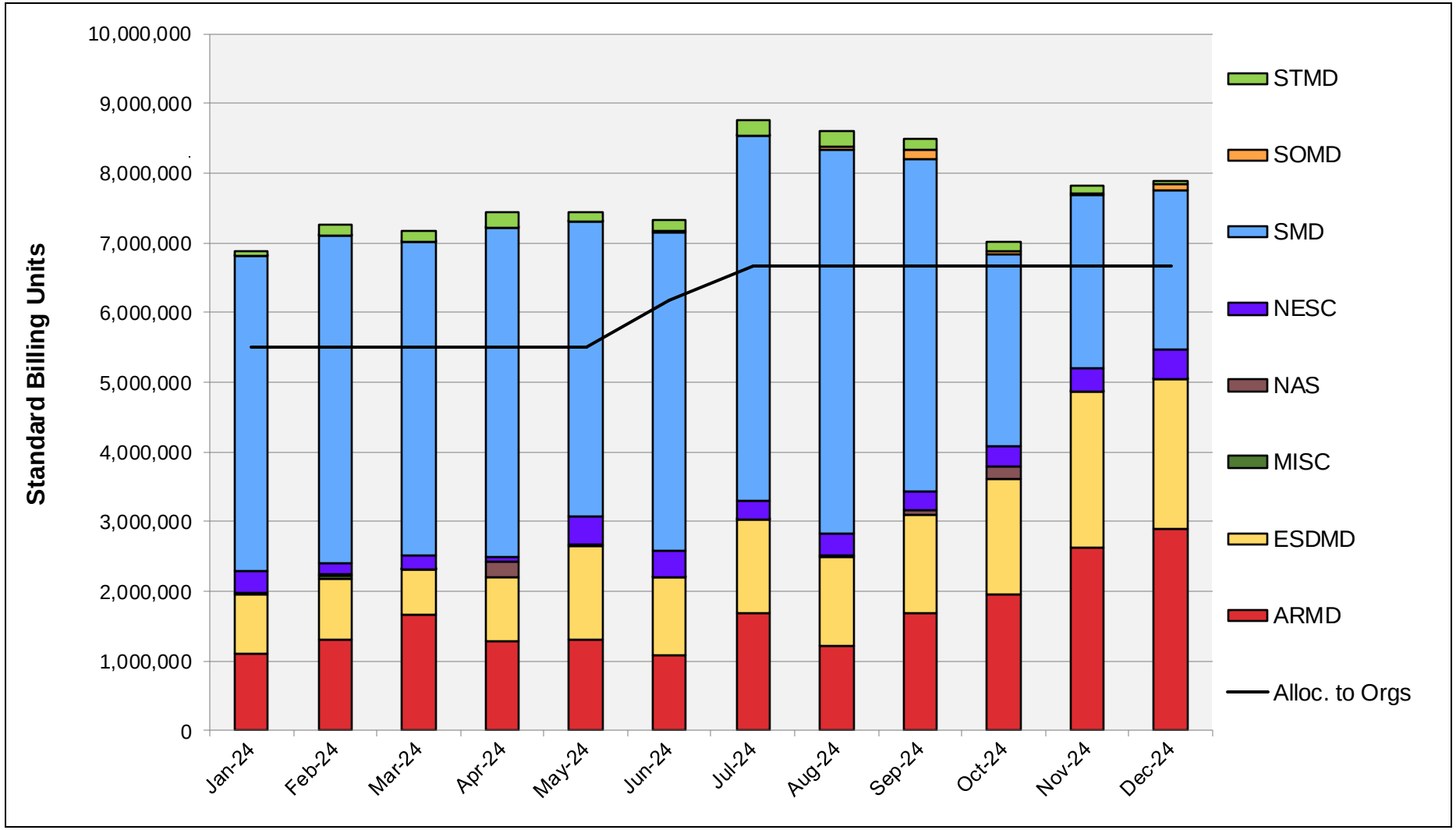
Tape Archive Status



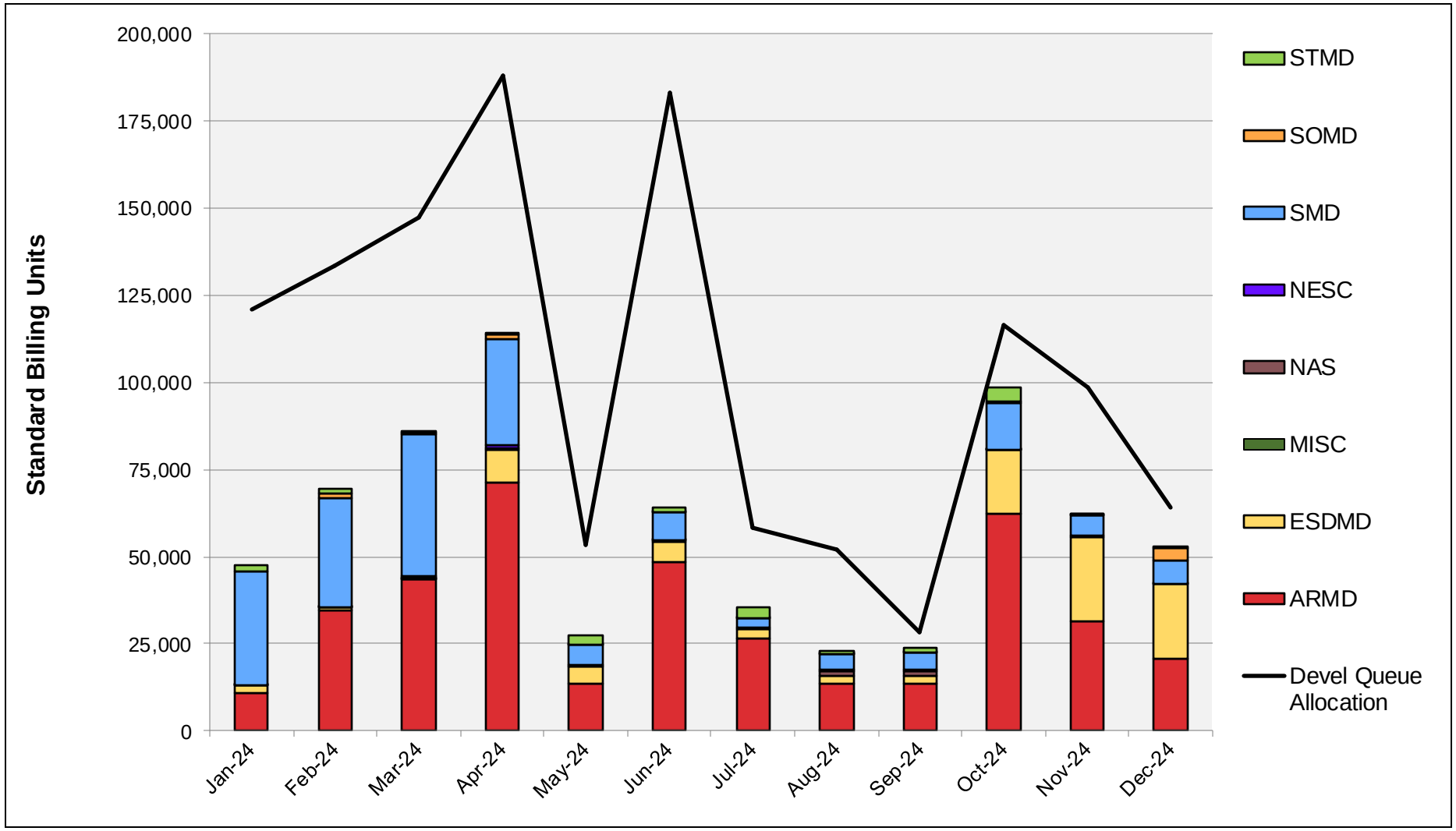
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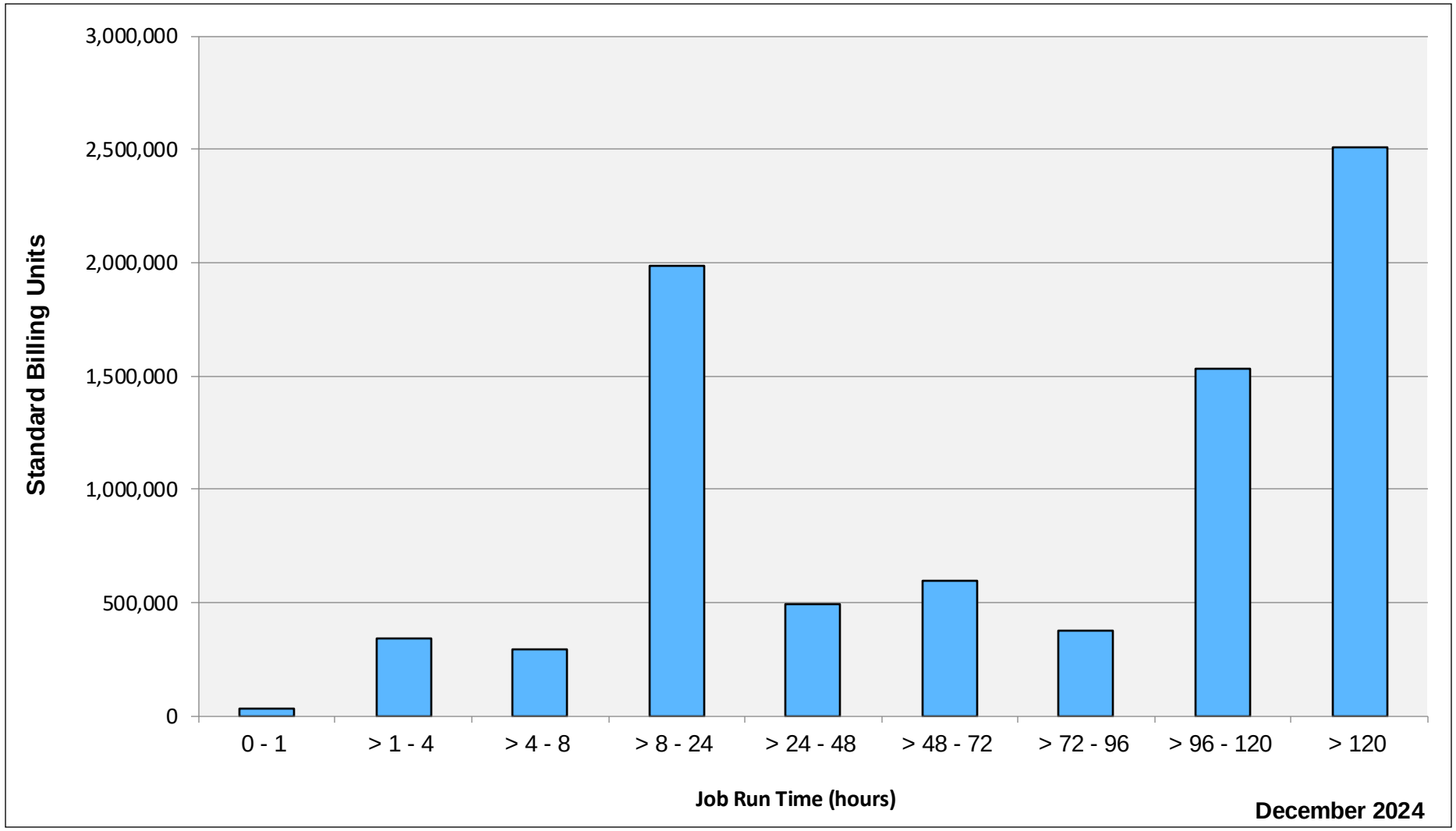
Aitken: SBUs Reported, Normalized to 30-Day Month



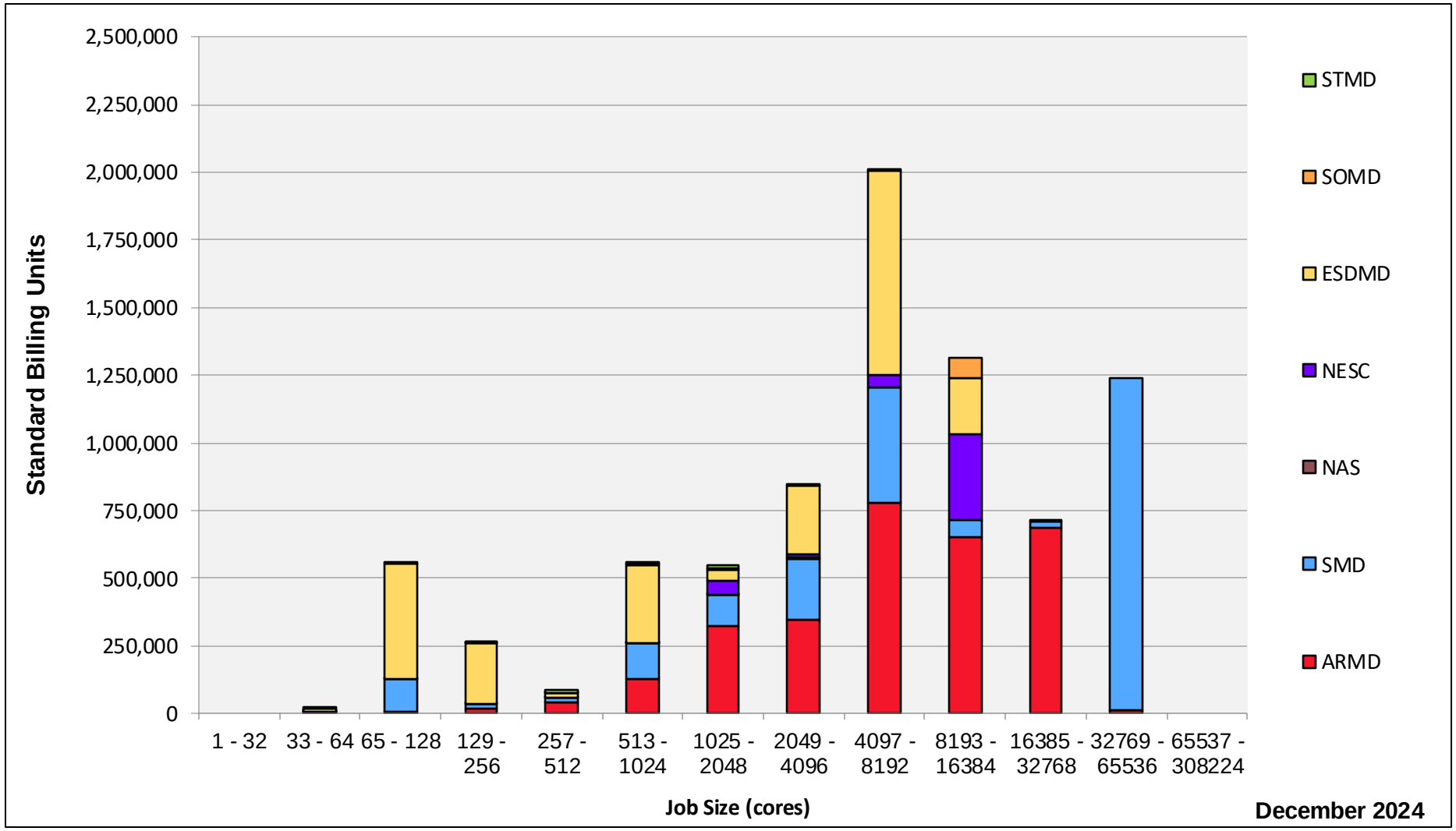
Aitken: Devel Queue Utilization



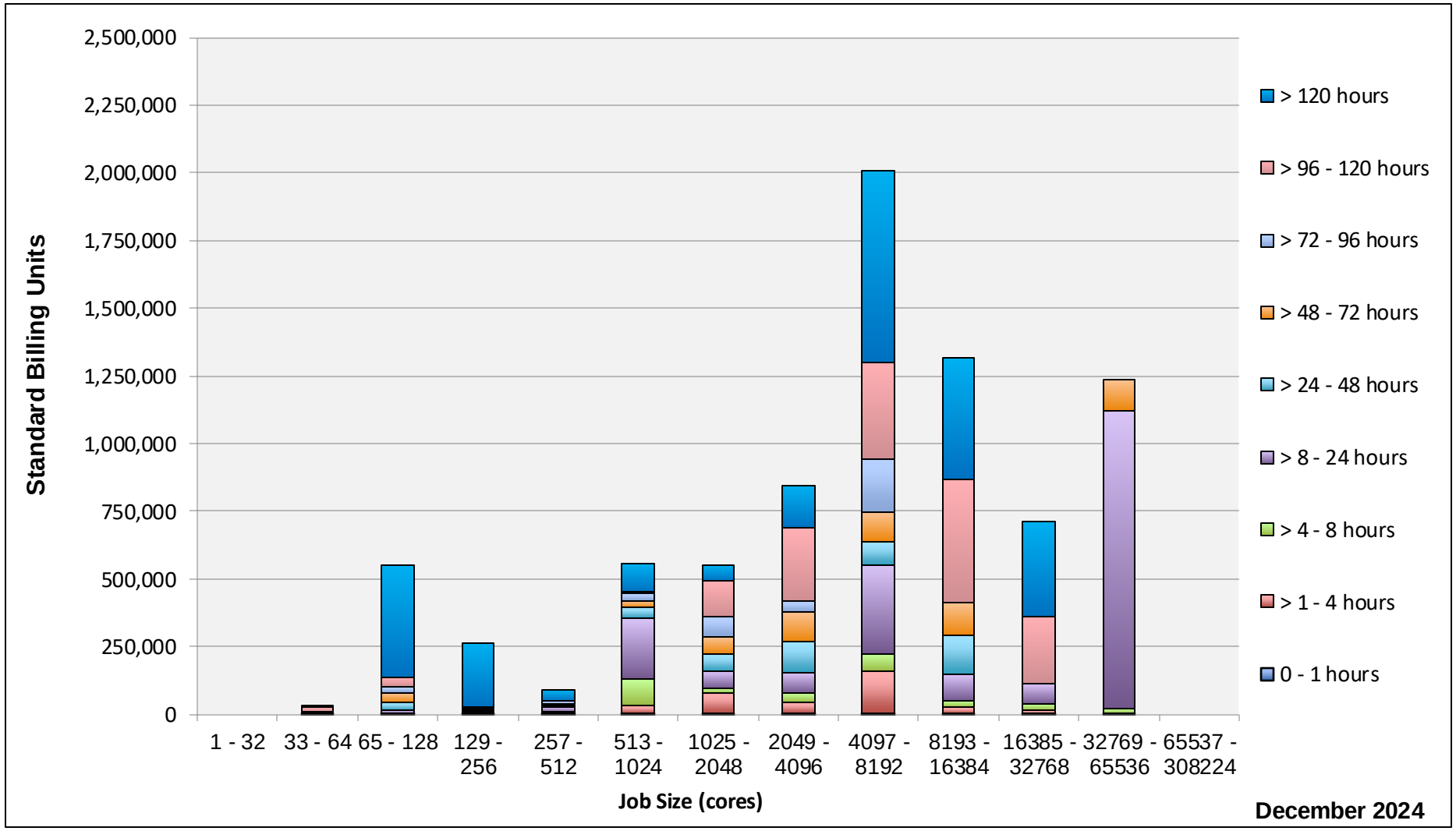
Aitken: Monthly Utilization by Job Length



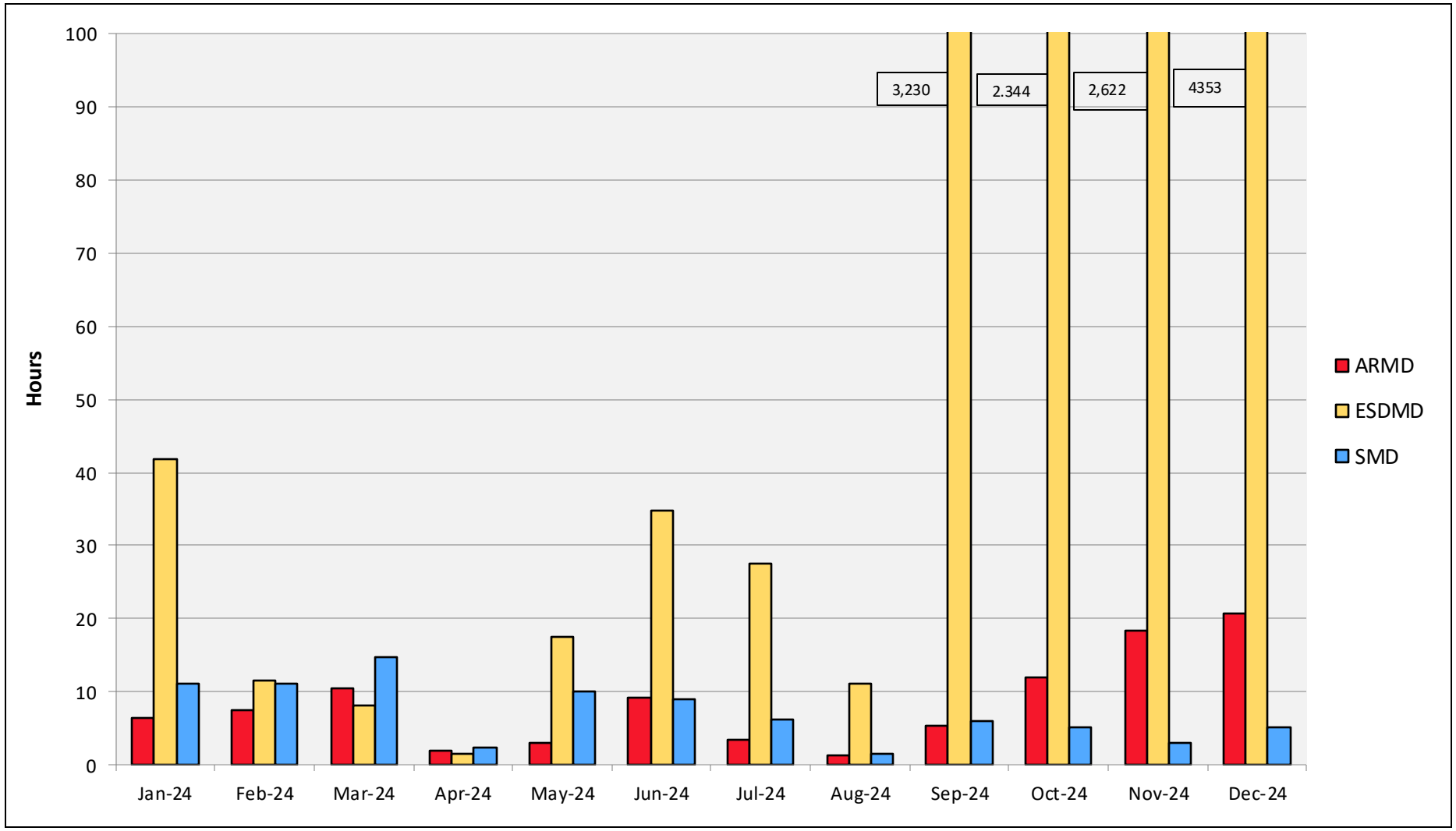
Aitken: Monthly Utilization by Job Size



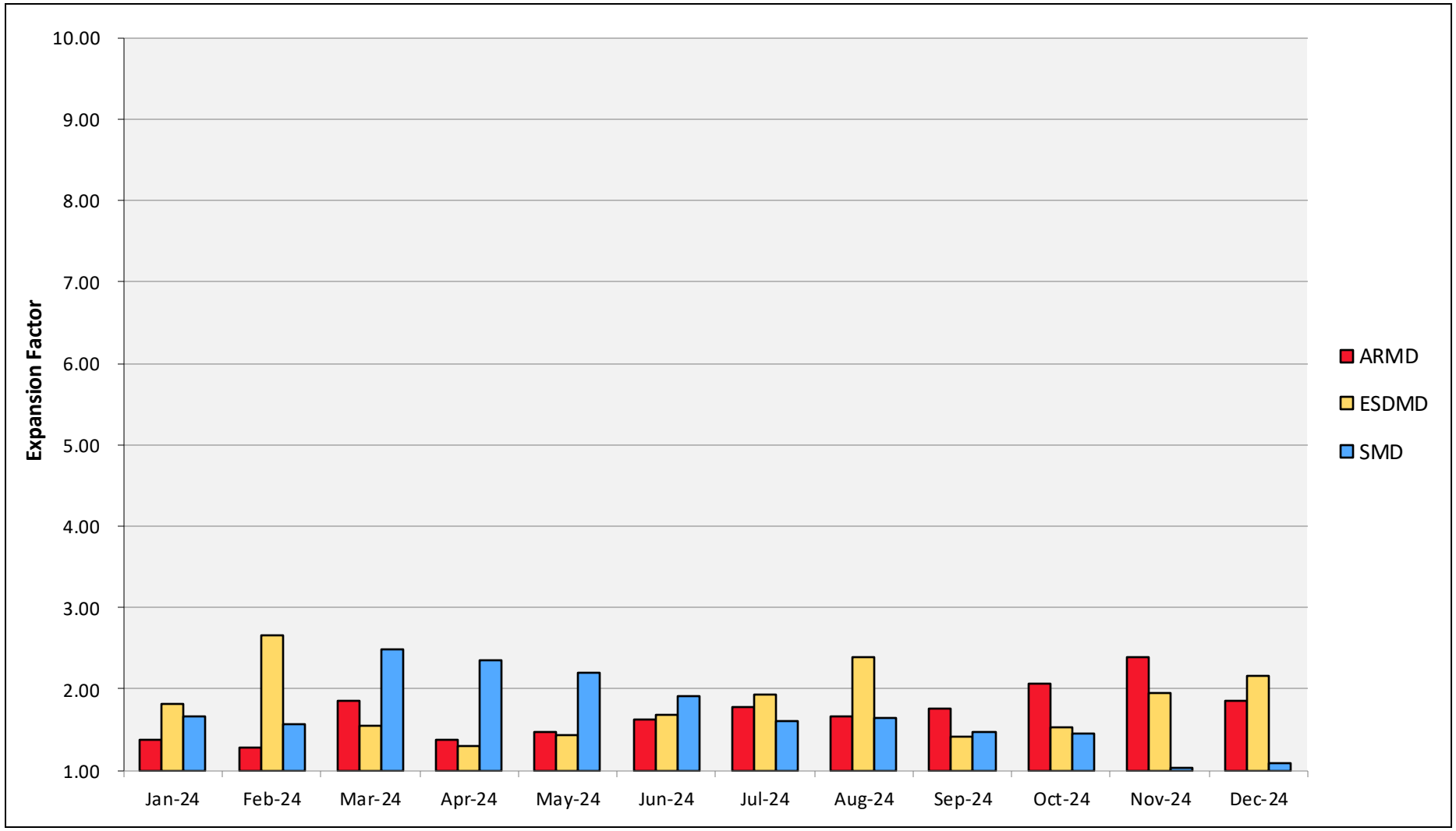
Aitken: Monthly Utilization by Size and Length



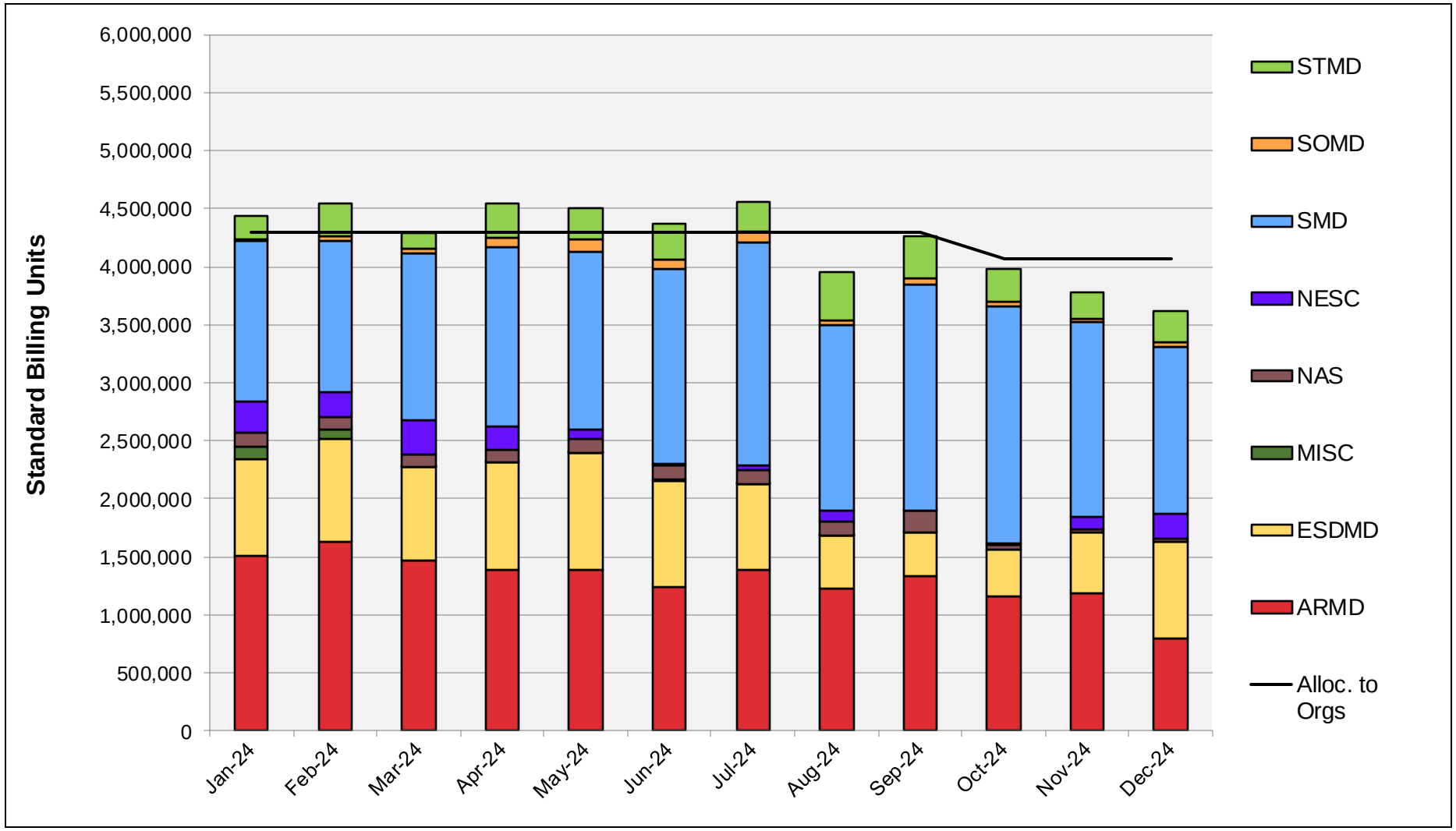
Aitken: Average Time to Clear All Jobs



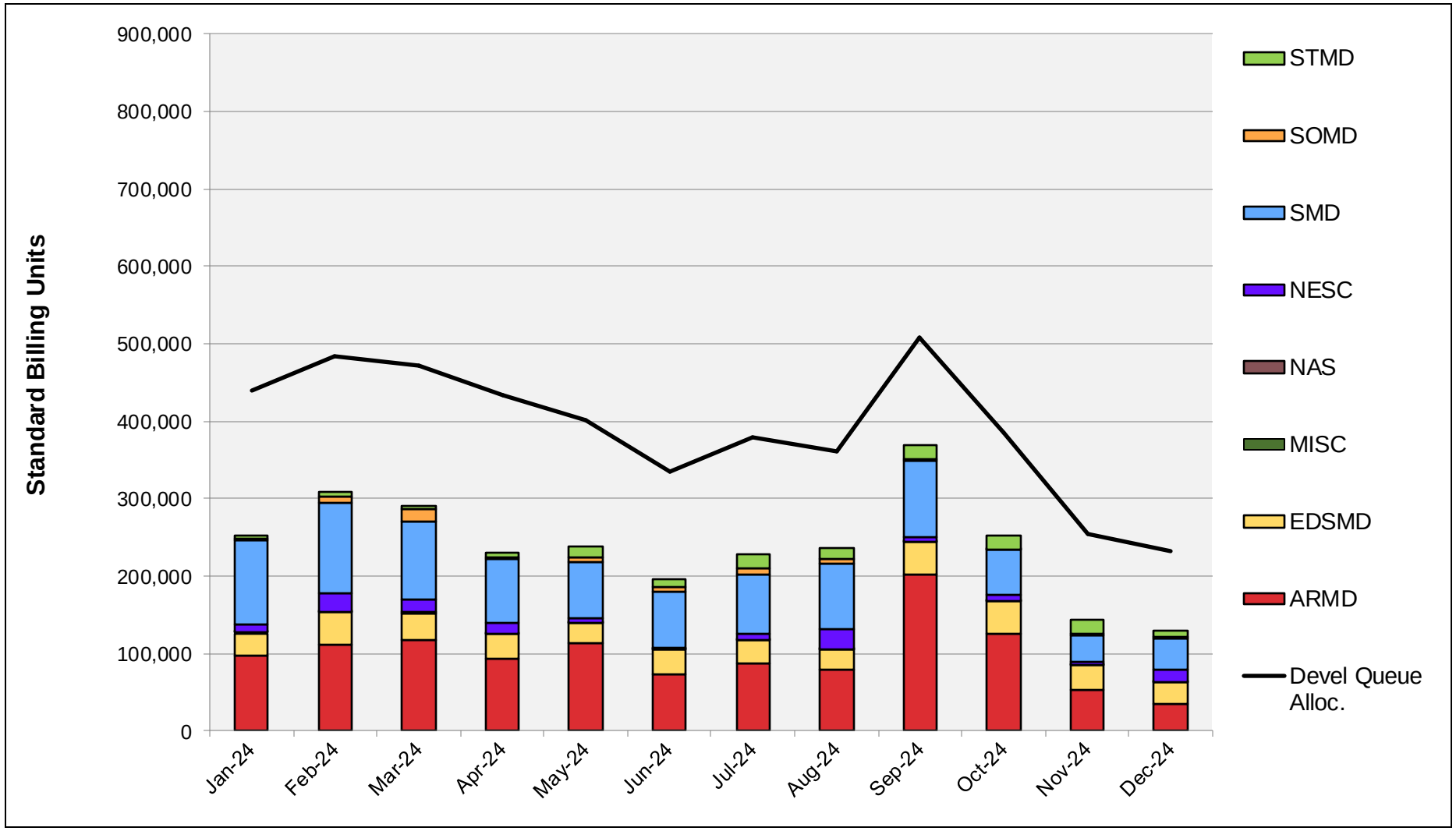
Aitken: Average Expansion Factor



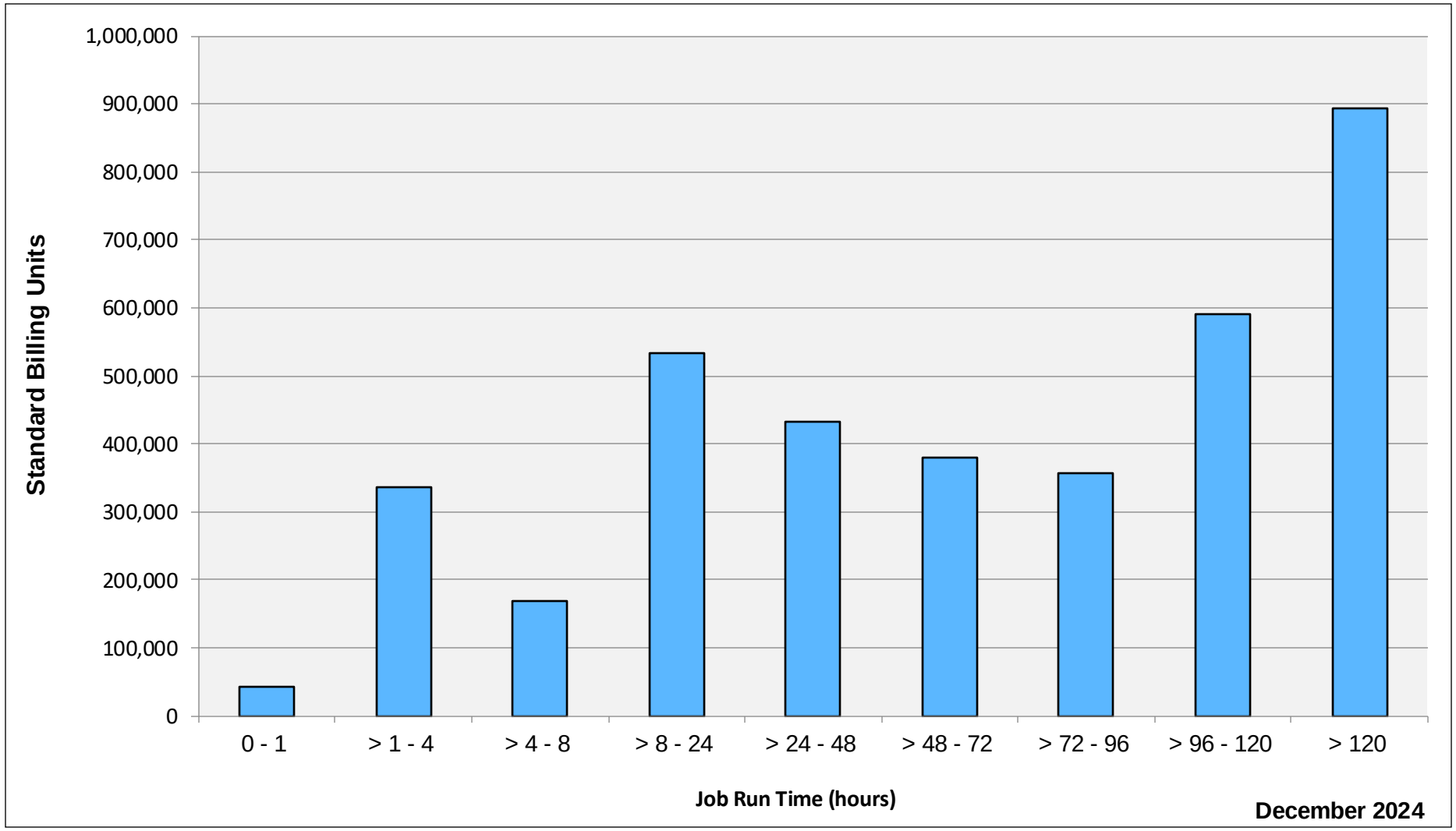
Pleiades: SBUs Reported, Normalized to 30-Day Month



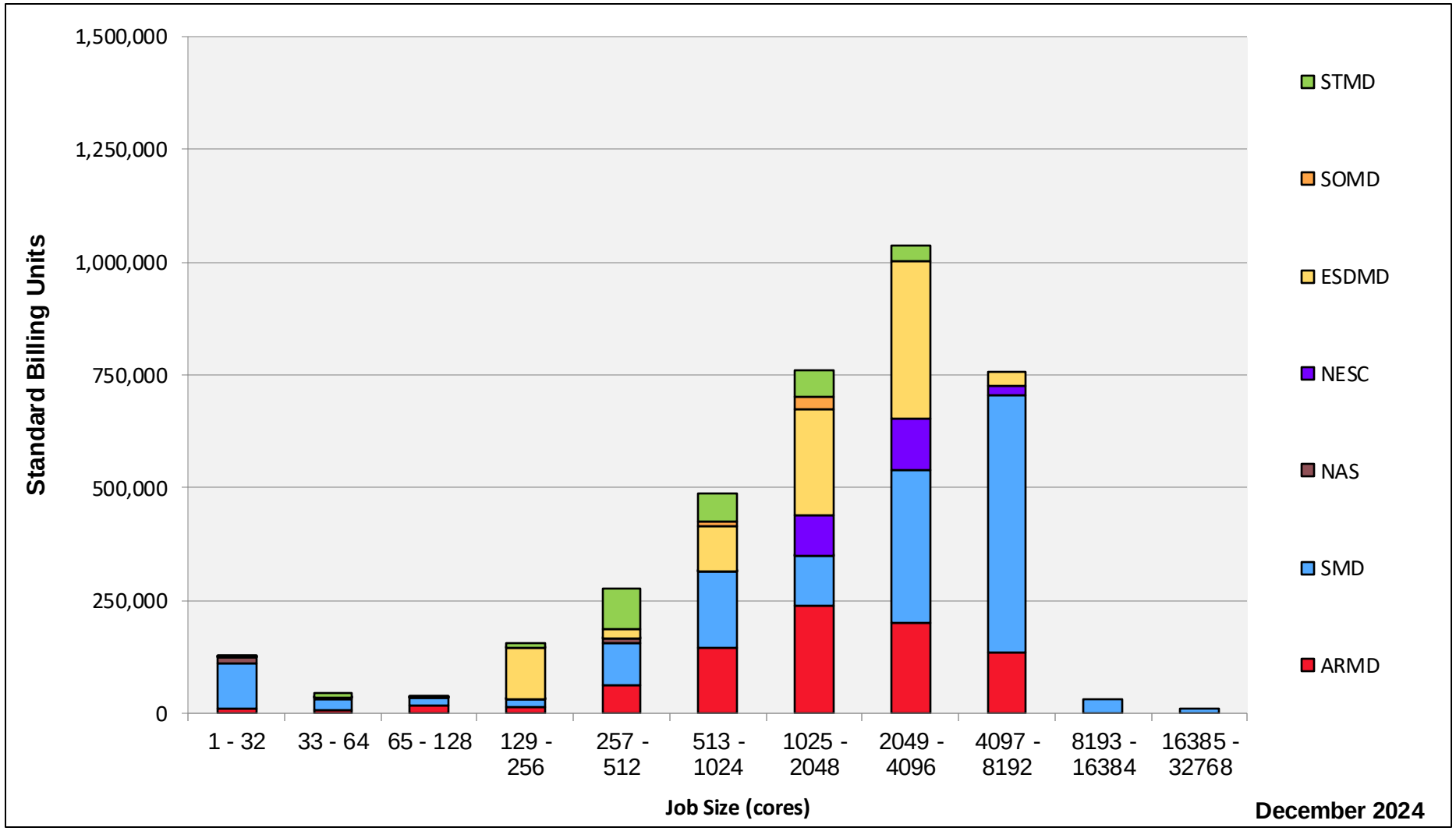
Pleiades: Devel Queue Utilization



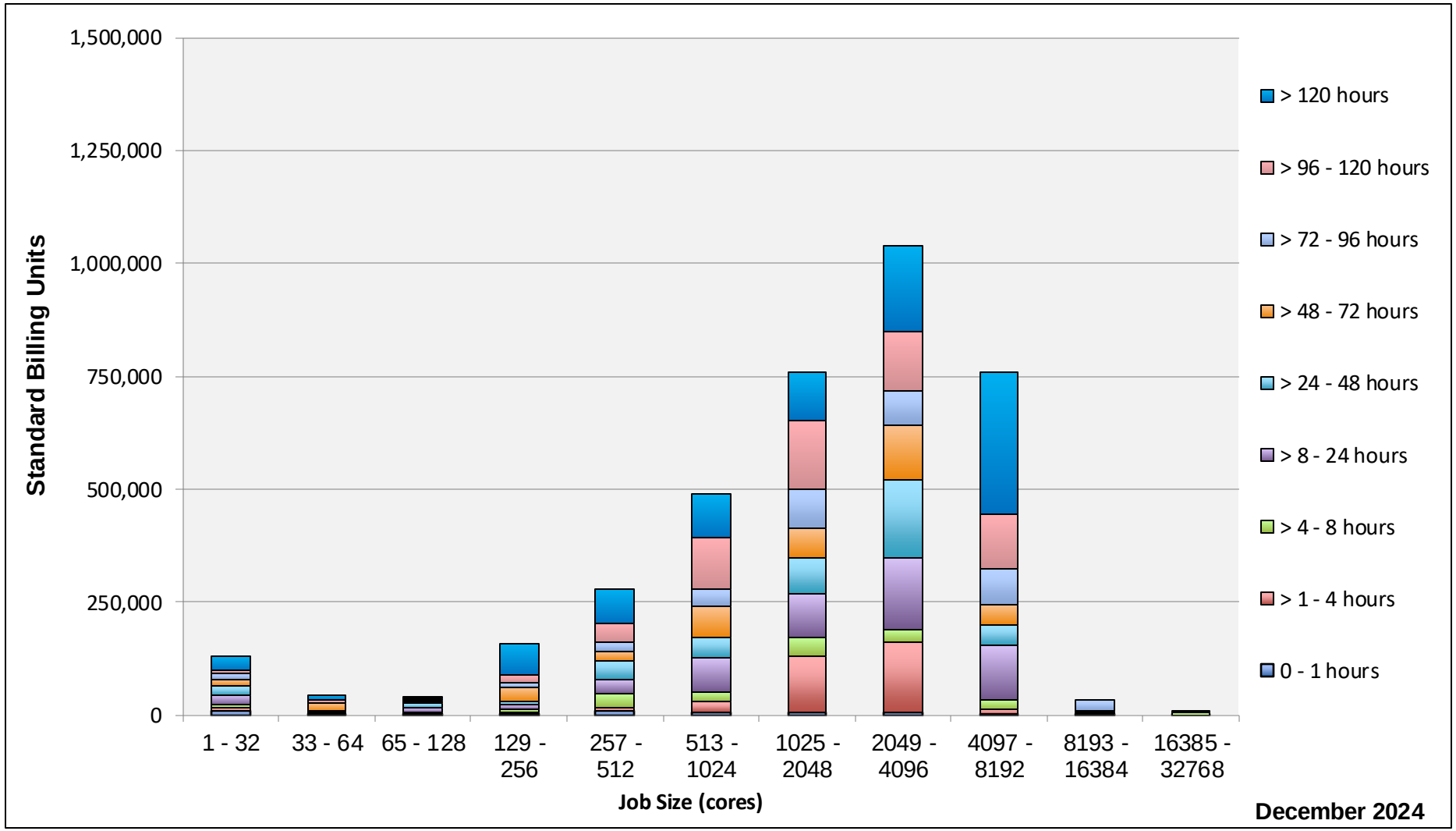
Pleiades: Monthly Utilization by Job Length



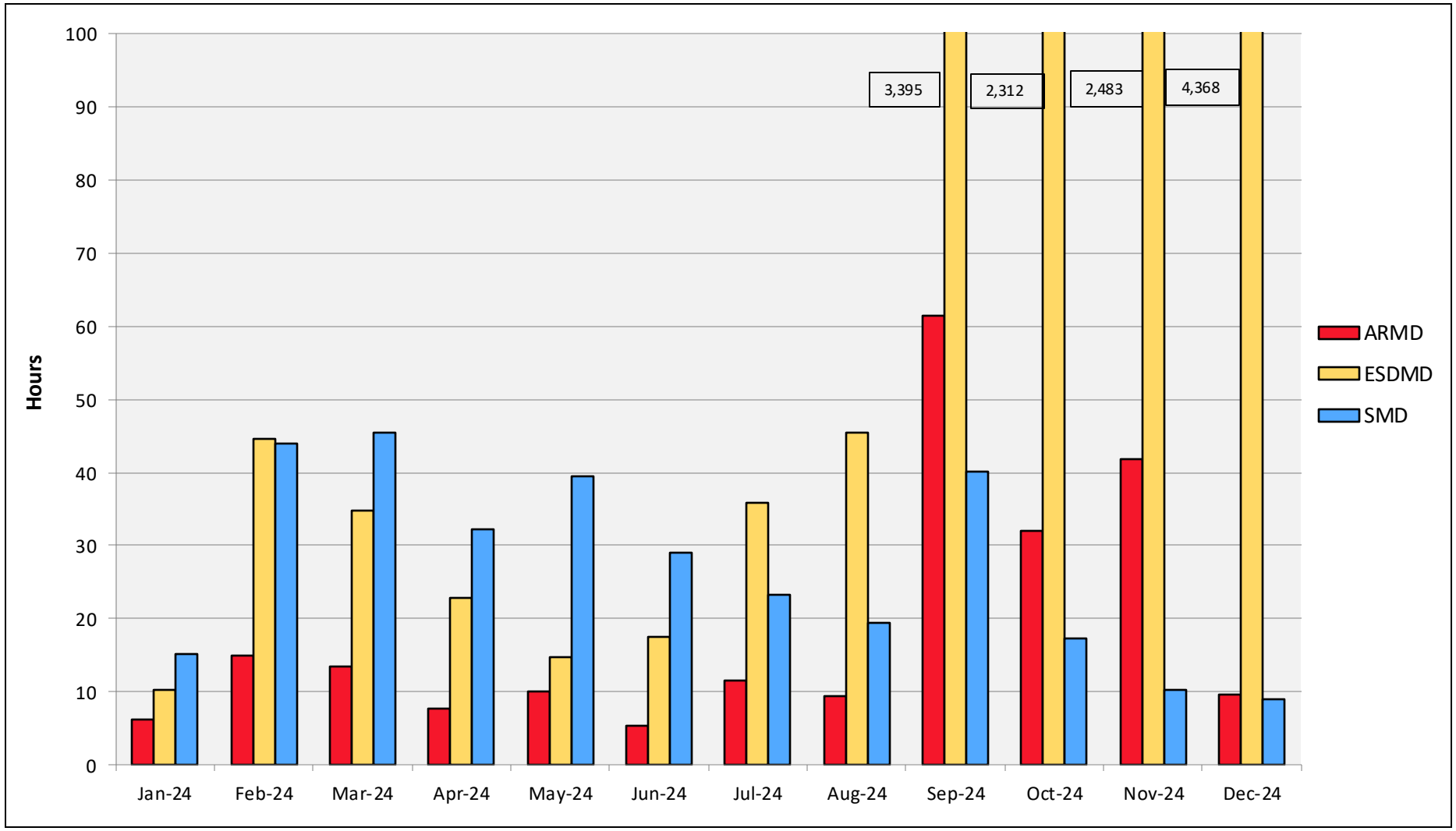
Pleiades: Monthly Utilization by Job Size



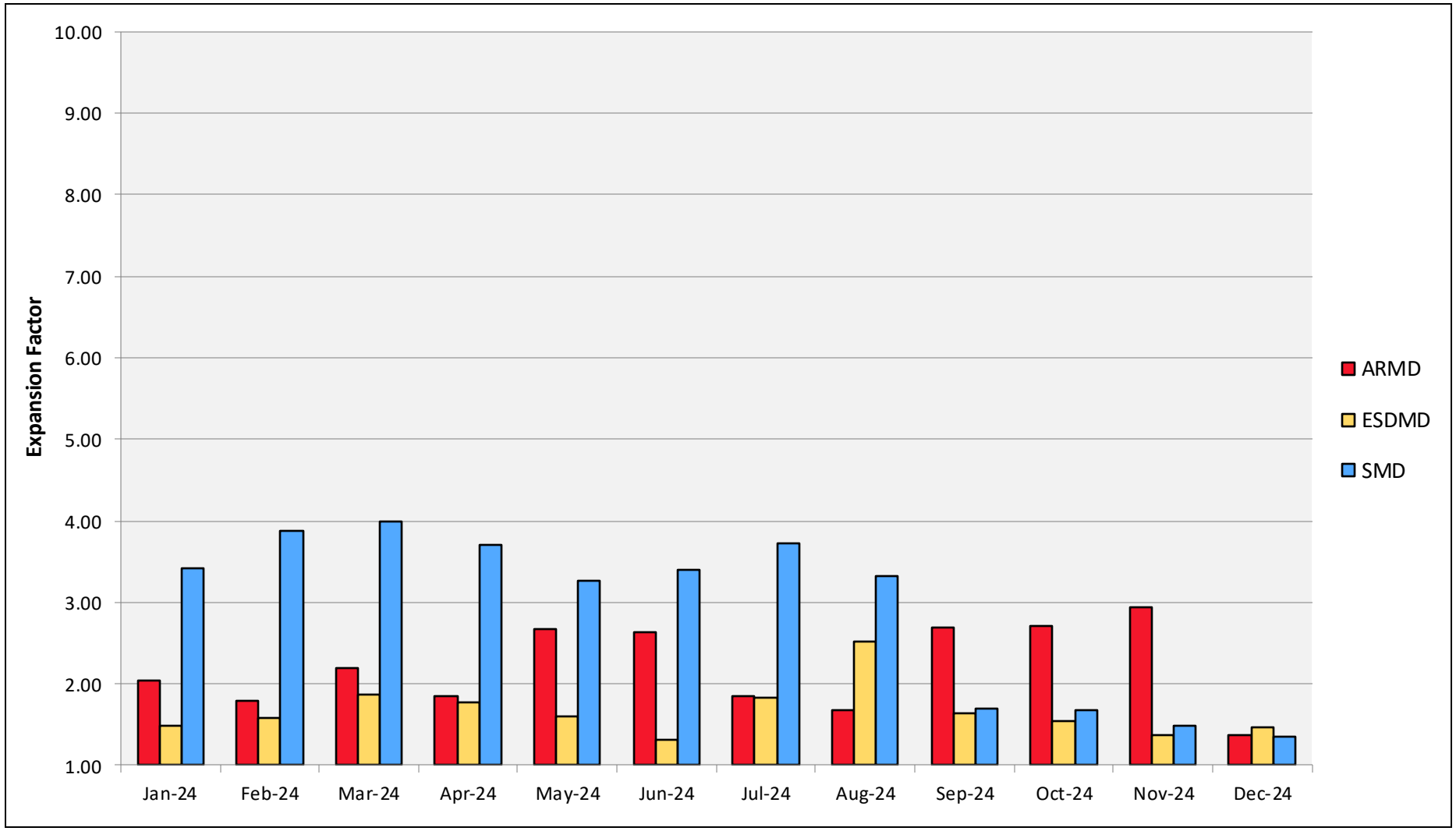
Pleiades: Monthly Utilization by Size and Length



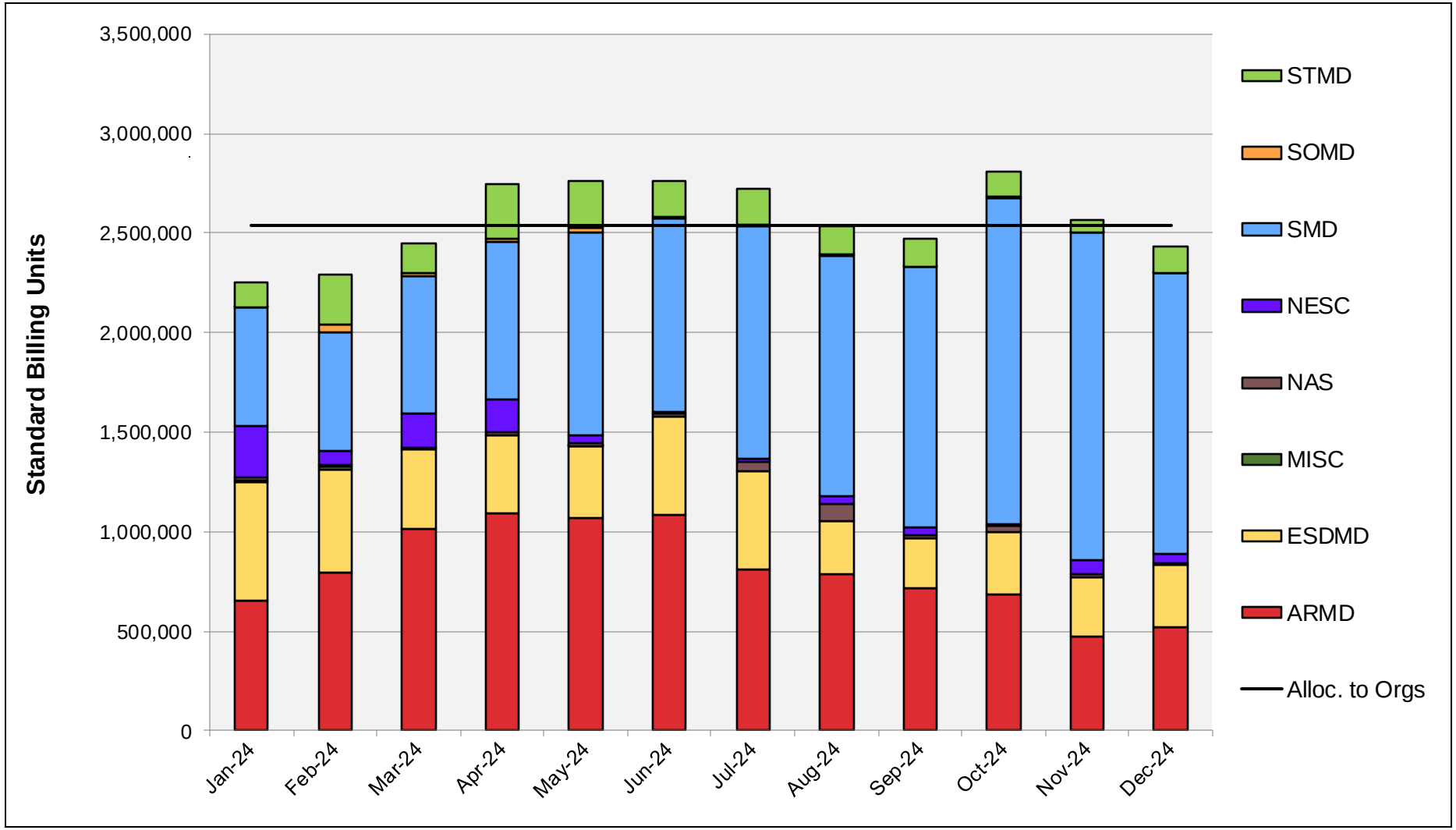
Pleiades: Average Time to Clear All Jobs



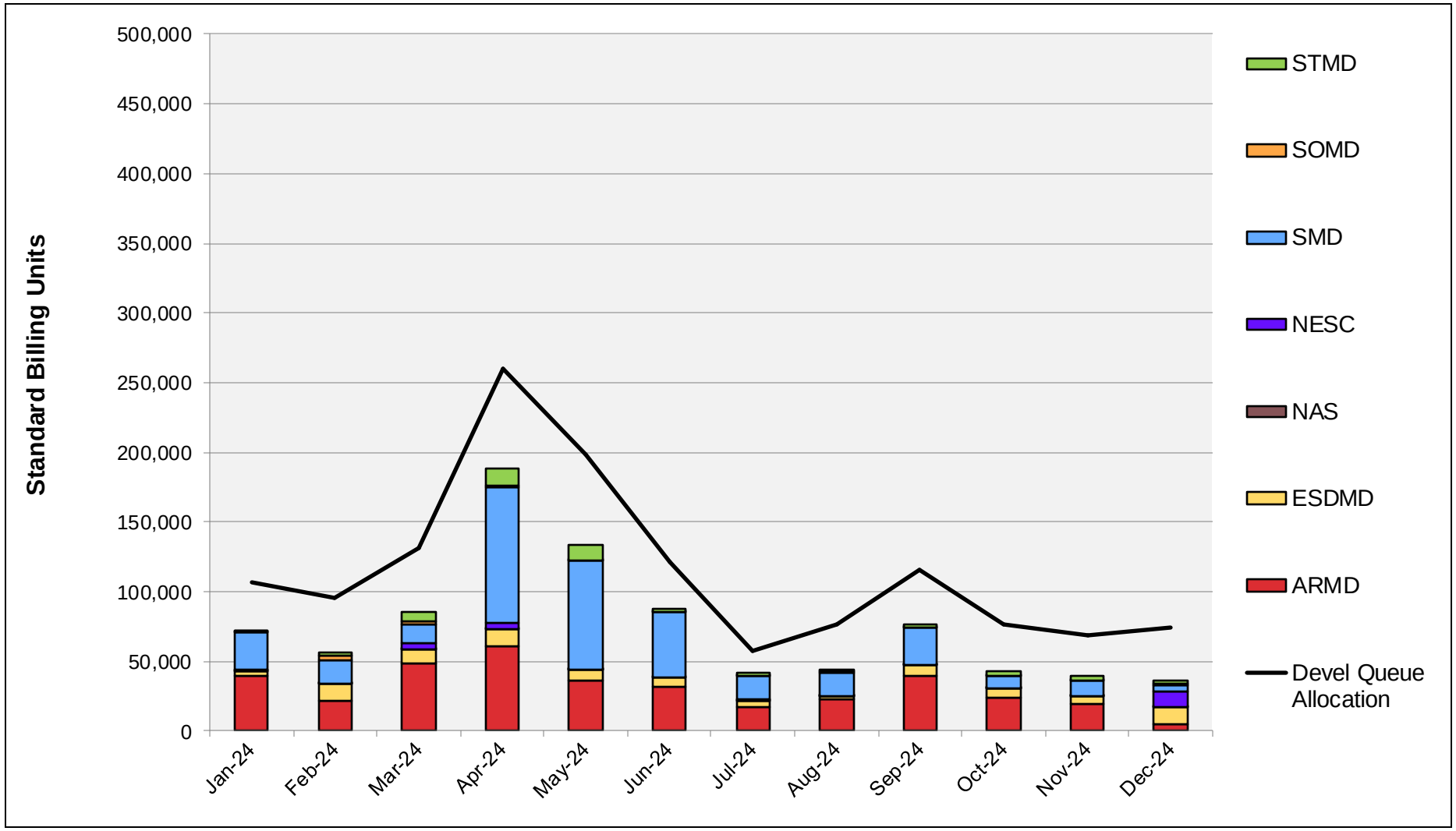
Pleiades: Average Expansion Factor



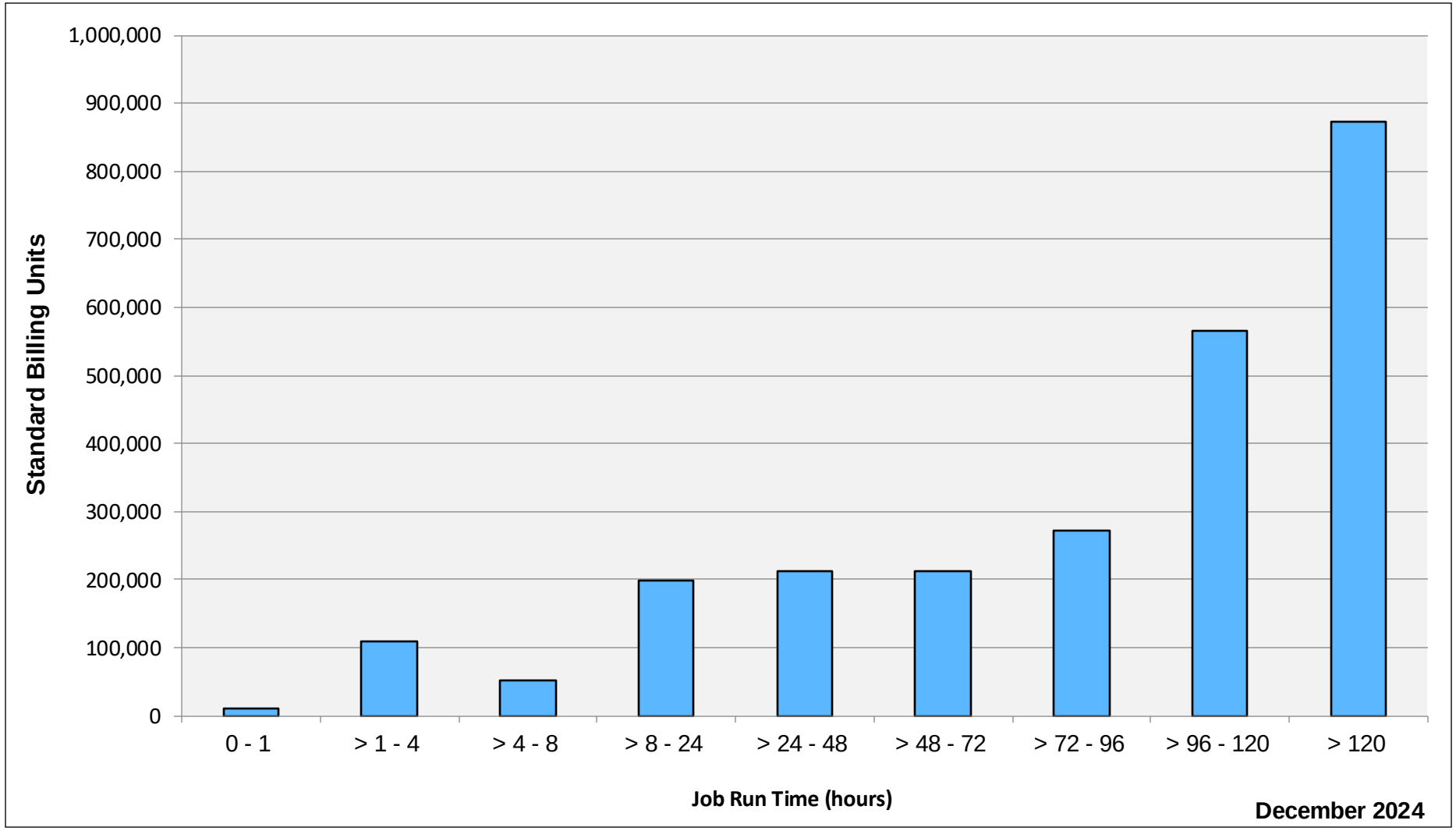
Electra: SBUs Reported, Normalized to 30-Day Month



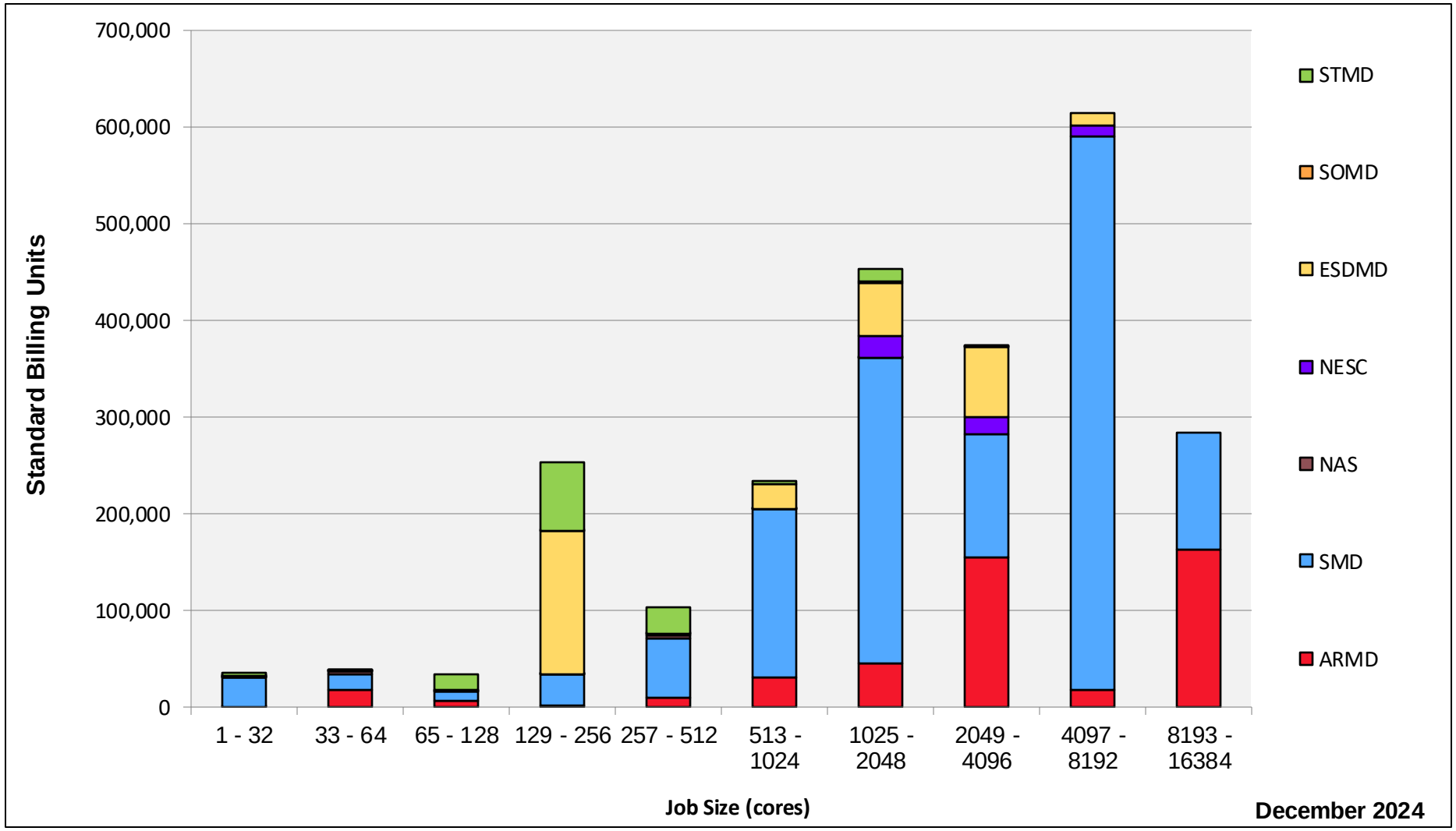
Electra: Devel Queue Utilization



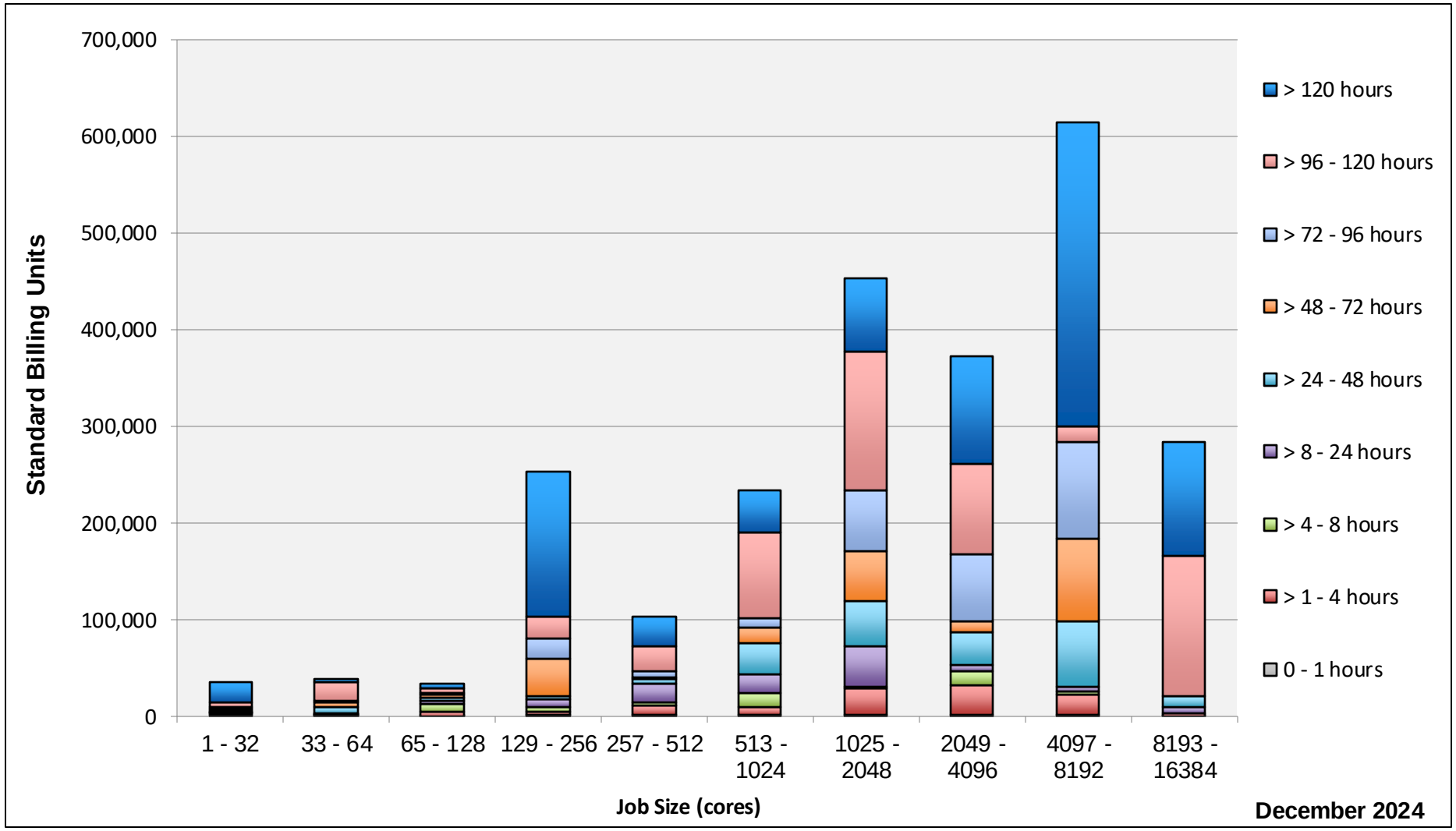
Electra: Monthly Utilization by Job Length



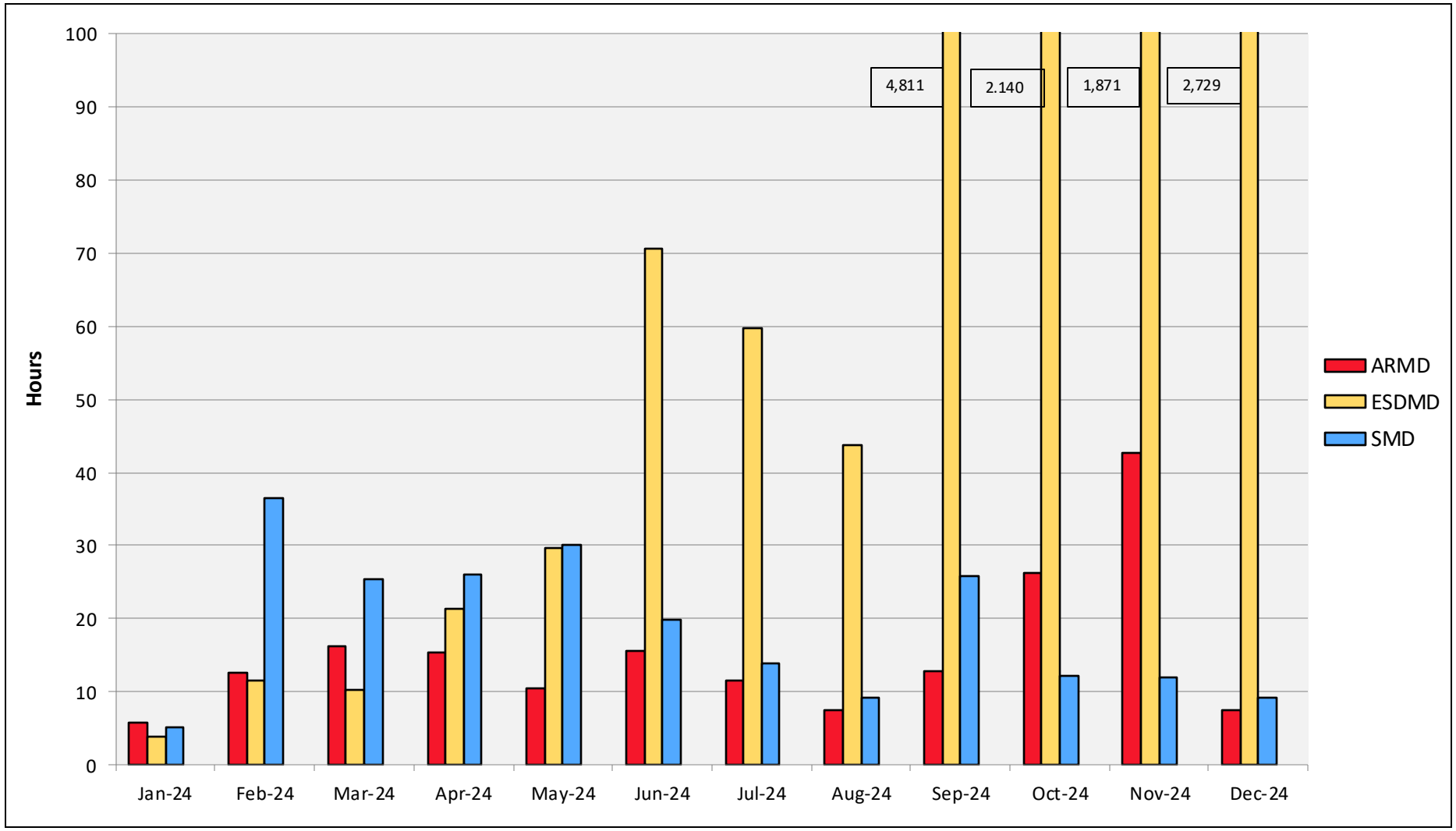
Electra: Monthly Utilization by Job Size



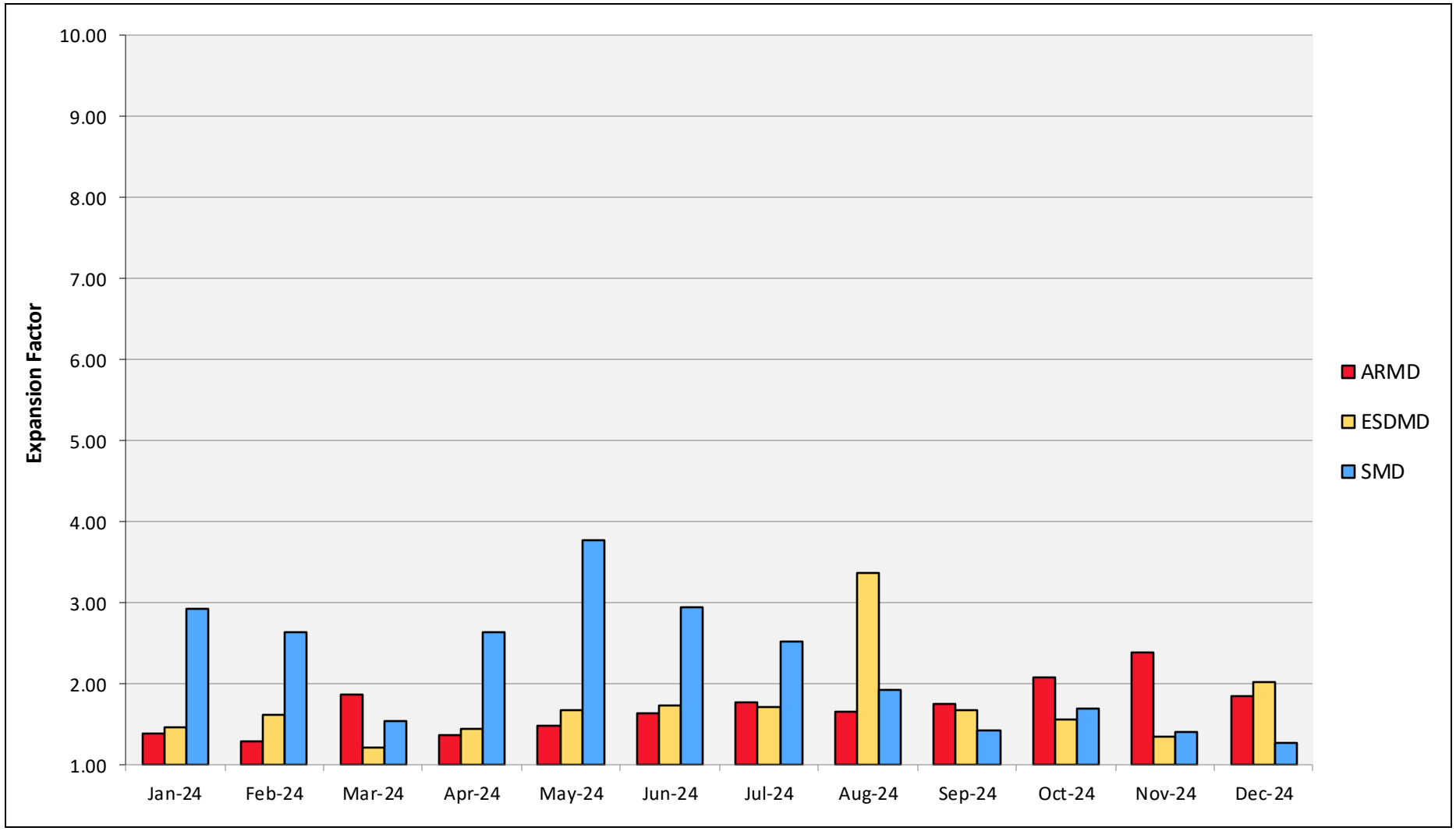
Electra: Monthly Utilization by Size and Length



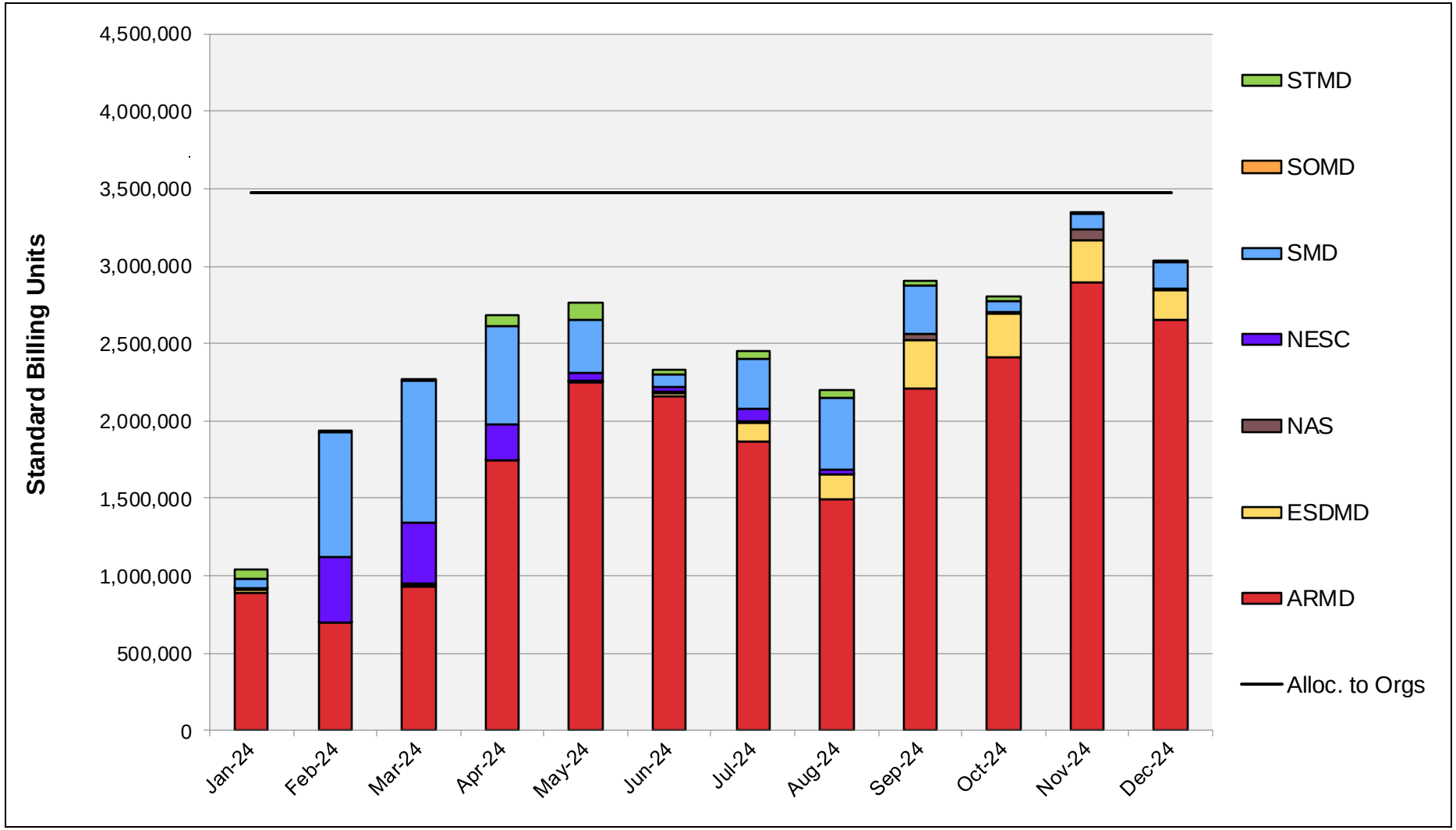
Electra: Average Time to Clear All Jobs



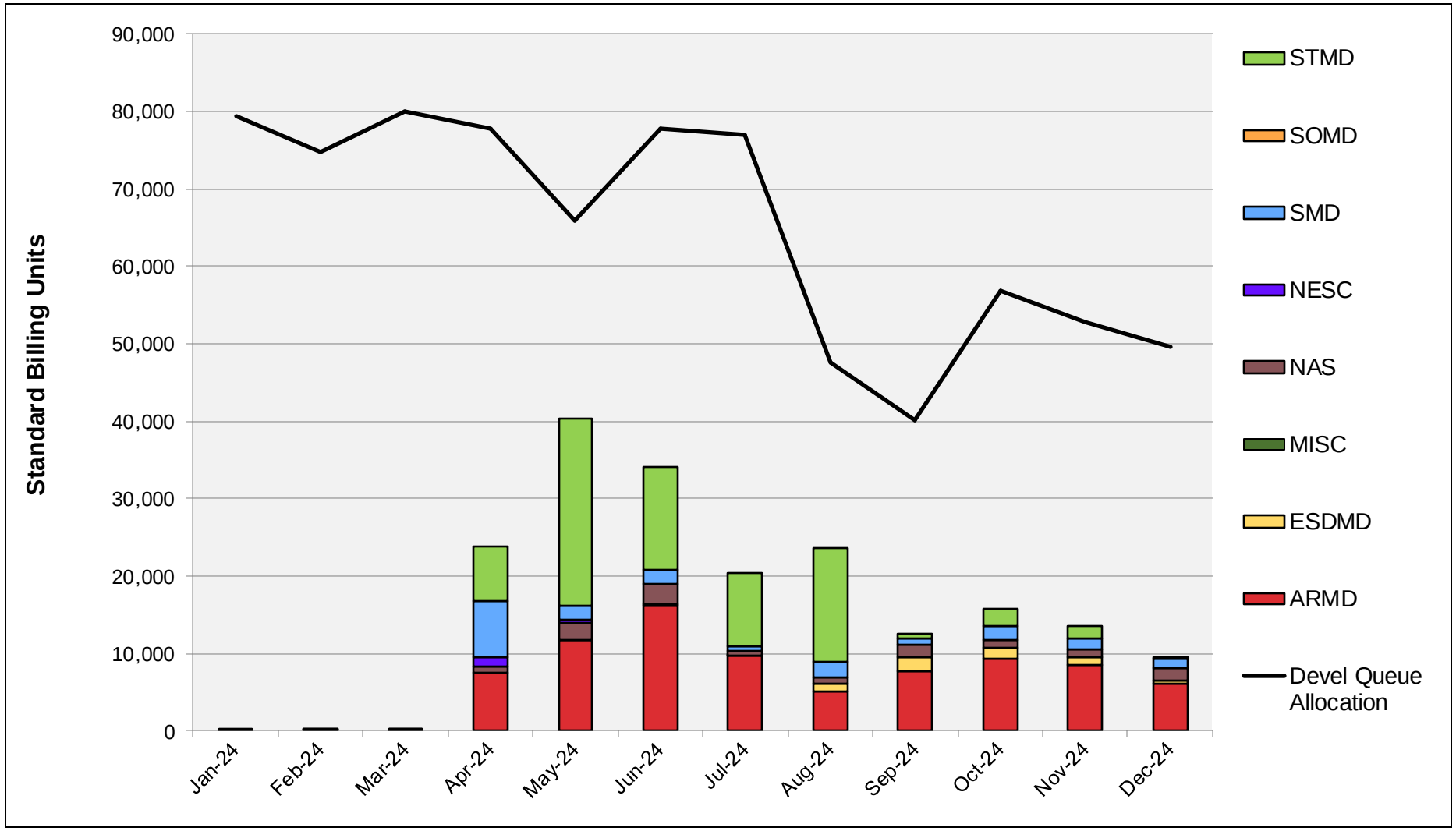
Electra: Average Expansion Factor



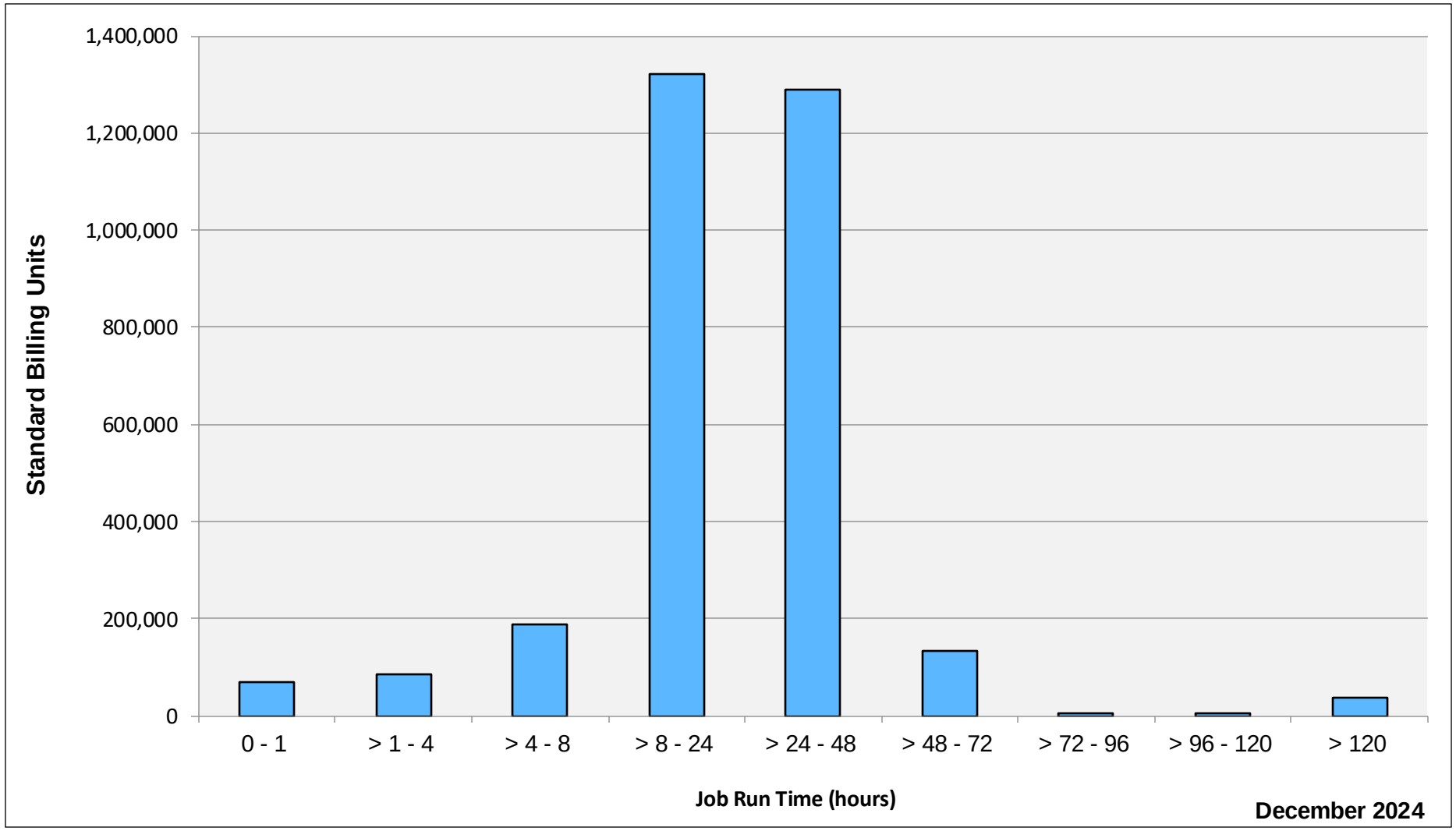
Cabeus: SBUs Reported, Normalized to 30-Day Month



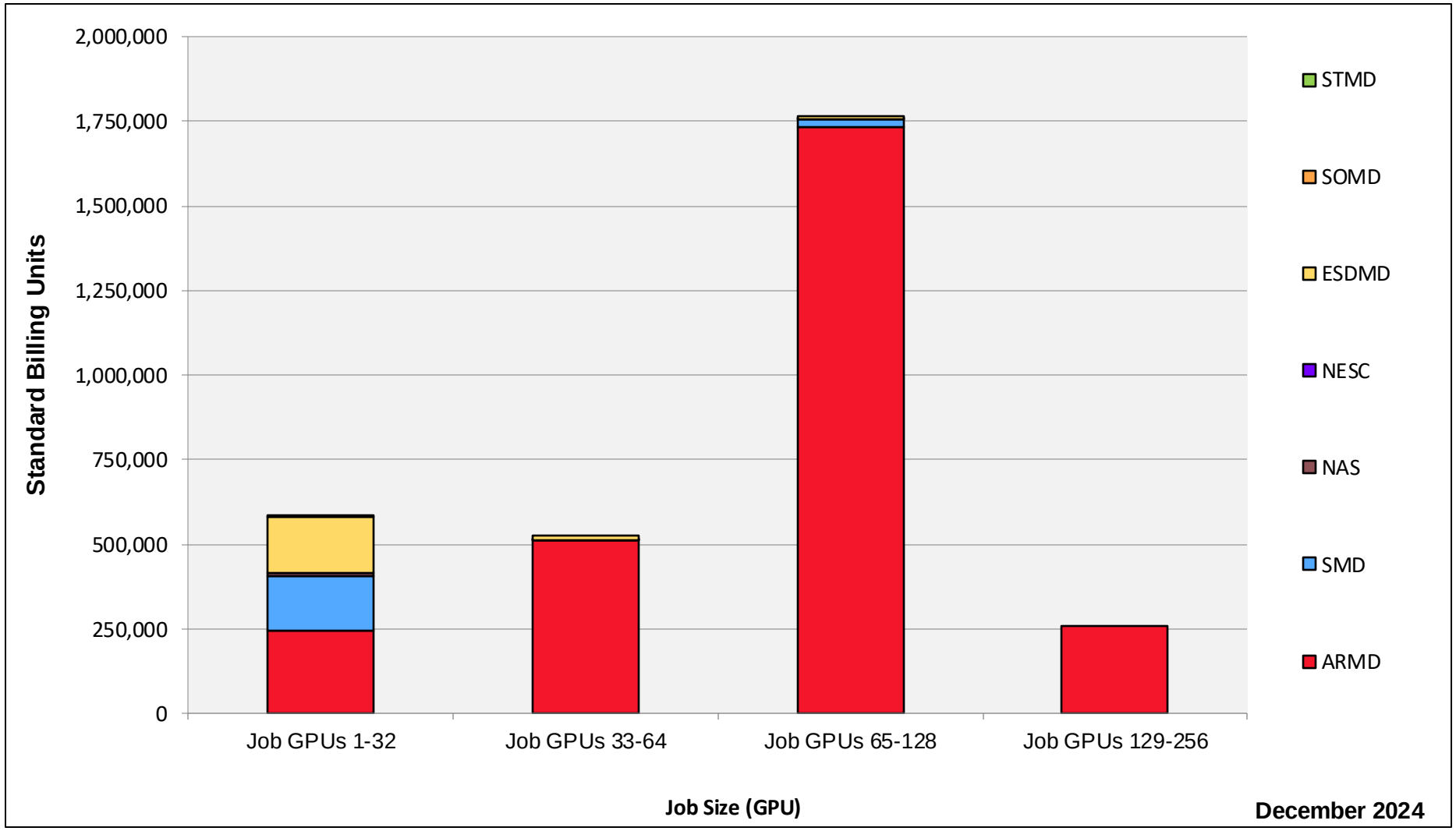
Cabeus: Devel Queue Utilization



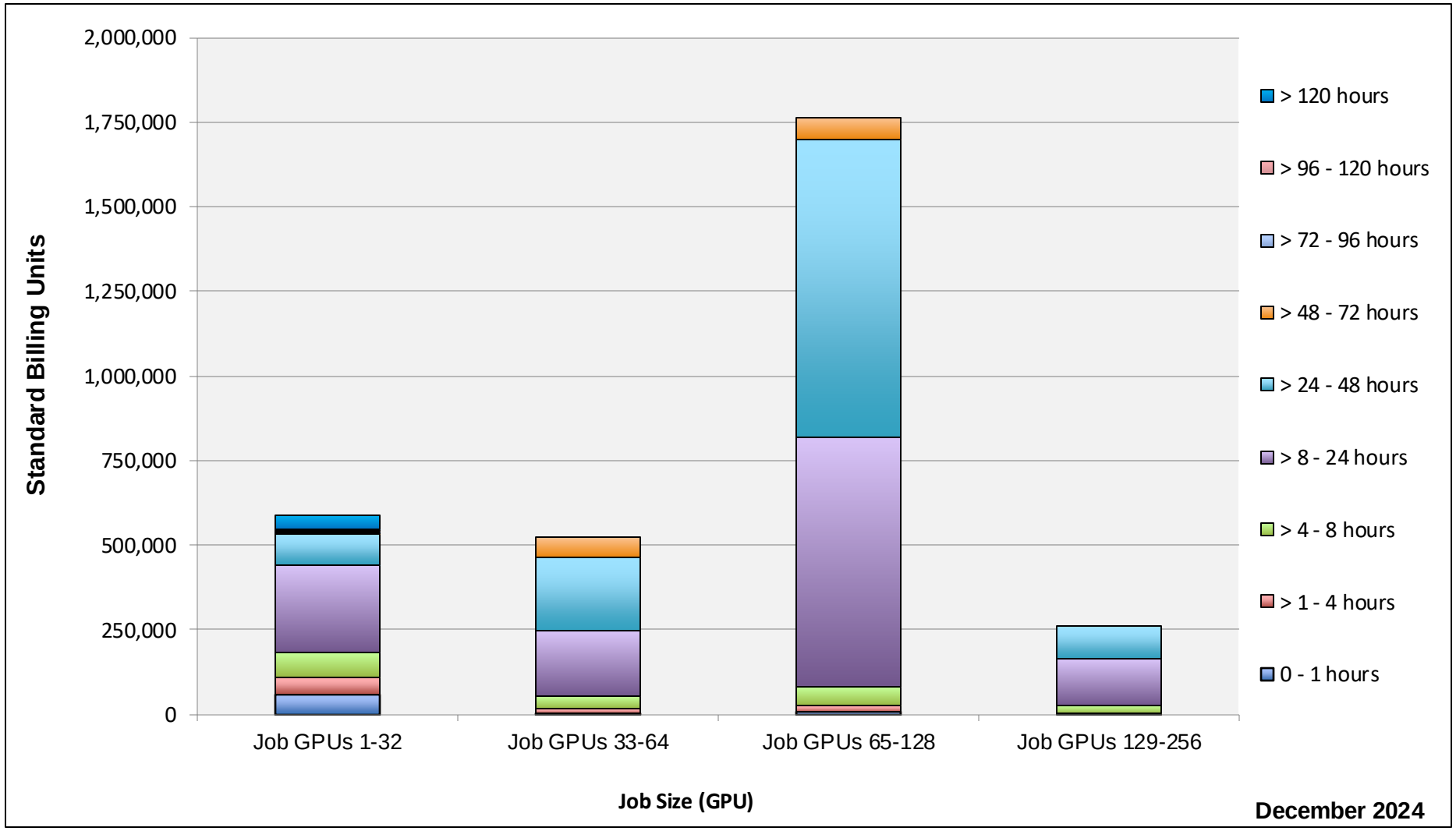
Cabeus: Monthly Utilization by Job Length



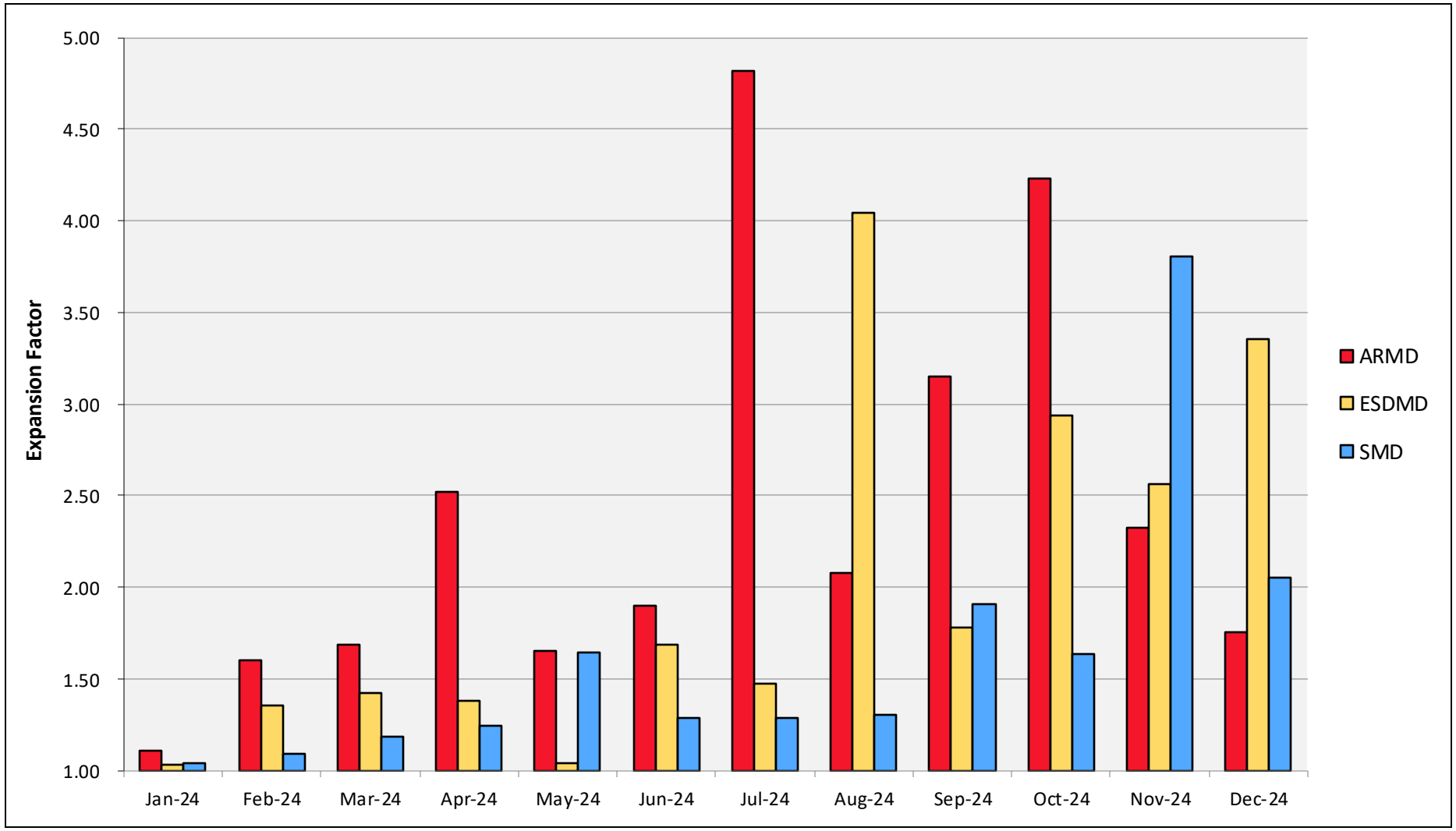
Cabeus: Monthly Utilization by Job Size



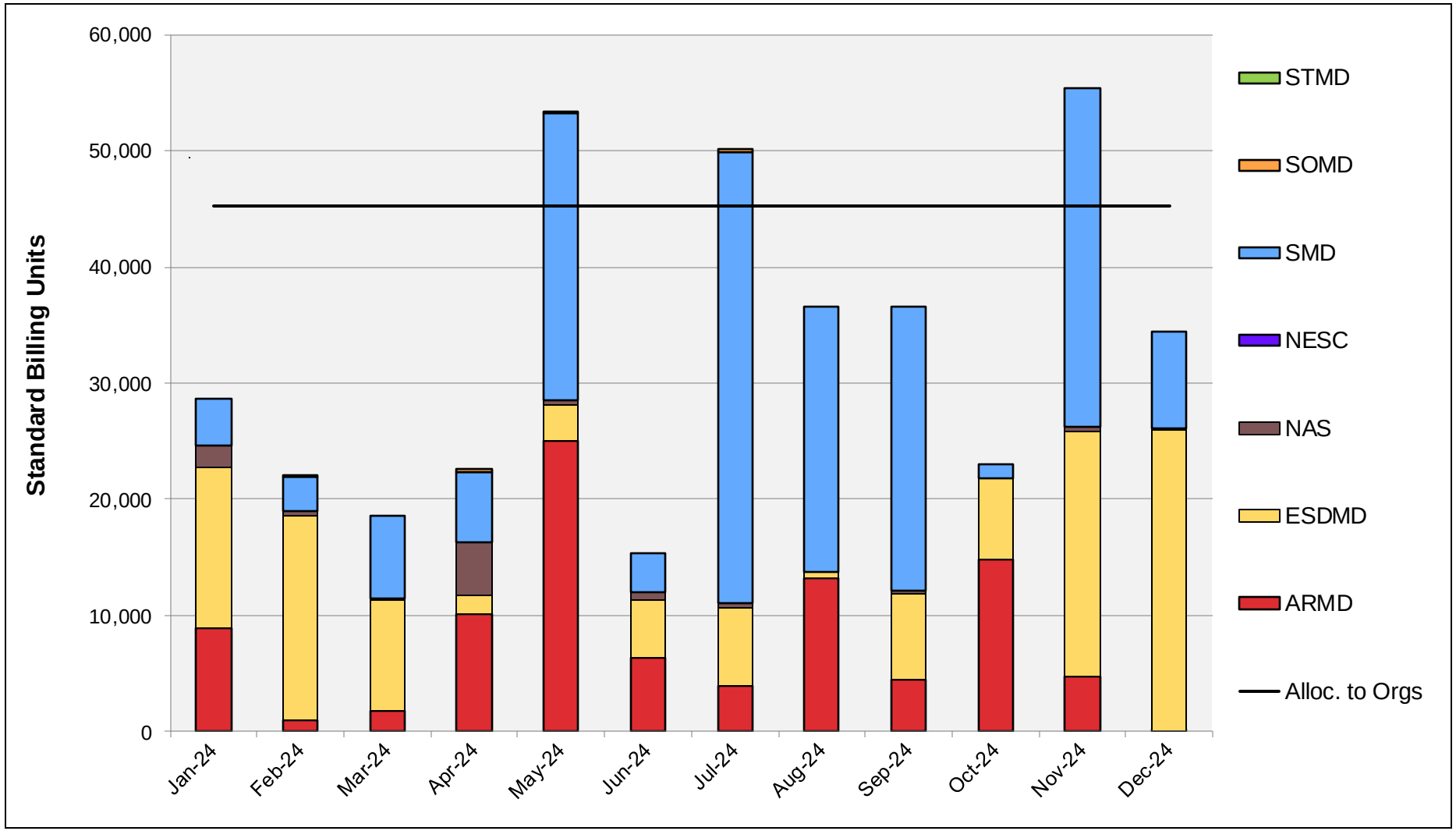
Cabeus: Monthly Utilization by Size and Length



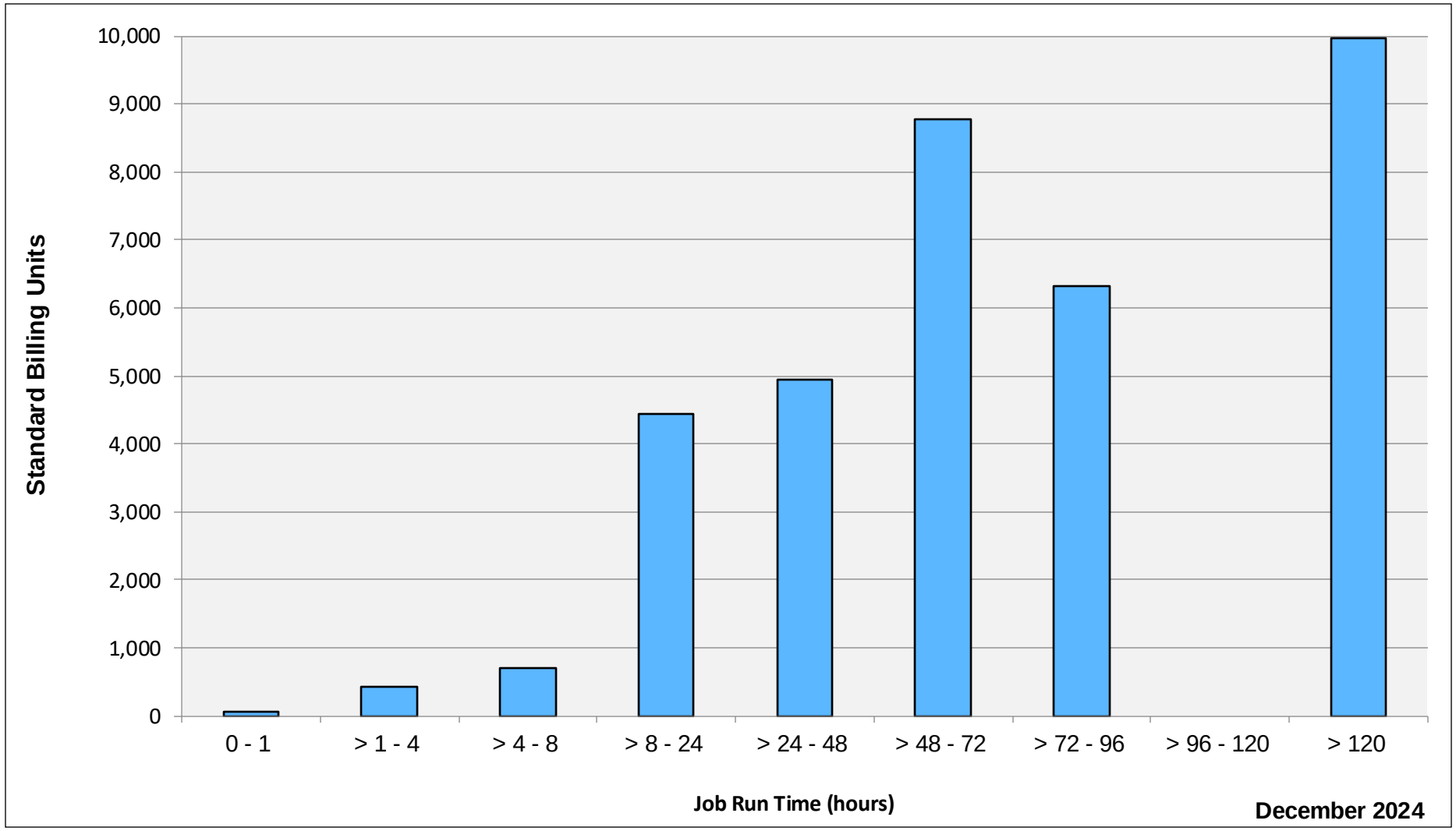
Cabeus: Average Expansion Factor



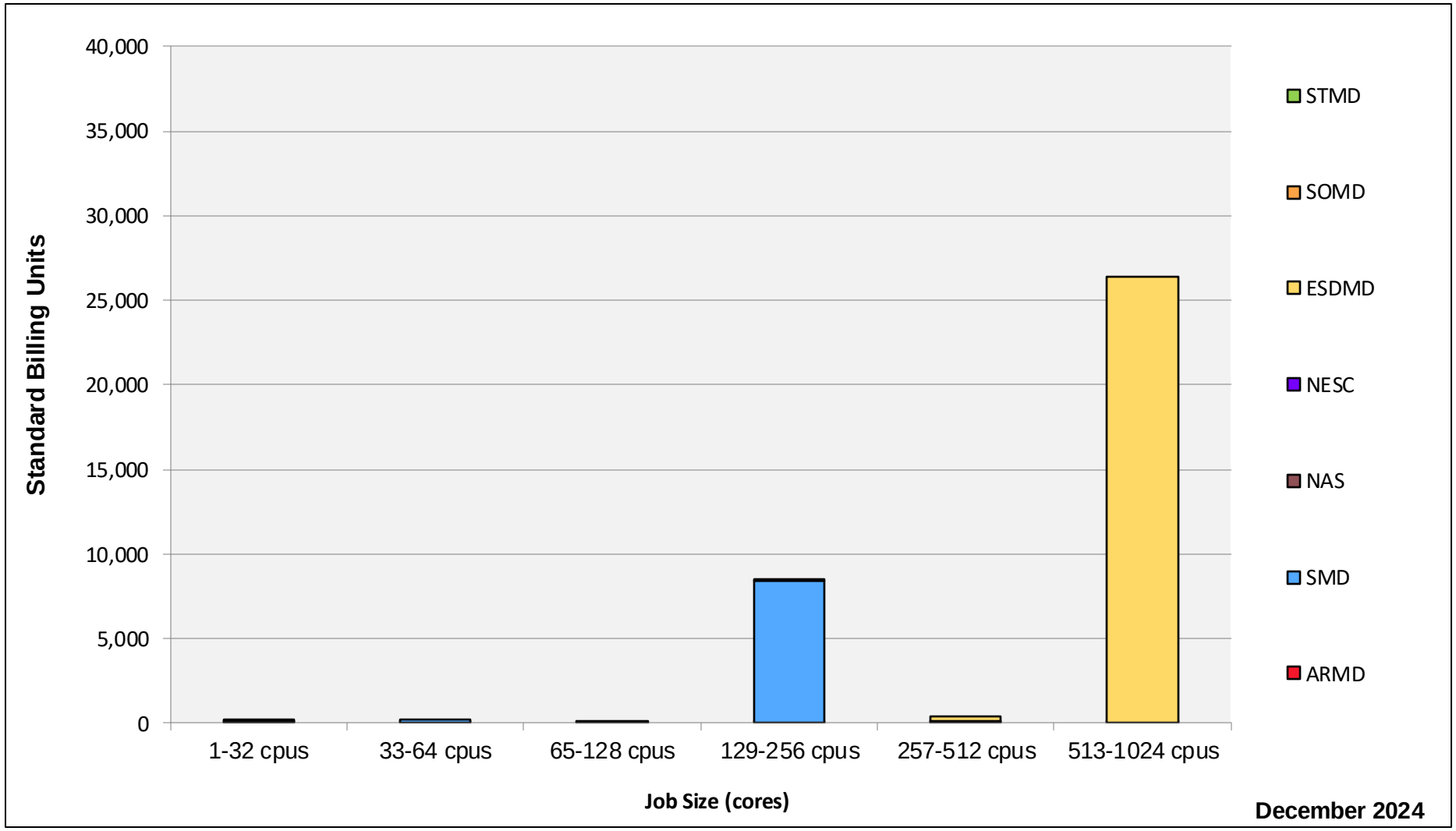
Endeavour: SBUs Reported, Normalized to 30-Day Month



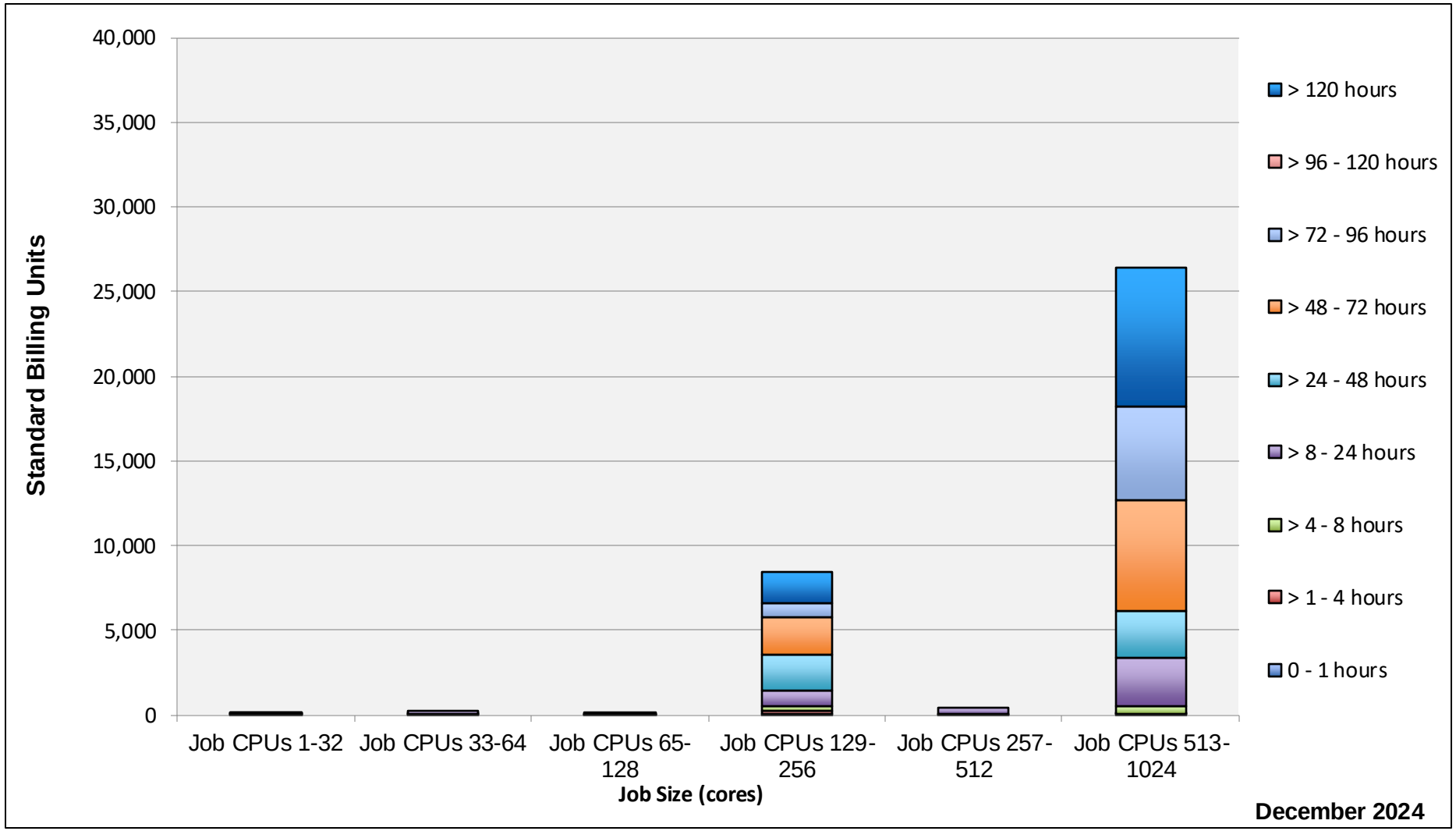
Endeavour: Monthly Utilization by Job Length



Endeavour: Monthly Utilization by Job Size



Endeavour: Monthly Utilization by Size and Length



Endeavour: Average Expansion Factor

