National Aeronautics and Space Administration



HIGH-END COMPUTING CAPABILITY PORTFOLIO

William Thigpen
NASA Advanced Supercomputing Division

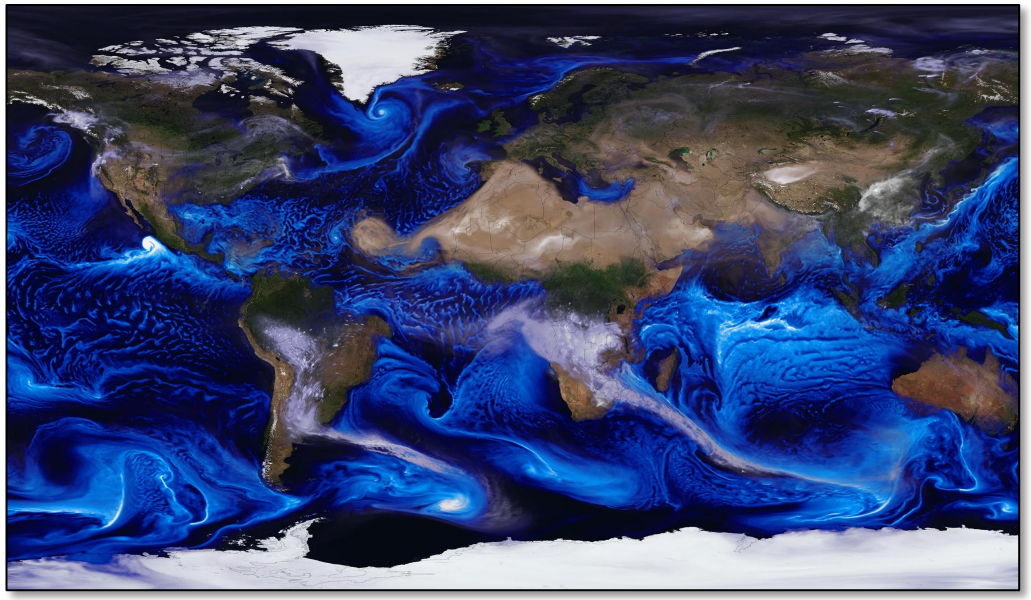
May 10, 2023

HECC Supercomputer Usage Sets New Normalized Record

- In April 2023, the combined usage of HECC supercomputers set a new normalized record of 14,258,671 Standard Billing Units (SBUs*).
- The usage by 373 of NASA's science and engineering groups exceeded the previous record of 14,046,689 SBUs set in March 2023 by 208,982 SBUs.
- The record was achieved in great part by the Science Mission Directorate supporting many high resolution simulations with GEOS for future observing system development. These simulations approach 1.5 km globally, with a focus on extreme events and storm-scale processes.
- Usage of Aitken, Pleaides, Electra, and Endeavour 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 277,006 and 1,062,137 SBUs and together accounted for over 41% of the total usage.
- 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 Pleiades Broadwell 28-core node.*

IMPACT: The combination of an increased capacity of HECC systems and hands-on support to optimize users' job run capacities enables mission directorates 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

Updated HECC Network Infrastructure Deployed

- The Network team completed upgrades to the HECC Enclave, NASLAN, and HSN (High-Speed Network) network infrastructures.
  - The Enclave network infrastructure upgrade replaced end-of-life (EoL) hardware to resolve security vulnerabilities on the older hardware.
  - The NASLAN network infrastructure upgrade replaced EoL hardware with modern high-availability, high-capacity network hardware.
  - The HSN network infrastructure upgrade replaced EoL hardware with hardware that supports a 100-gigabit-per-second (Gbps) network backbone.
- The team successfully met objectives of this year-long project:
  - Increased bandwidth for the HECC Enclave network infrastructure: replaced multiple saturated 10-Gbps uplinks with 40-Gbps connectivity.
  - Increased redundancy and performance: HECC Enclave server access switches were replaced with switch chassis that provide improved performance (240-Gbps backplane speed, increased CPU and memory capacity) and increased port density for 1-Gbps copper and 10-Gbps fiber connectivity.
  - Refreshed Network Equipment: Replaced EoL equipment as part of an ongoing five-year hardware refresh cycle.
  - Improved power resiliency: All deployed network devices now have redundant power supplies that are connected to different power distribution units with uninterruptible power supply backup.

IMPACT: These network upgrades improve reliability and availability, update the HECC security posture, and provide enhanced performance for the network services that are provided to users, scientific institutions, colleges, and other NASA centers and missions through HECC.

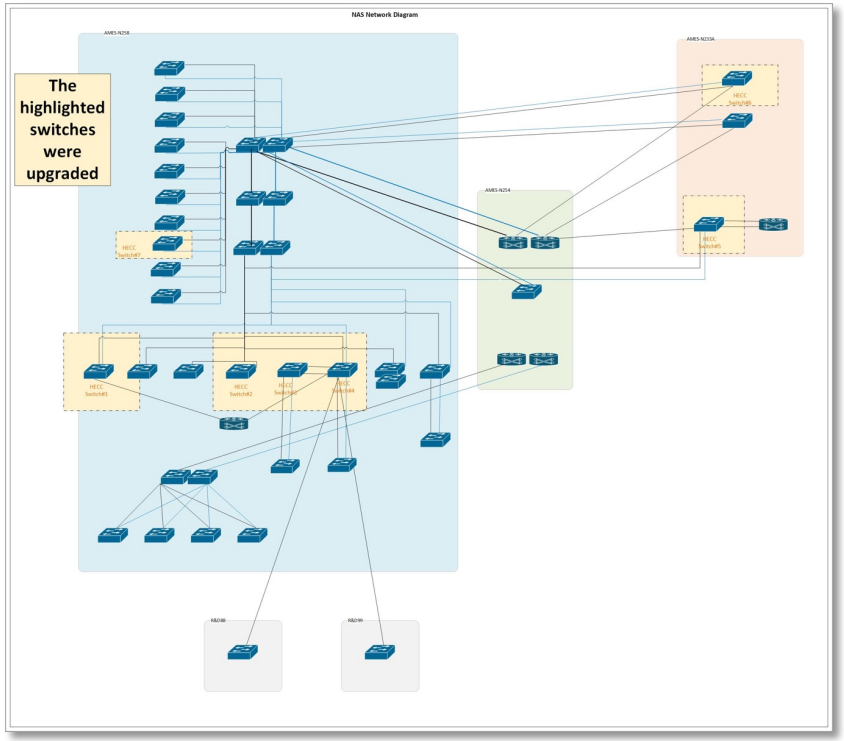


Diagram highlighting switch replacements in the HECC enclave.

CSS Team Provides Essential HECC Computing Support

- The HECC Supercomputing Systems (CSS) team is involved in all aspects of system support including evaluating, testing, building, and maintaining systems in support of NASA missions. They also respond to user requests for assistance with login issues, data migration, quota limits, scheduling PBS jobs, and running jobs that use the Shiftc tool.
- The team performs routine operational tasks and maintains uptime metrics, including:
  - Ensuring that the availability of the compute nodes remains above 90% across all architectures.
  - Balancing the load across all storage systems, migrating data for users, and performing maintenance and file system upgrades.
  - Responding to changing user requirements, such as providing job reservations to allow high priority jobs to be run in a timely manner.
  - Responding to outages 24/7, resolving incidents and conducting postmortem root cause analyses.
  - Patching system vulnerabilities to meet NASA IT security requirements during regular patch cycles.
- To meet updated Cyber Security Evaluation Tool (CSET) security requirements, CSS is migrating all systems to CSET-approved operating systems. HECC systems currently score at 95.5% compliance with CSET requirements, as measured by BigFix, the agency's endpoint management platform.

IMPACT: By responding to user requests and outages, and maintaining the health of the compute nodes, storage, and supporting systems, the Supercomputing Systems team ensures that HECC is able to provide reliable supercomputing resources to its customers.



The new Cabeus supercomputer will provide HECC users 512 NVIDIA A100 GPUs and 128 AMD Rome CPUs. *Don Story, NASA/Ames*

HECC Applications Team Enhances User Experience, System Utilization

- The Application Performance and Productivity (APP) team supports users and system capabilities in variety of ways. The team solves about 70 user-submitted Remedy tickets each month. For example:
  - Some users reported jobs aborting on Rome nodes after an OS kernel update. APP found the issue was due to a kernel panic caused by a new version of the Lustre client. The Systems team quickly released a new kernel with a rolled-back version of the Lustre client. The job aborts have not resurfaced.
  - When users reported performance issues, APP determined the cause to be congestion in some of the /nobackup filesystems. For some users, performance was improved by relocating their data to other filesystems.
- Some requests result in longer engagements with the user, often involving deep dives into application performance. For example:
  - The team made an initial profiling and optimization assessment of the CubeP OpenMP application from the U.S. Geological Survey and improved it five-fold with compiler flag changes. They are now in the process of moving the code from the OpenMP shared-memory model to MPI.
  - A user at NASA Johnson requested assistance with performance improvement in the Ramtares application, which models flights for the Orion spacecraft. In ongoing work, the APP team provides compile suggestions and profiles data.
- In addition to supporting user requests, the APP team also monitors system performance and proactively approaches users who have issues.
  - APP's load imbalance tool reported a 121-process code running 14 processes per Broadwell node on 10 nodes total. This resulted in half of the cores being used on 9 nodes, with the 10th node left idle. Since the job had a low memory footprint, the team showed the user how to distribute the process load across both sockets and run on only 5 nodes, resulting in a 50% SBU savings.

IMPACT: By responding both to user requests and issues identified by system monitoring, the Applications team is able to improve user experience, job turnaround times, and system utilization.



In addition to working with users on application issues, the APP team also evaluates computer architectures that may help meet NASA's future HEC requirements. Recently, the team has been evaluating an NEC SX Aurora vector machine, pictured here. *Alexander Pelkey, NASA Ames*

NASA Ames Supercomputing History, Capabilities Featured on Popular Social Media Channel

- The importance of the NASA Advanced Supercomputing Division—from its early beginnings at NASA Ames to its critical role in shaping the state-of-the-art in high-end computing technologies—is featured in a new episode of The History Guy Channel on YouTube, narrated by Lance Geiger, aka The History Guy.
- The History Guy channel has over 1 million followers. The episode "A History of NASA's Supercomputers" has garnered nearly 60 thousand views to date.
- The episode gives viewers background on the founding of NASA Ames, building on the foundational need for supercomputers, and leading through the early HPC technologies to the present capability, including the Modular Supercomputing Facility.
- The HECC Publications and Media team worked with Geiger's producer to fact check and edit the draft script, provide images and visualizations, and make corrections to the production video.
- Viewer comments are enthusiastic, for example:
  - "Had no idea Ames had been so influential. Makes it clear that the role of NASA is not limited to producing vehicles that can reach escape velocity."

IMPACT: Assisting external media sources supports NASA High-End Computing (HEC) communications goal to improve understanding and appreciation of the value and impact of agency supercomputing efforts, and communicates HEC directly leads to tangible science and engineering advances and critical mission support.



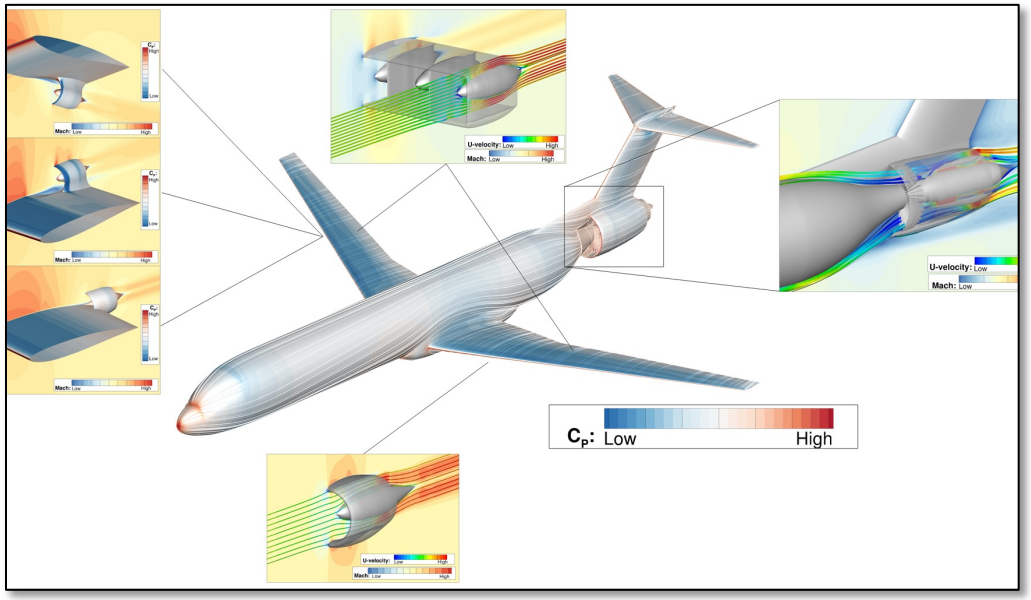
Screenshot of the opening segment of the History Guy episode on NASA's Supercomputer. *The History Guy Channel*

NASA's SUSAN Electrofan Aircraft: Designing the Future of Green Aviation

- Using the Pleiades supercomputer, researchers from NASA Ames, Glenn, Langley, and Armstrong investigated the design and performance of the hybrid-electric SUSAN Electrofan concept aircraft, designed to reduce fuel consumption and emissions.
- They performed CFD analyses with the LAVA flow solver, developed in the NASA Advanced Supercomputing Division, to mature the design of the advanced propulsion technologies being considered for this aircraft concept.
- To accurately assess the potential benefits of distributed electric propulsion (DEP) and boundary layer ingestion (BLI) technologies, the researchers studied three wing-mounted electric propulsion system configurations: 1) Two underwing podded propulsors; 2) A pylon-mounted DEP system consisting of 16 electric ducted fans in a mail-slot nacelle; and 3) A mail-slot nacelle DEP system mounted directly onto the lower side of the wing to leverage BLI.
- The design of the SUSAN Electrofan continues, with emphasis on applying high-fidelity aerodynamic shape optimization to improve the aero-propulsive performance of each aircraft component.

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

IMPACT: These investigations contribute to further understanding the design and integration of advanced propulsion technologies into next-generation commercial aircraft, with the potential to significantly reduce aviation energy consumption and emissions—key elements in the future of aviation as the industry pushes for greener aircraft solutions.



Simulation of the NASA's SUbsonic Single Aft eNgine (SUSAN) concept aircraft. *Leonardo Machado, Jared Duensing, NASA/Ames*

Papers

- "**Numerical Simulation of the High-Speed Leg of the National Transonic Facility**," A. Elmiligui, S. M. Rivers, E. Walker, Journal of Aircraft, published online April 2, 2023. *
  https://arc.aiaa.org/doi/full/10.2514/1.C036961
- "**3D Simulation of Lower-Hybrid Drift Waves in Strong Guide Field Asymmetric Reconnection in Laboratory Experiments**," J. Ng, J. Yoo, L.-J. Chen, N. Bessho, H. Ji, Physics of Plasmas, vol. 30, issue 4, April 3, 2023. *
  https://pubs.aip.org/aip/pop/article/30/4/042101/2882935/3D-simulation-of-lower-hybrid-drift-waves-in
- "**Cool and Gusty, with a Chance of Rain: Dynamics of Multiphase CGM around Massive Galaxies in the Romulus Simulations**," V. Saeedzadeh, et al., arXiv:2304.03798 [astro-ph.GA], April 7, 2023. *
  https://arxiv.org/abs/2304.03798
- "**TOI-733 b: A Planet in the Small-Planet Radius Valley Orbiting a Sun-like Star**," I. Georgieva, et al., arXiv:2304.06655 [astro-ph.EP], April 13, 2023. *
  https://arxiv.org/abs/2304.06655
- "**Optimizing the Resolution of Hydrodynamics Simulations for MCRaT Radiative Transfer Calculations**," J. Arita-Escalante, et al., arXiv:2304.07287 [astro-ph.HE], April 14, 2023. *
  https://arxiv.org/abs/2304.07287
- "**Spectral Calculations of 3D RMHD Simulations of Super-Eddington Accretion onto a Stellar-Mass Black Hole**," B. Mills, et al., arXiv:2304.07977 [astro-ph.HE], April 17, 2023. *
  https://arxiv.org/abs/2304.07977

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

Papers (cont.)

- "**Two Warm Super-Earths Transiting the Nearby M Dwarf TOI-2095**," E. Quintana, et al., arXiv:2304.09189 [astro-ph.EP], April 18, 2023. *
  https://arxiv.org/abs/2304.09189
- "**Blade-Wake Interaction Nosie for Small Hovering Rotors, Part I: Characterization Study**," C. Thurman, J. Baeder, AIAA Journal of Aeronautics and Astronautics, published online April 18, 2023. *
  https://arc.aiaa.org/doi/full/10.2514/1.J062565
- "**Nature of Intense Magnetism and Differential Rotation in Convective Dynamos of M-Dwarf Stars with Tachoclines**," C. Bice, J. Toomre, The Astrophysical Journal, vol. 947, no. 1, published online April 18, 2023. *
  https://iopscience.iop.org/article/10.3847/1538-4357/acac78/meta
- "**Dataset of Monthly Downscaled Future Vapor Pressure Projections for the Conterminous USA for RCP 4.5 and RCP 8.5 Compatible with NEX-DCP30**," R. Drapek, B. Thrasher, J. Kim, Data in Brief, vol. 28, published online April 20, 2023. *
  https://www.sciencedirect.com/science/article/pii/S2352340923002883
- "**Anisotropic Satellite Galaxy Quenching: A Unique Signature of Energetic Feedback by Supermassive Black Holes?**" J. Karp, J. Lange, R. Wechsler, arXiv:2304.10403 [astro-ph.GA], April 20, 2023. *
  https://arxiv.org/abs/2304.10403
- "**Spatial Intermittency of Particle Distribution in Relativistic Plasma Turbulence**," C. Vega, S. Boldyrev, V. Roytershteyn, arXiv:2304.11000 [physics.plasm-ph], April 21, 2023. *
  https://arxiv.org/abs/2304.11000

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Papers (cont.)

- "**Forces, Electric Fields and Currents at the Subsolar Martian MPB: MAVEN Observations and Multifluid MHD Simulation**," G. Boscoboinik, et al., Icarus, vol. 401, published online April 25, 2023. *
  https://www.sciencedirect.com/science/article/abs/pii/S0019103523001756
- "**Efficient Spectral Implementation of ODE Wall Model and the Extension of Integral Wall Model to Unstructured LES Solvers**," I. Hayat, G. I. Park, Journal of Computational Physics, vol. 487, published online April 25, 2023. *
  https://www.sciencedirect.com/science/article/abs/pii/S002199912300270X
- "**Numerical and Boundary Condition Effects on the Prediction of Detonation Engine Behavior using Detailed Numerical Simulations**," T. Sato, C. Van Beck, V. Raman, Frontiers in Aerospace Engineering, vol. 2, April 26, 2023. *
  https://www.frontiersin.org/articles/10.3389/fpace.2023.1123249/full
- "**Validation of TOI-1221 b: A Warm Sub-Neptune Exhibiting Transit Timing Variations around a Sun-like Star**," C. Mann, et al., The Astronomical Journal, vol. 165, no. 5, April 28, 2023. *
  https://iopscience.iop.org/article/10.3847/1538-3881/acc8d4/meta
- "**Numerical Investigation of Asymmetric Mach 2.5 Turbulent Shock Wave Boundary Interaction**," J.-P. Mosele, A. Gross, J. Slater, Aerospace (Special Issue: Flow Control and Drag Reduction), published online April 29, 2023. *
  https://www.mdpi.com/2226-4310/10/5/417

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News and Events

- **3 CFD Simulations in Space Answer Big Questions**, *Engineering.com*, April 27, 2023—How NASA and its partners are using CFD for bleeding-edge research, including developing flow solvers to run on supercomputers for aerospace projects across the agency.
  https://www.engineering.com/story/3-cfd-simulations-in-space-answer-big-questions
- **A History of NASA's Supercomputers**, *The History Guy (YouTube)*, April 26, 2023--The History Guy highlights the history of supercomputers at NASA Ames Research Center and the development of the Numerical Aerodynamic Simulation Division, which later became the NASA Advanced Supercomputing Division, which houses HECC resources.
  https://www.youtube.com/watch?v=t5ArVnTp_Kg
- **Predicting the Sonic Boom**, *Air & Cosmos International*, April 24, 2023—In anticipation of the flight test campaign of the X-59 Quesst, NASA carried out several simulations of the supersonic flight and the generated bang. As for the wind tunnel campaign, NASA did not put all its eggs in the same basket and multiplied the simulations.
  https://aircosmosinternational.com/article/predicting-the-sonic-boom-3808
- **Celebrating Our Ocean World at NASA in Silicon Valley**, *NASA Ames*, April 21, 2023—NASA Ames Office of Communications asked researchers studying our planet to share what excites them about Earth science and explain how they're working to better understand, predict, and protect Earth's life-sustaining water systems. Nina McCurdy, Data Visualization Scientist in the NAS Division highlights how HECC supercomputers and complex visualization are helping an international group of scientists run complex ocean and atmospheric circulation models.
  https://www.nasa.gov/feature/ames/celebrating-our-ocean-world-at-nasa-in-silicon-valley

News and Events (cont.)

- **Behind the Scenes at NASA: Supercomputers Empower NASA Mission Success**, *SciTech Daily*, April 17, 2023—Whether developing new technologies for landing on other planets, improving air travel here at home, or more realistically simulating global weather and climate, supercomputing is key to the success of NASA missions. *https://scitechdaily.com/behind-the-scenes-at-nasa-supercomputers-empower-nasa-mission-success/*
- **Predicting Buffet Onset on the Transonic Truss-Braced Wing,** *Tech Briefs*, April 11, 2023—NASA and Boeing are working together to develop a sustainable flight demonstrator, the TTBW concept, which has an unconventional configuration, leading to complex aerodynamic flows. Groups like the LAVA team in the NASA Advanced Supercomputing Division are using CFD and HECC supercomputers to help design the aircraft. *https://www.techbriefs.com/component/content/article/tb/pub/features/applications/47937*
- **A New Look at Climate Data Shows Substantially Wetter Rain and Snow Days Ahead**, *UC San Diego*, April 10, 2023—Scientists at Scripps Institution of Oceanography at UC San Diego and Lawrence Berkeley National Laboratory report that extremely intense days of rain or snow will be more frequent by the end of this century than previously thought. The High-End Computing Capability Project provided resources supporting this work through HECC, the NASA Earth Exchange, and the Earth Science Division.
  https://scripps.ucsd.edu/news/new-look-climate-data-shows-substantially-wetter-rain-and-snow-days-ahead
  - **Future Forecast: More Extreme Precipitation Ahead**, *Earth.com*, April 13, 2023.
    https://www.earth.com/news/future-forecast-more-extreme-precipitation-ahead/

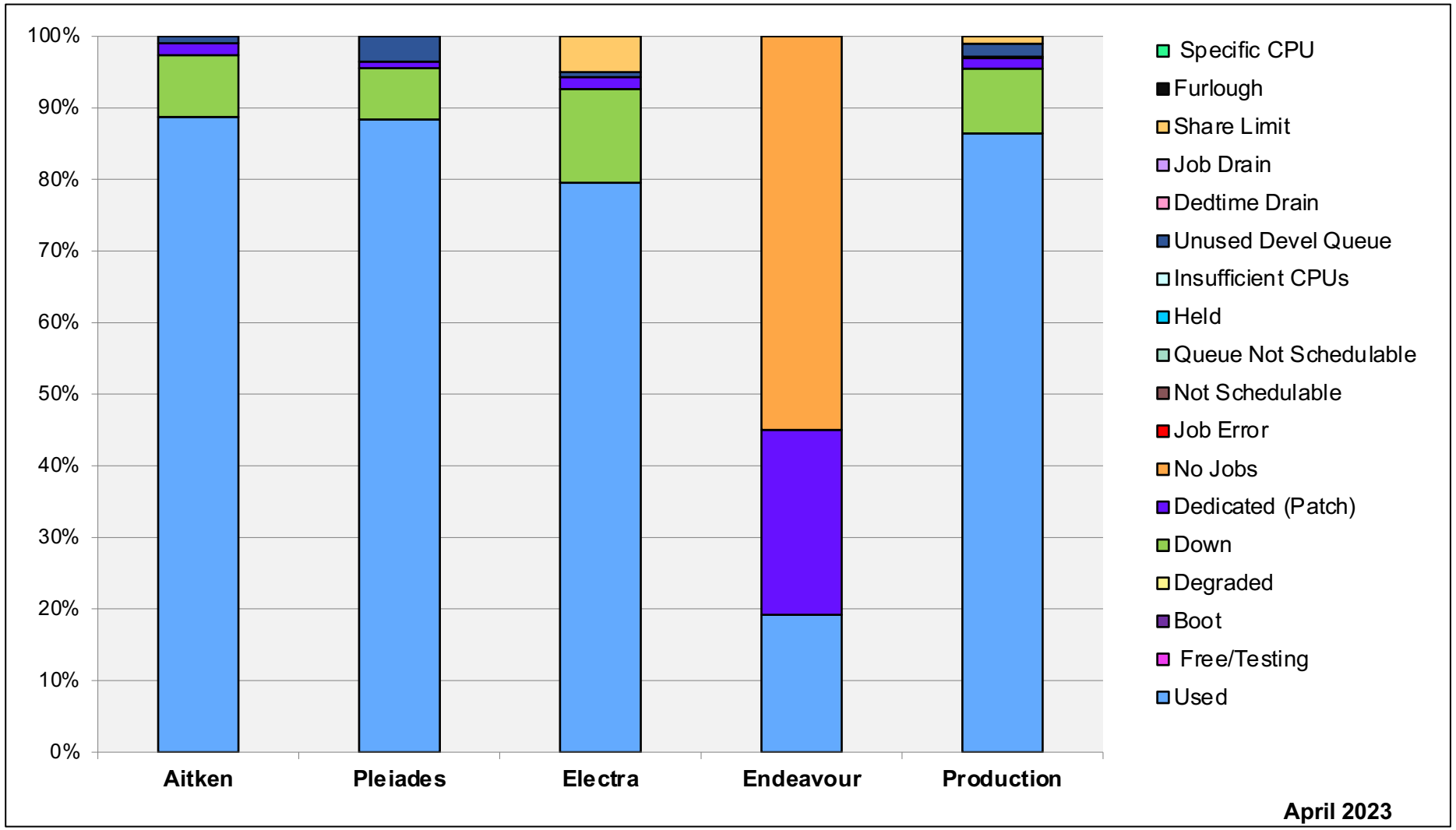
News and Events (cont.)

- **This is What Would Happen if Scientists Found an Asteroid Heading to Earth**, *Space.com,* April 6, 2023—In support of NASA's Near Earth Object (NEO) Program Office, a team of scientists in the NAS Division presented a hypothetical asteroid impact scenario at the 8th Planetary Defense Conference in Vienna, Austria.
  https://www.space.com/nasa-models-hypothetical-asteroid-impact-scenario
  - **Outer Space: 8th IAA Planetary Defense Conference**, *United Nations Office*, April 6, 2023.
    https://media.un.org/en/asset/k1a/k1ajrlvavq?kalturaStartTime=3658

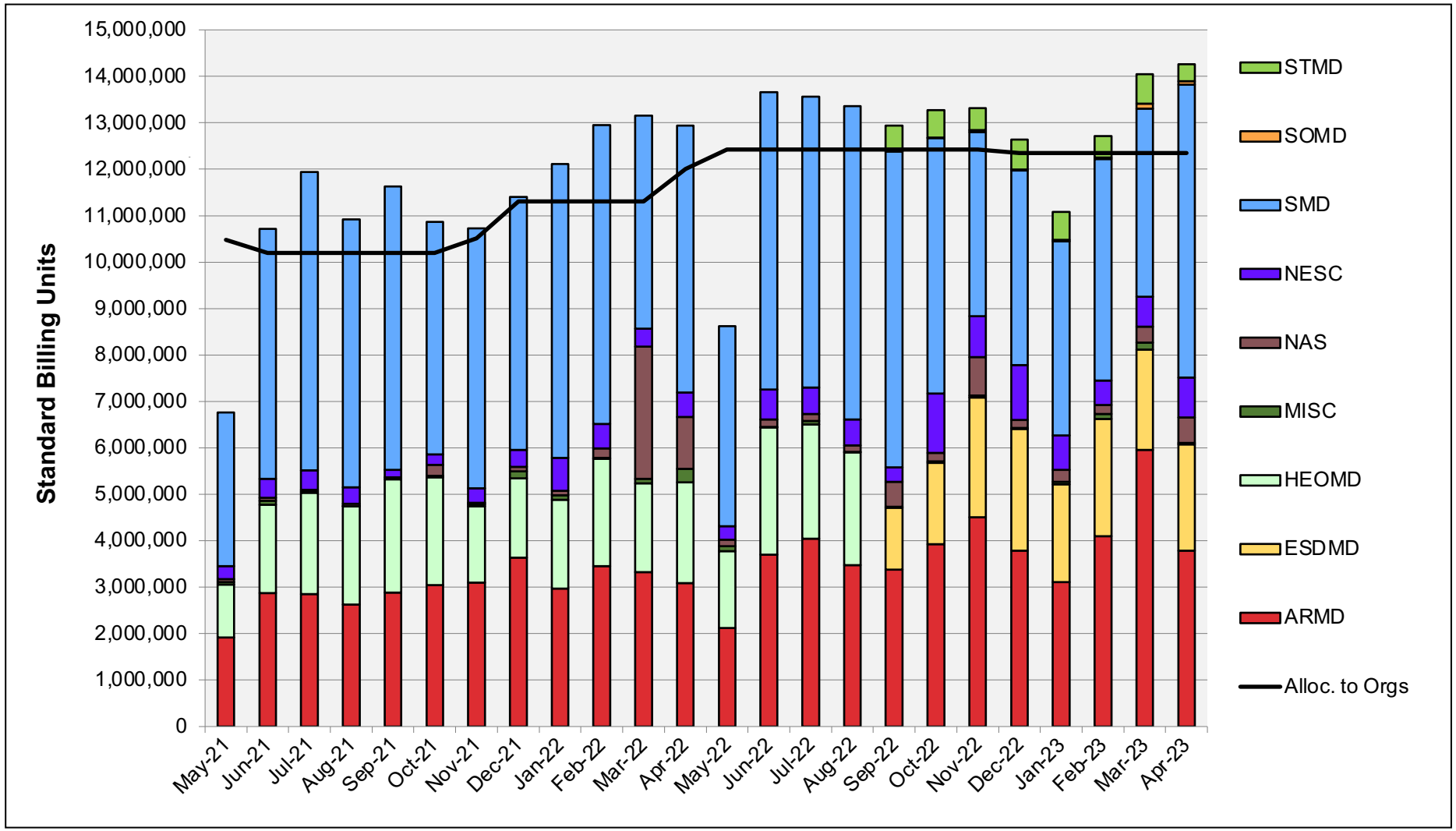
News and Events: Social Media

- **Coverage of NAS Stories**
  - Earth Day (Ames Feature):
    - NASA Ames: Instagram 17,181 likes; Facebook 34 reactions; Twitter 20 retweets, 110 likes.
    - NASA Supercomputing: Facebook 22 reactions
  - Planetary Defense Presentations:
    - NASA Supercomputing: Facebook 9 reactions
    - NAS Division: Twitter 1 retweet, 2 likes.

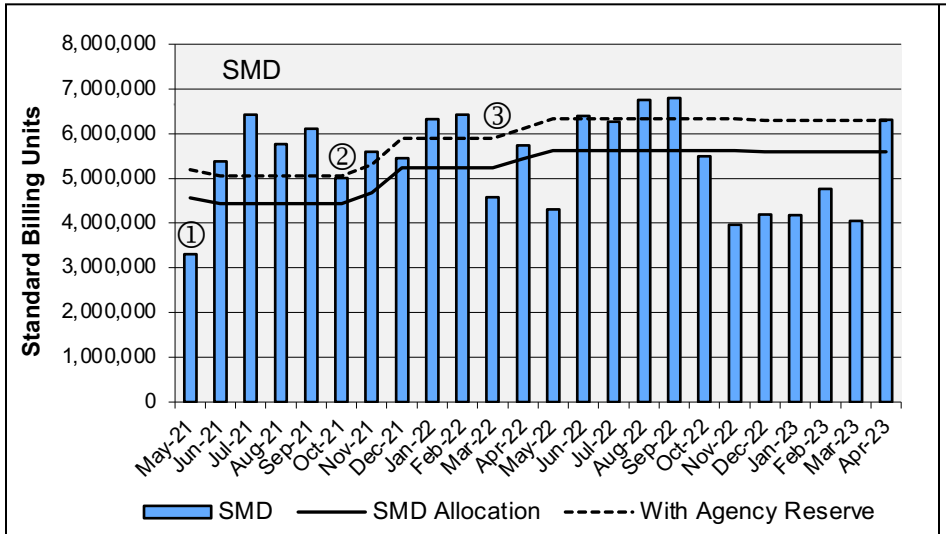
HECC Utilization

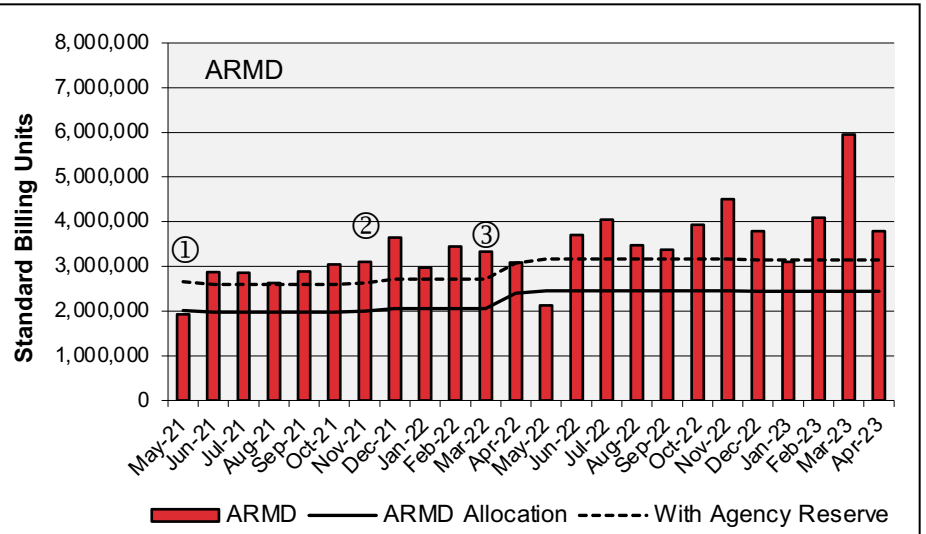


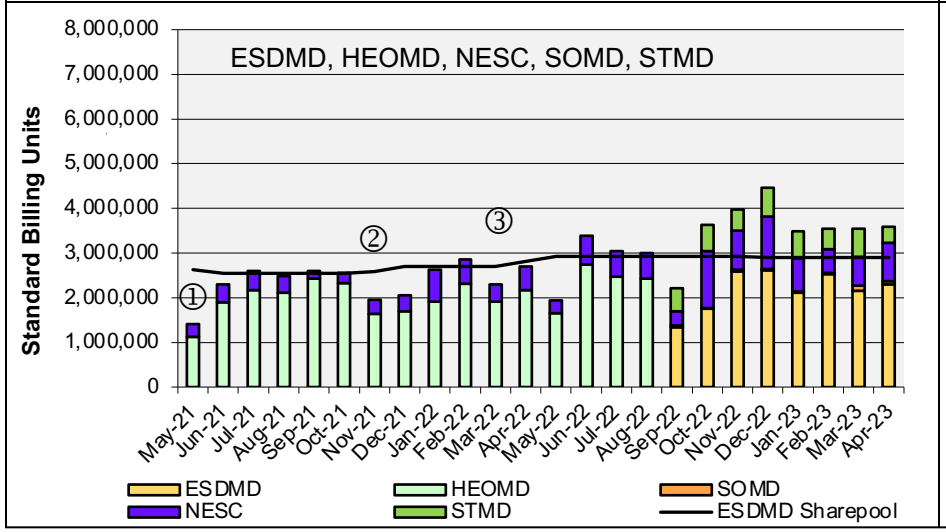
HECC Utilization Normalized to 30-Day Month



HECC Utilization Normalized to 30-Day Month





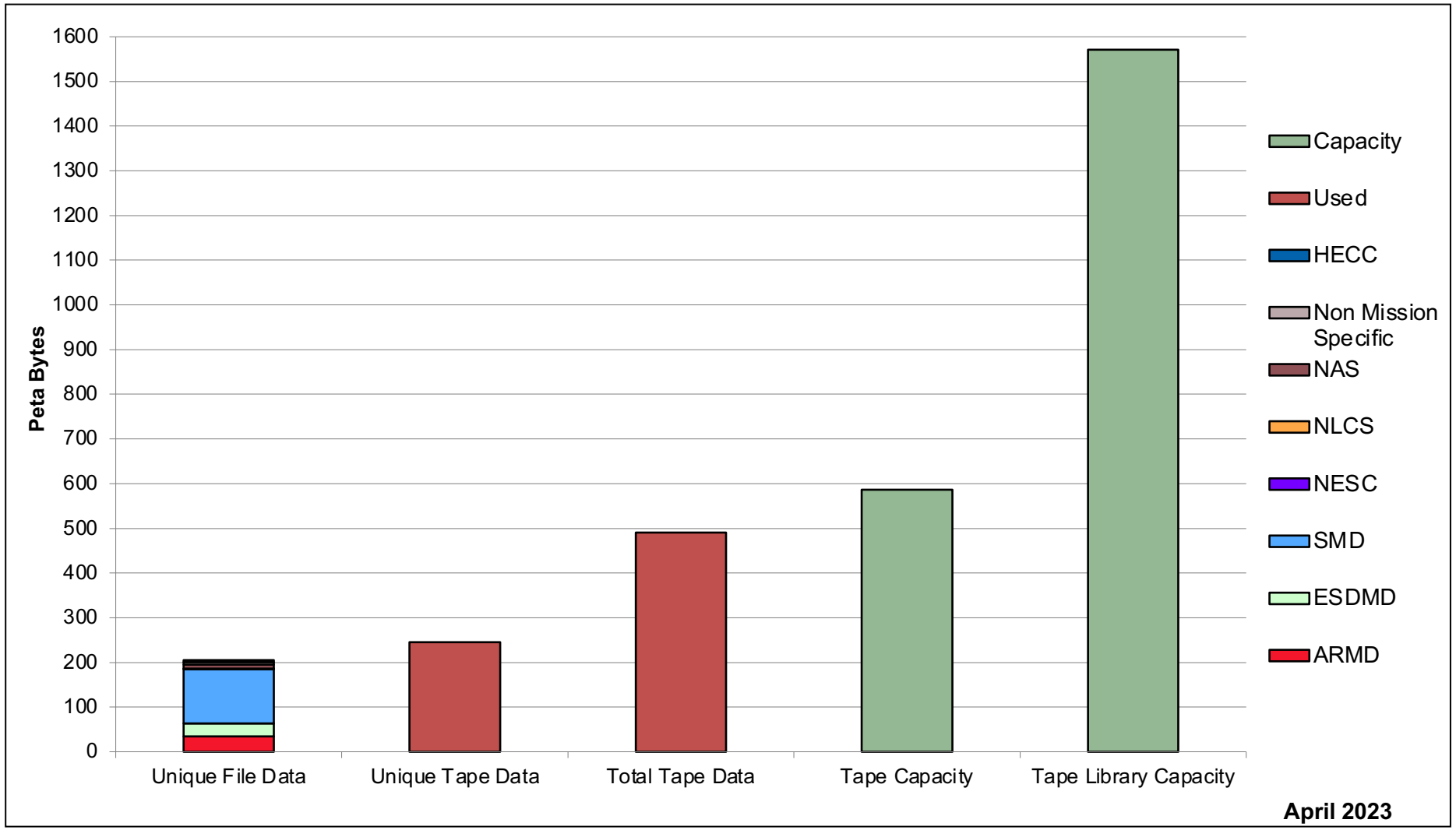


① Merope retired; Annual Maintenance

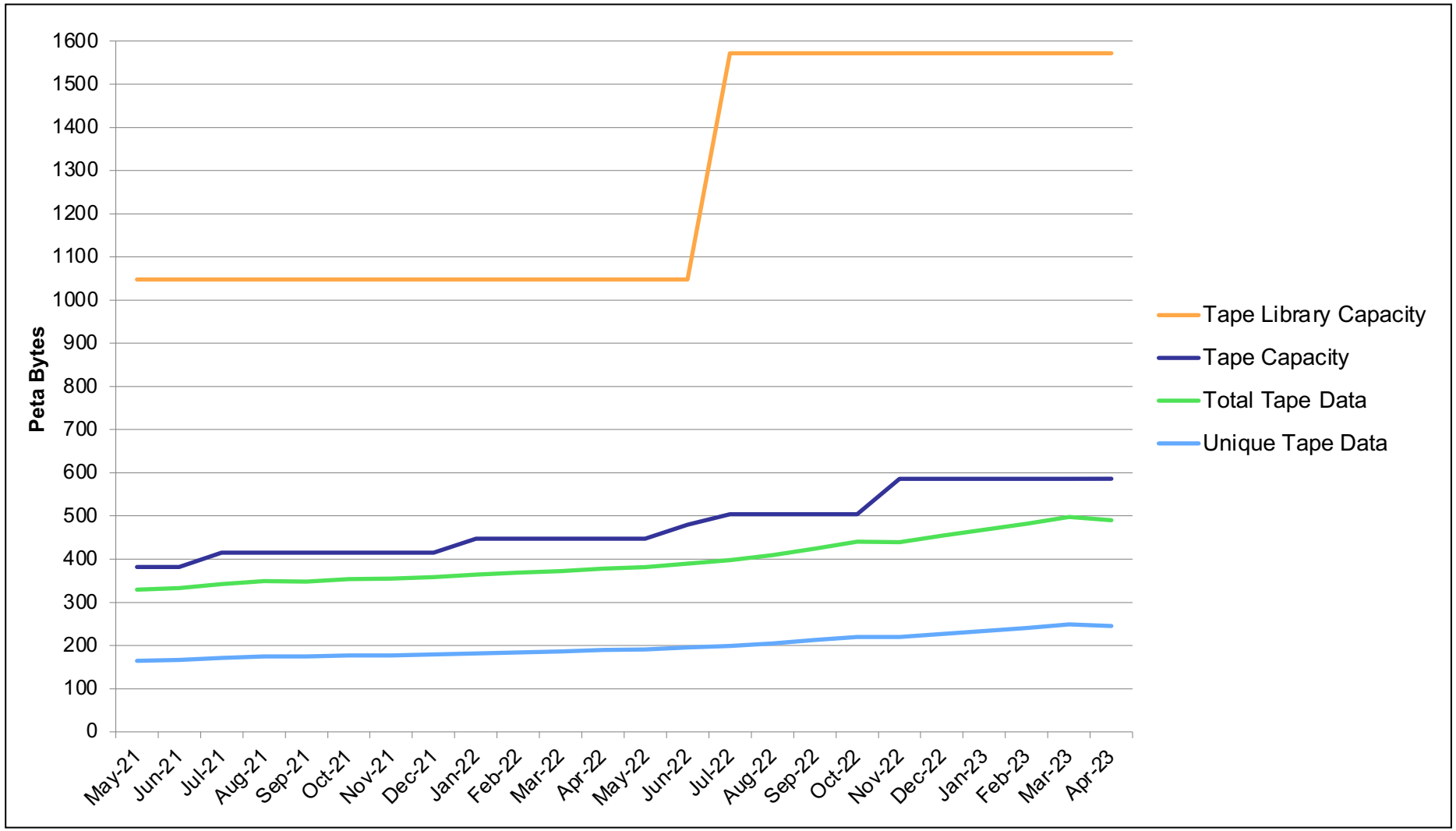
② 4 Rome Apollo Racks added to Aitken

③ 4 Rome Apollo Racks added to Aitken

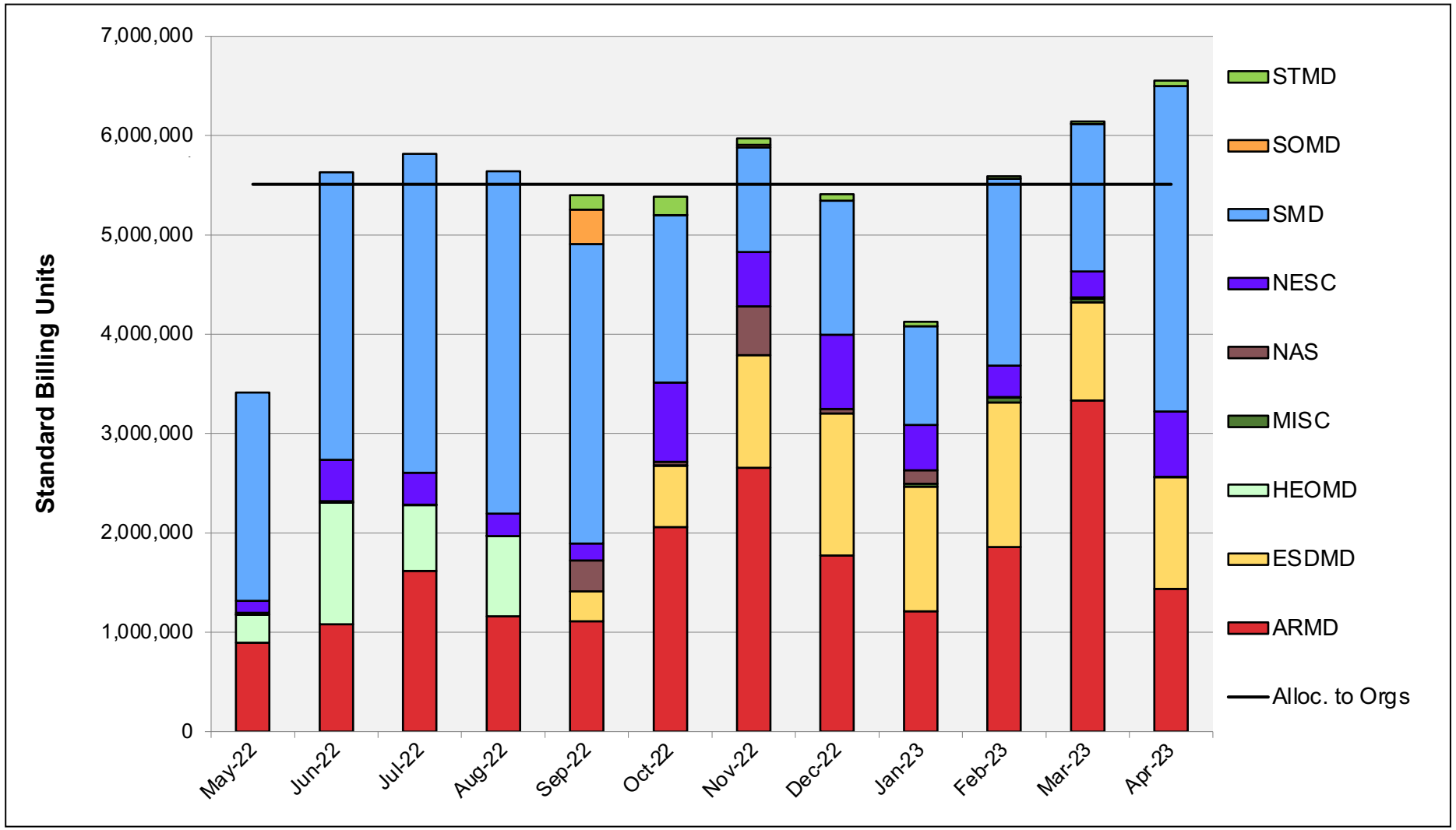
Tape Archive Status



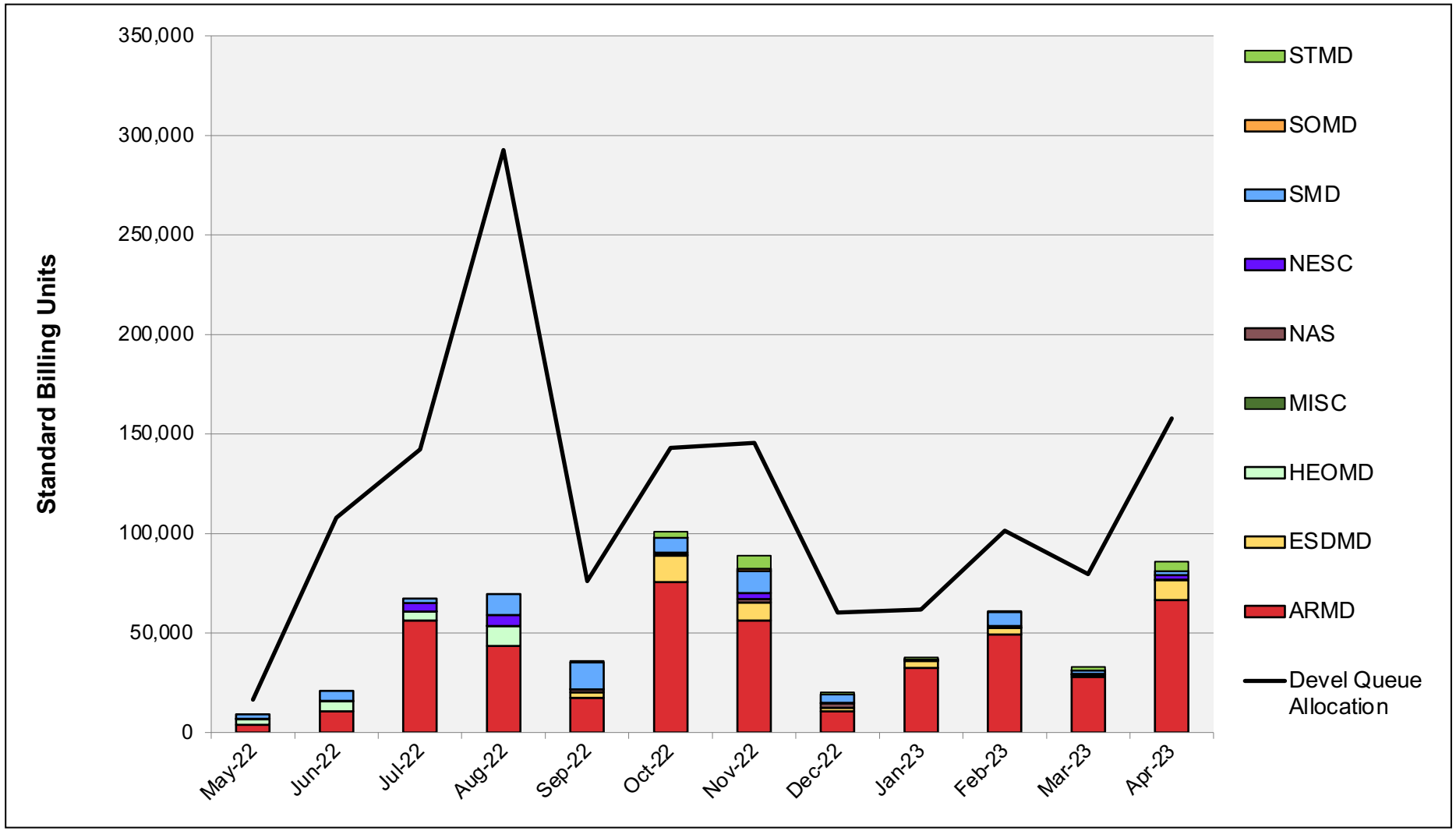
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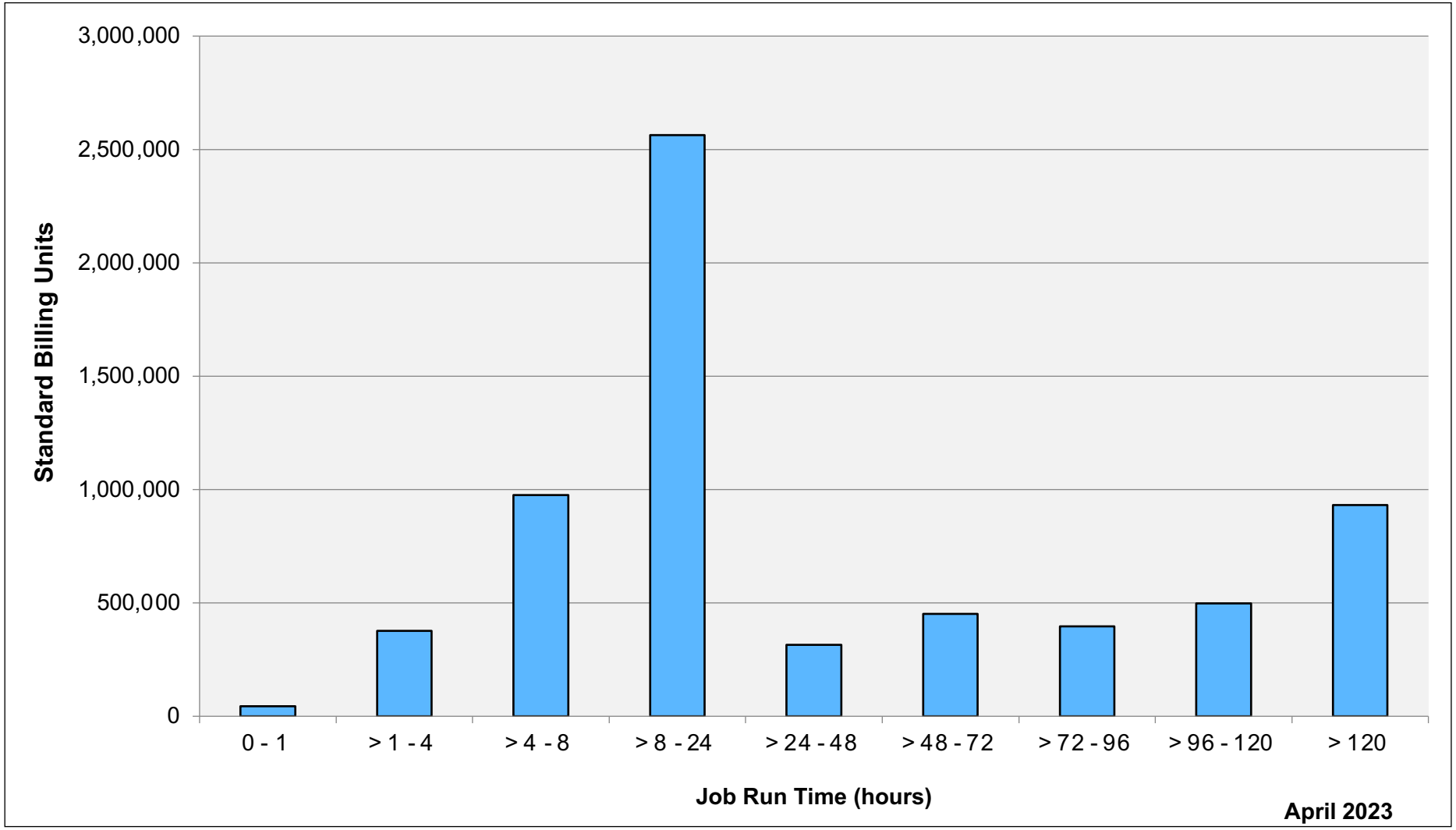
Aitken: SBUs Reported, Normalized to 30-Day Month



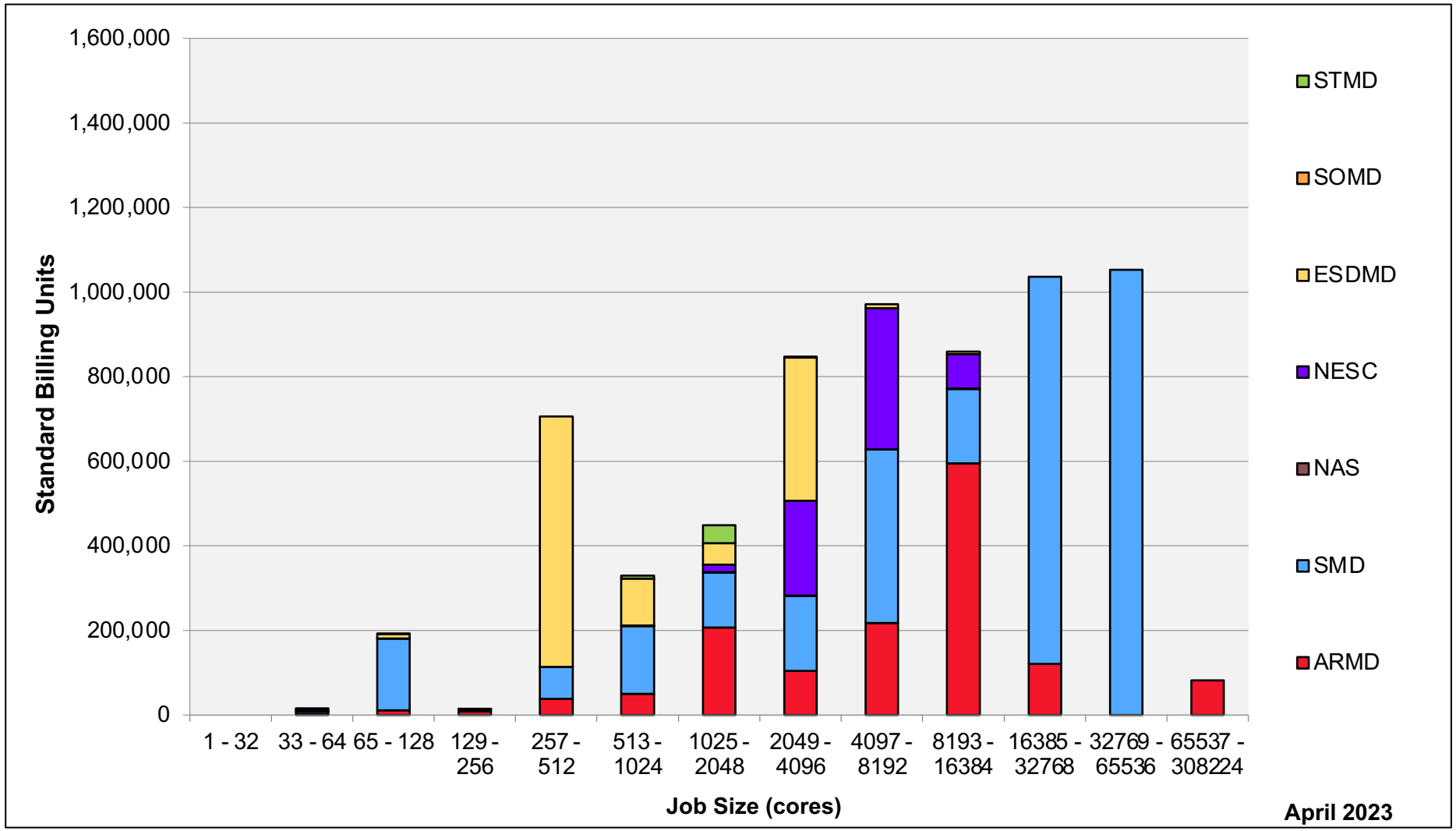
Aitken: Devel Queue Utilization



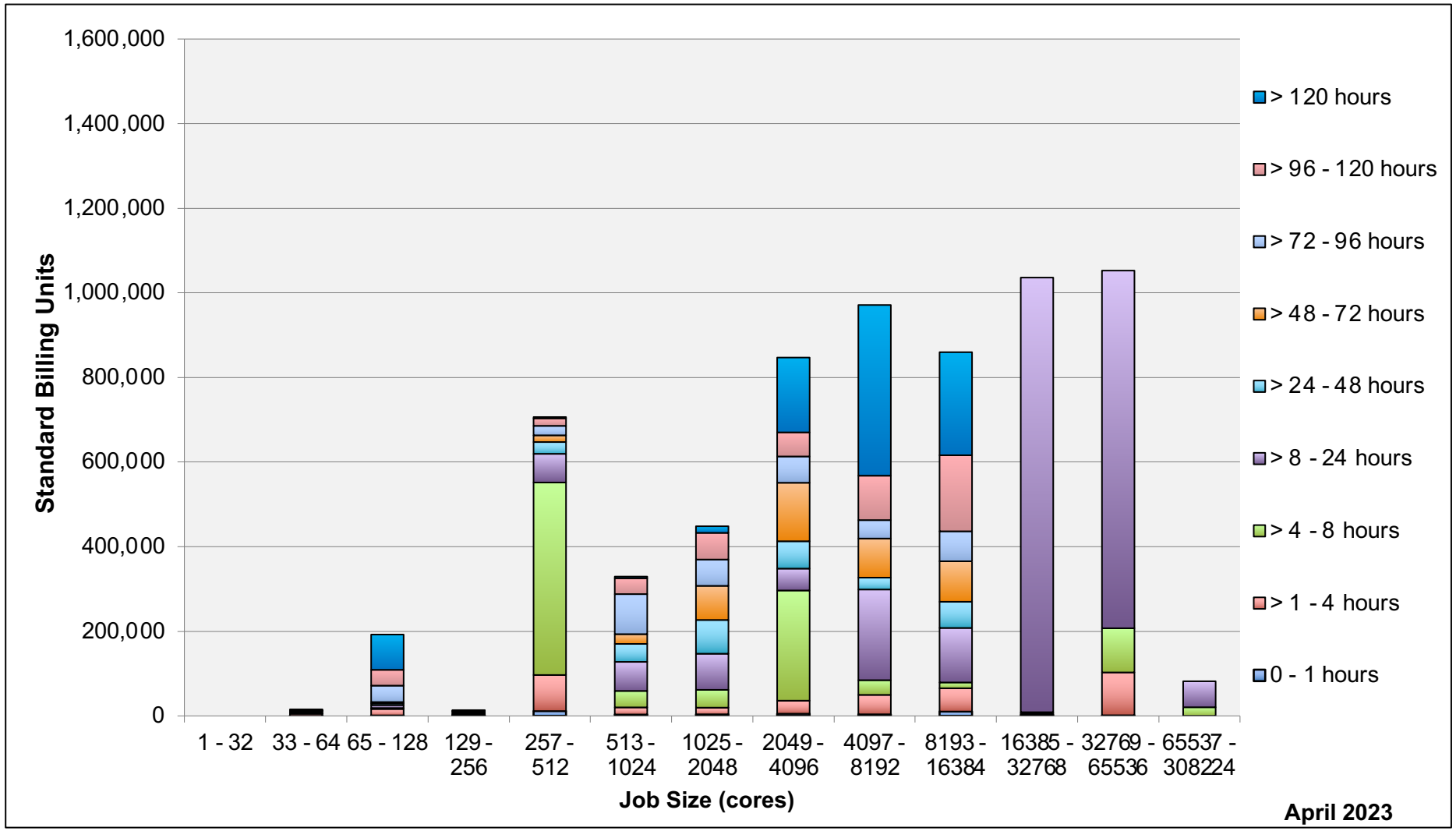
Aitken: Monthly Utilization by Job Length



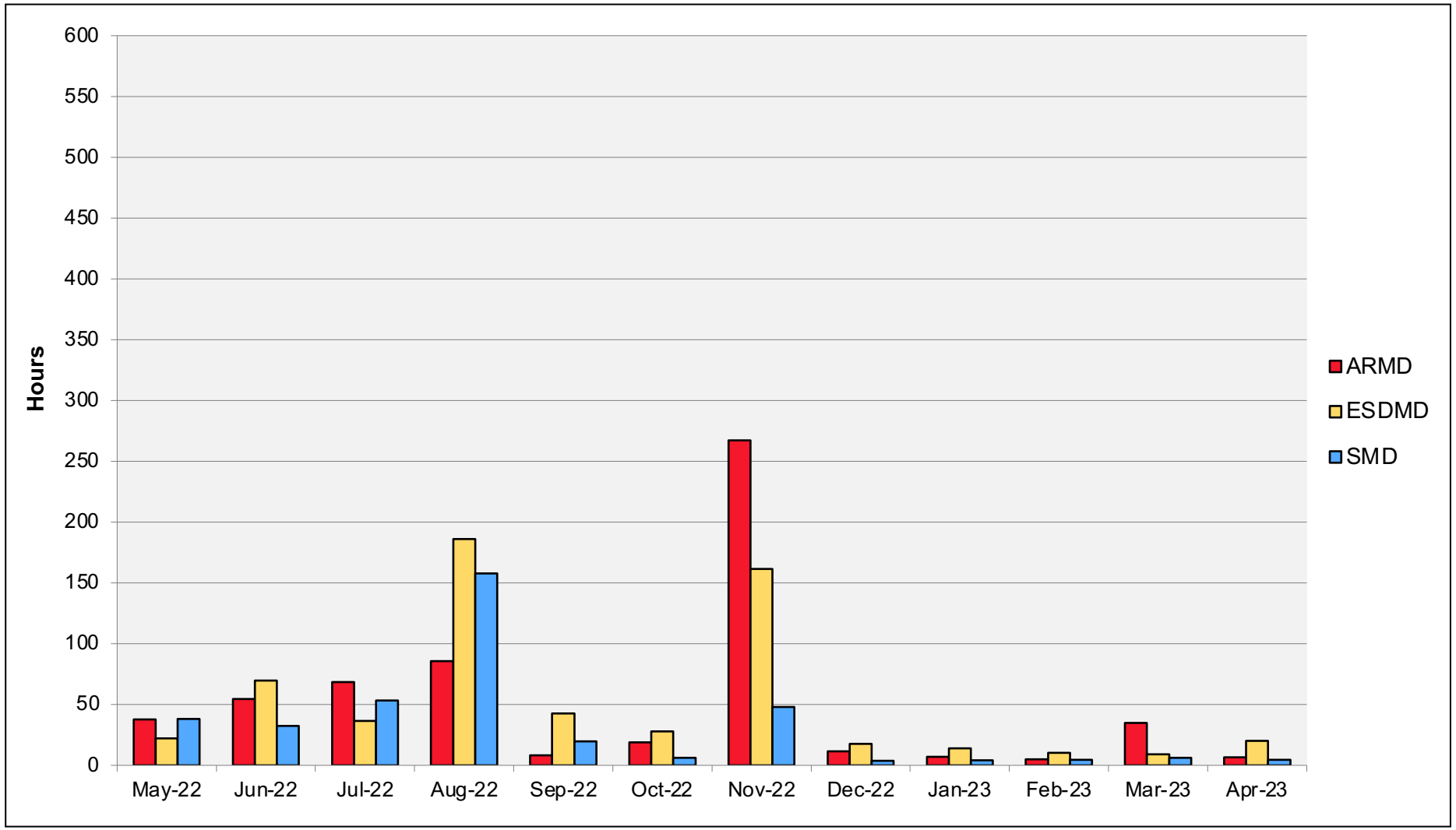
Aitken: Monthly Utilization by Job Size



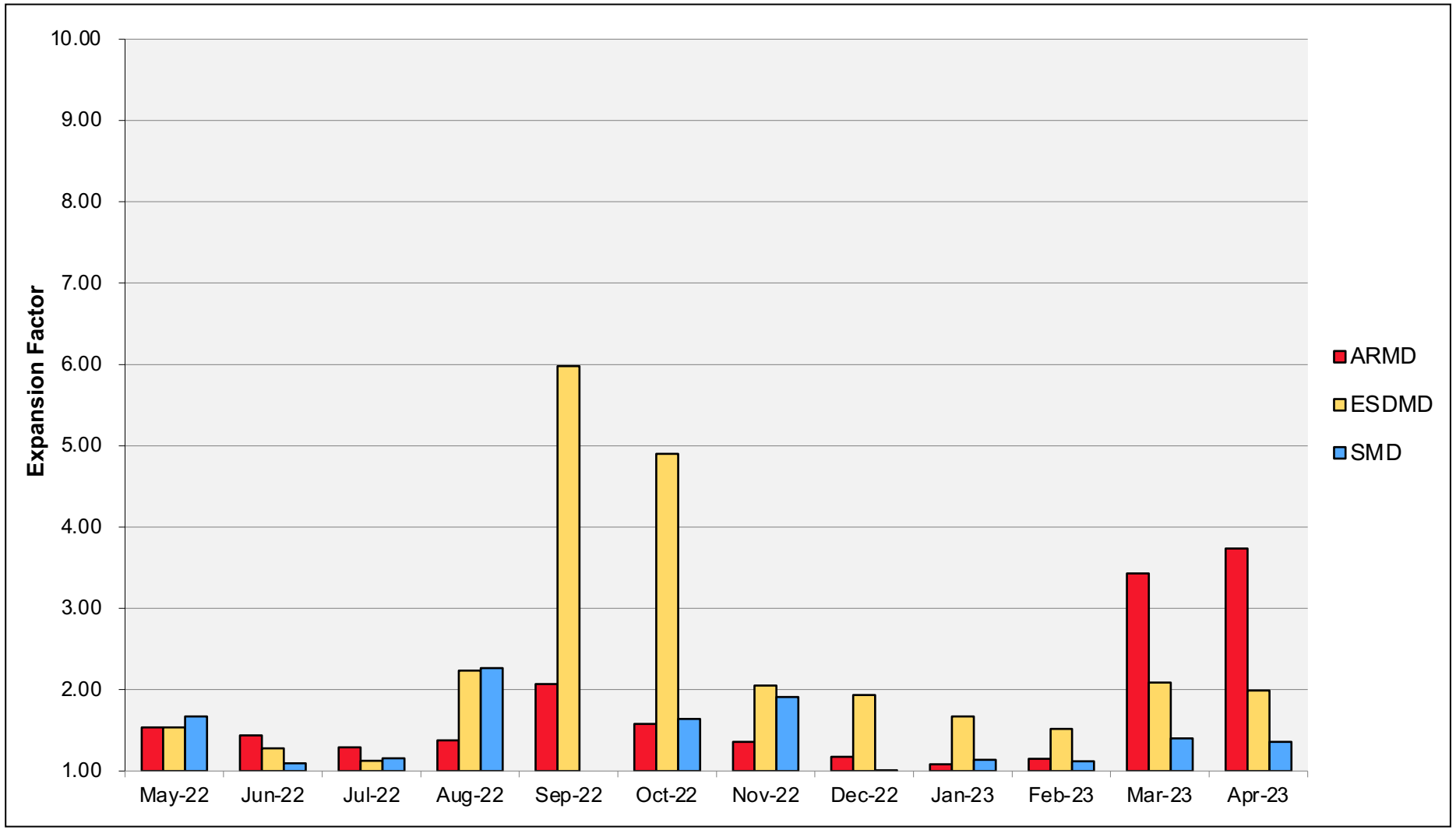
Aitken: Monthly Utilization by Size and Length



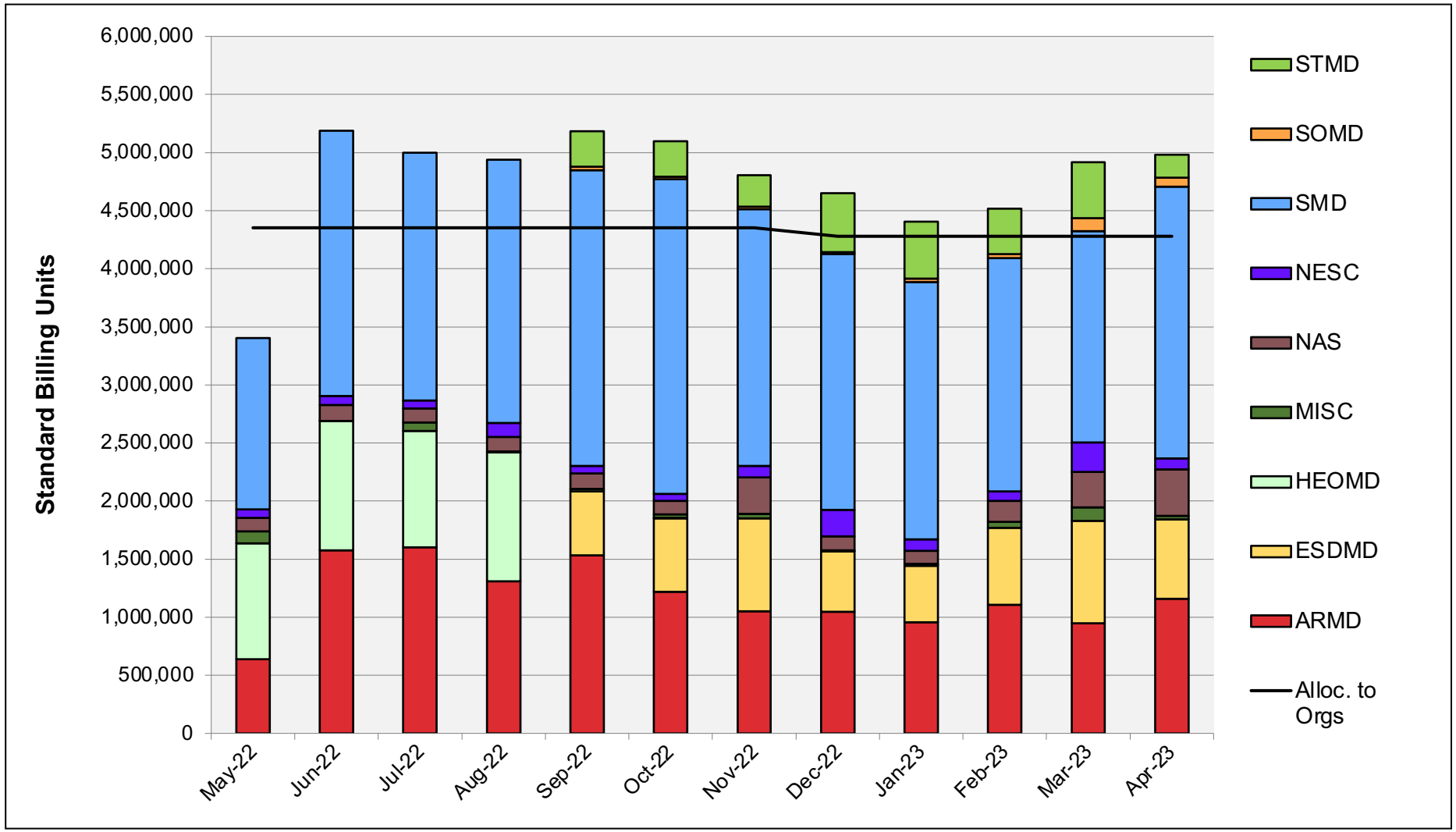
Aitken: Average Time to Clear All Jobs



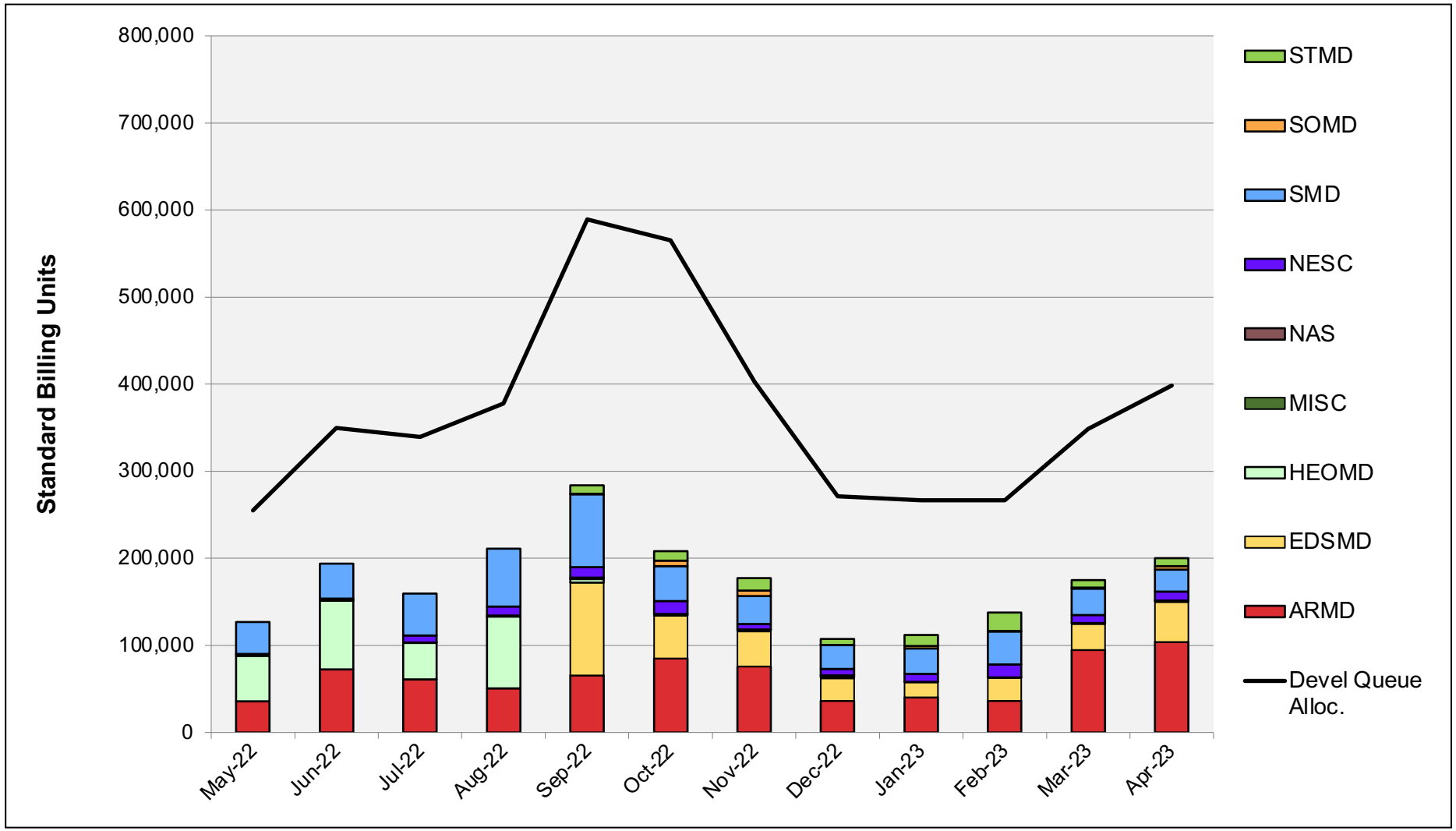
Aitken: Average Expansion Factor



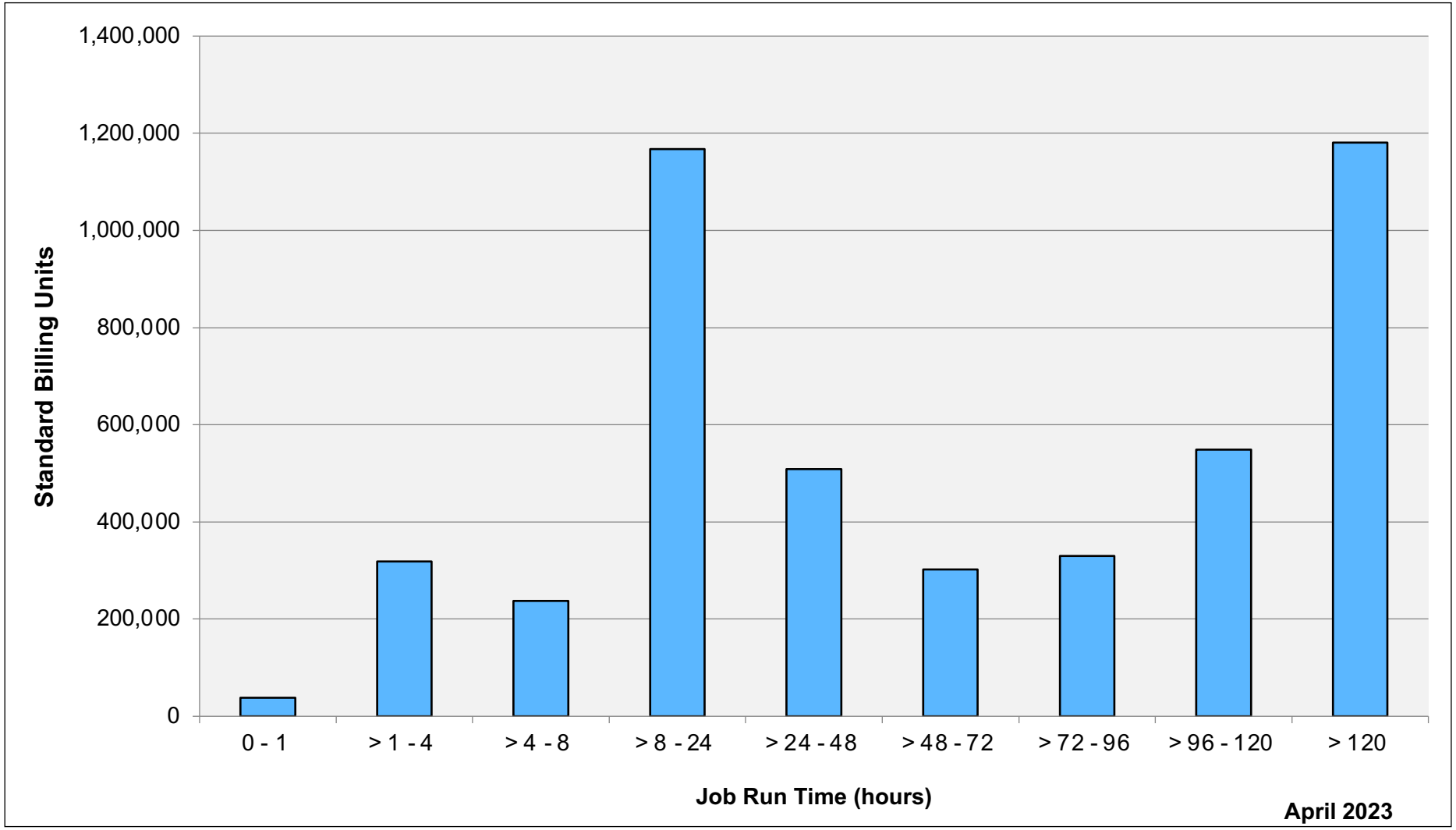
Pleiades: SBUs Reported, Normalized to 30-Day Month



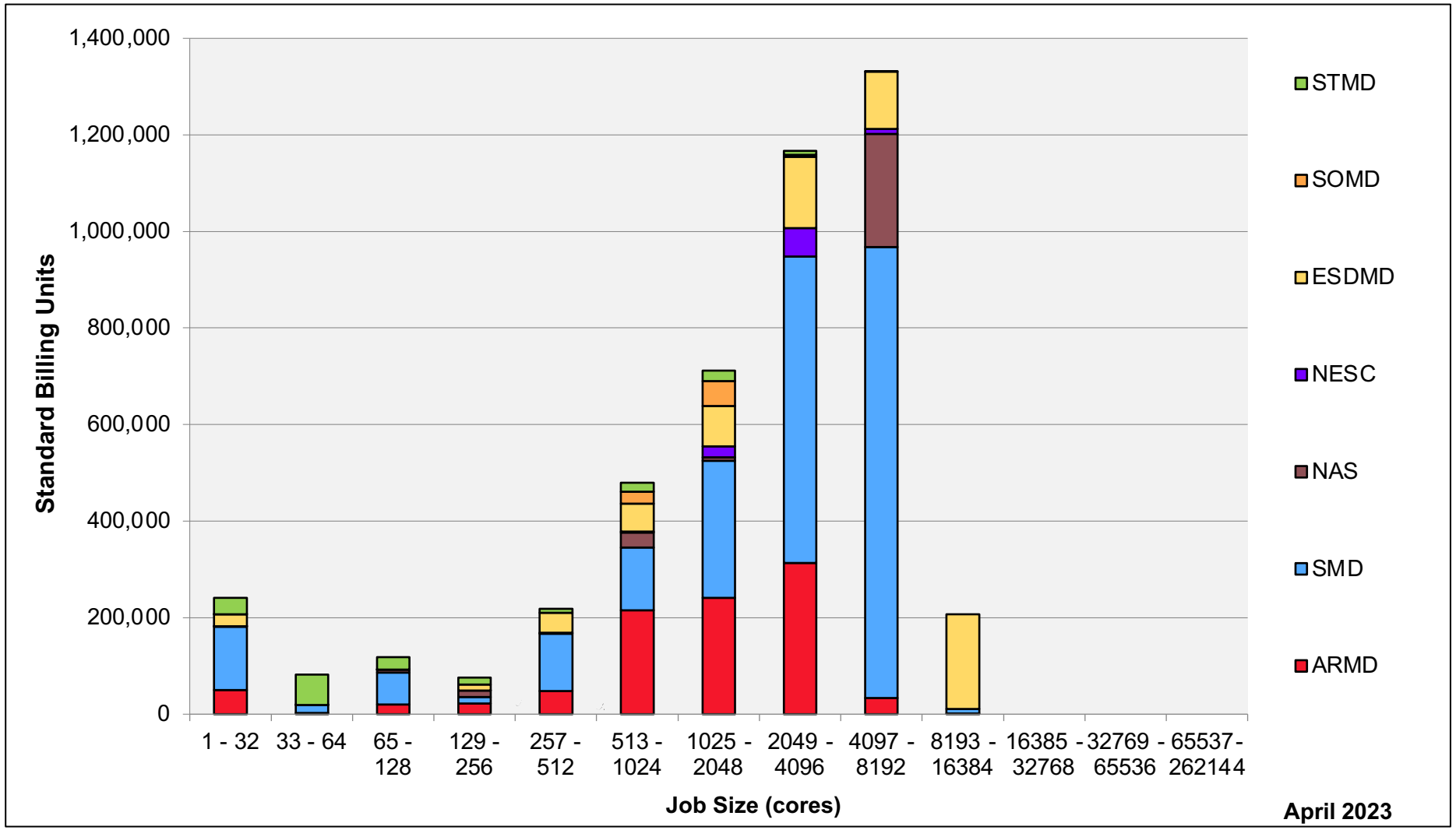
Pleiades: Devel Queue Utilization



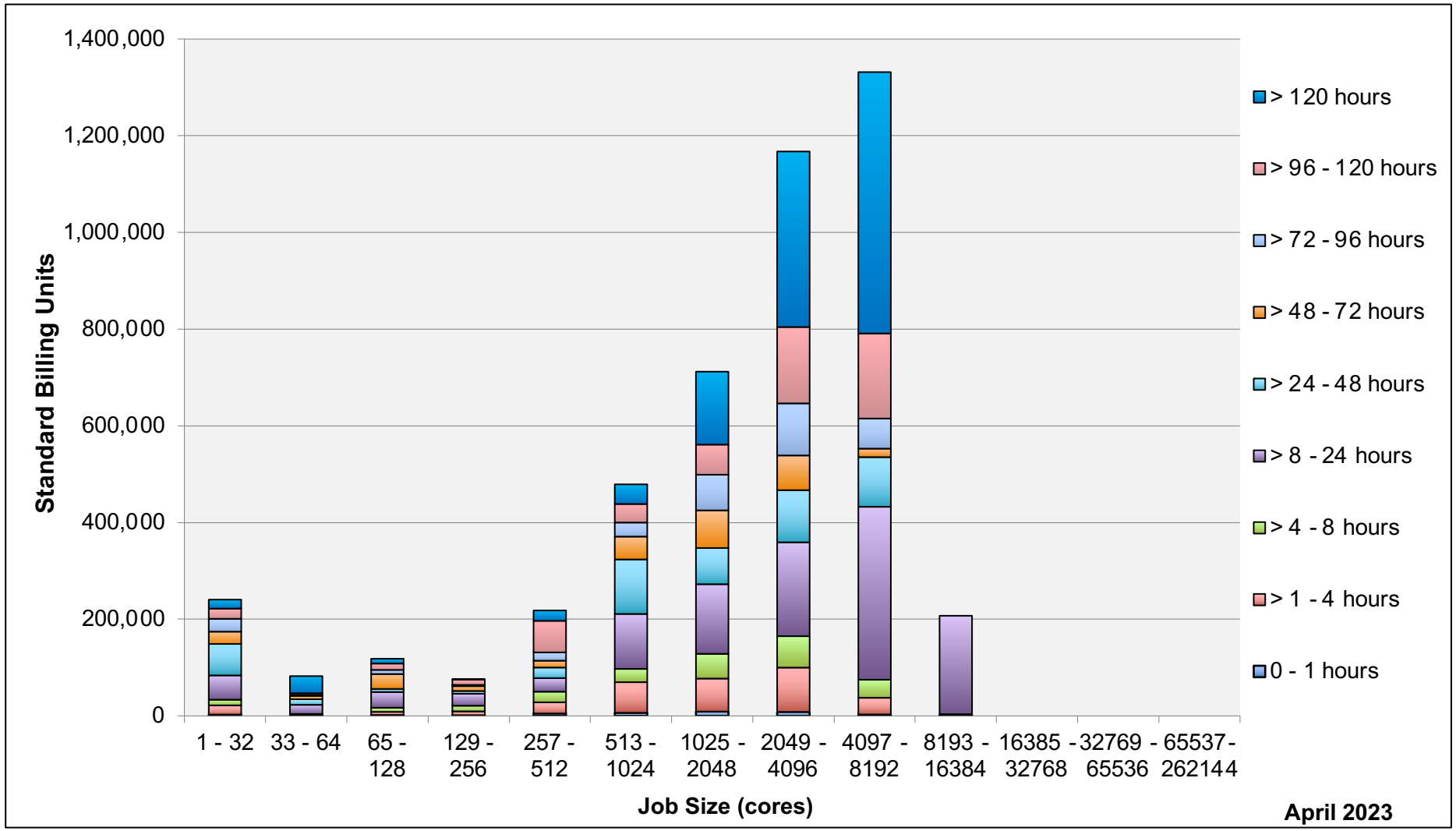
Pleiades: Monthly Utilization by Job Length



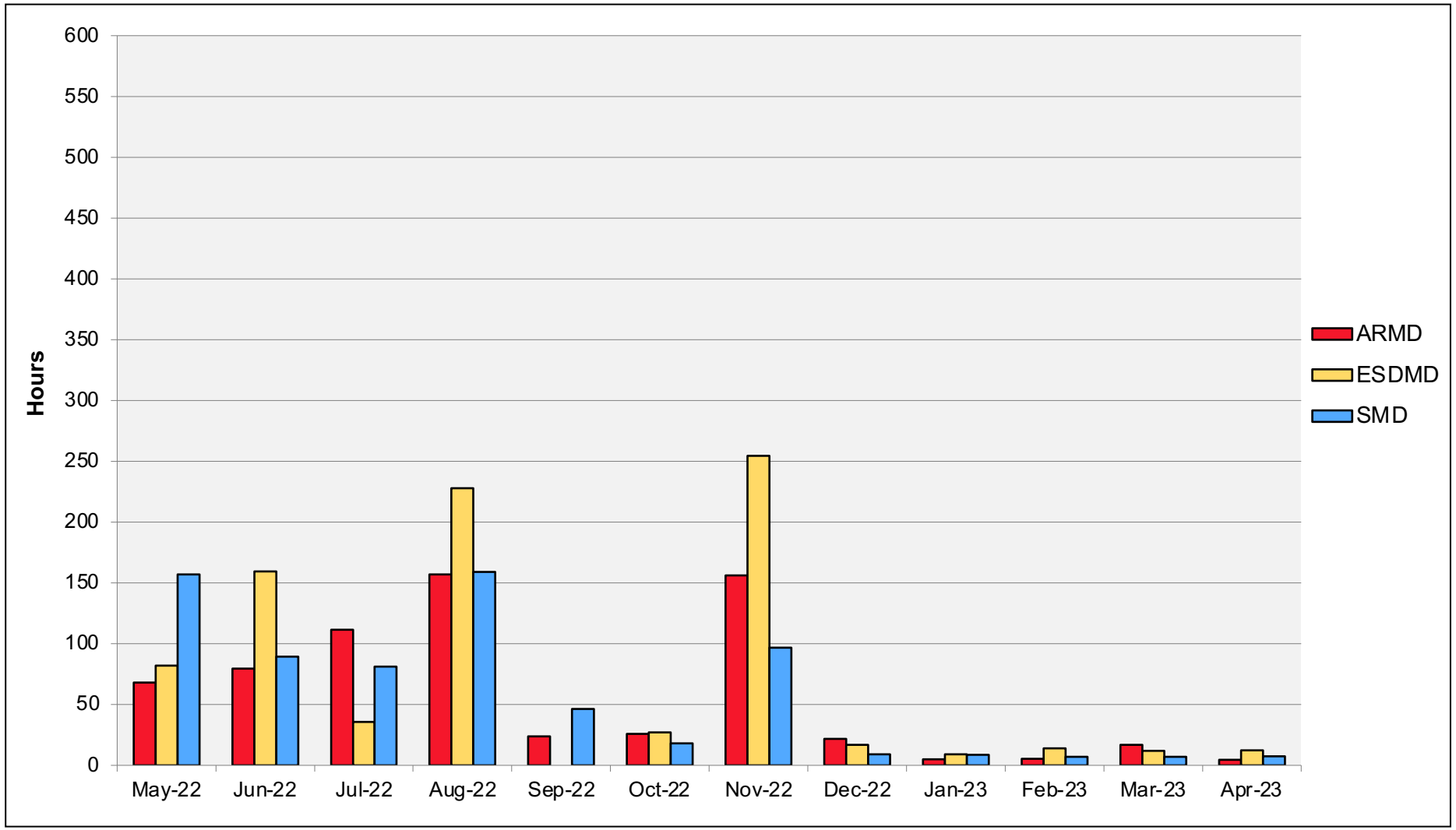
Pleiades: Monthly Utilization by Job Size



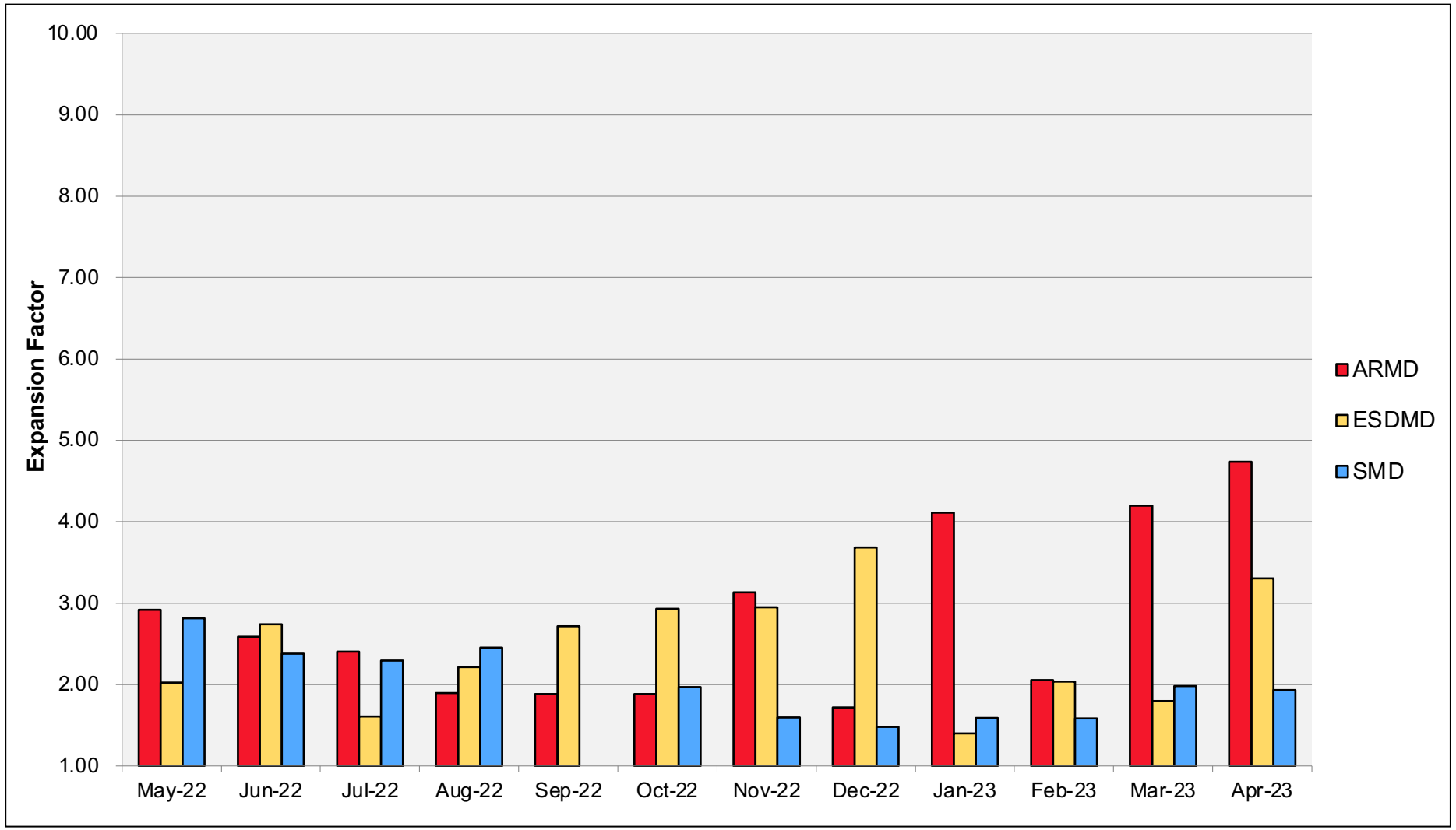
Pleiades: Monthly Utilization by Size and Length



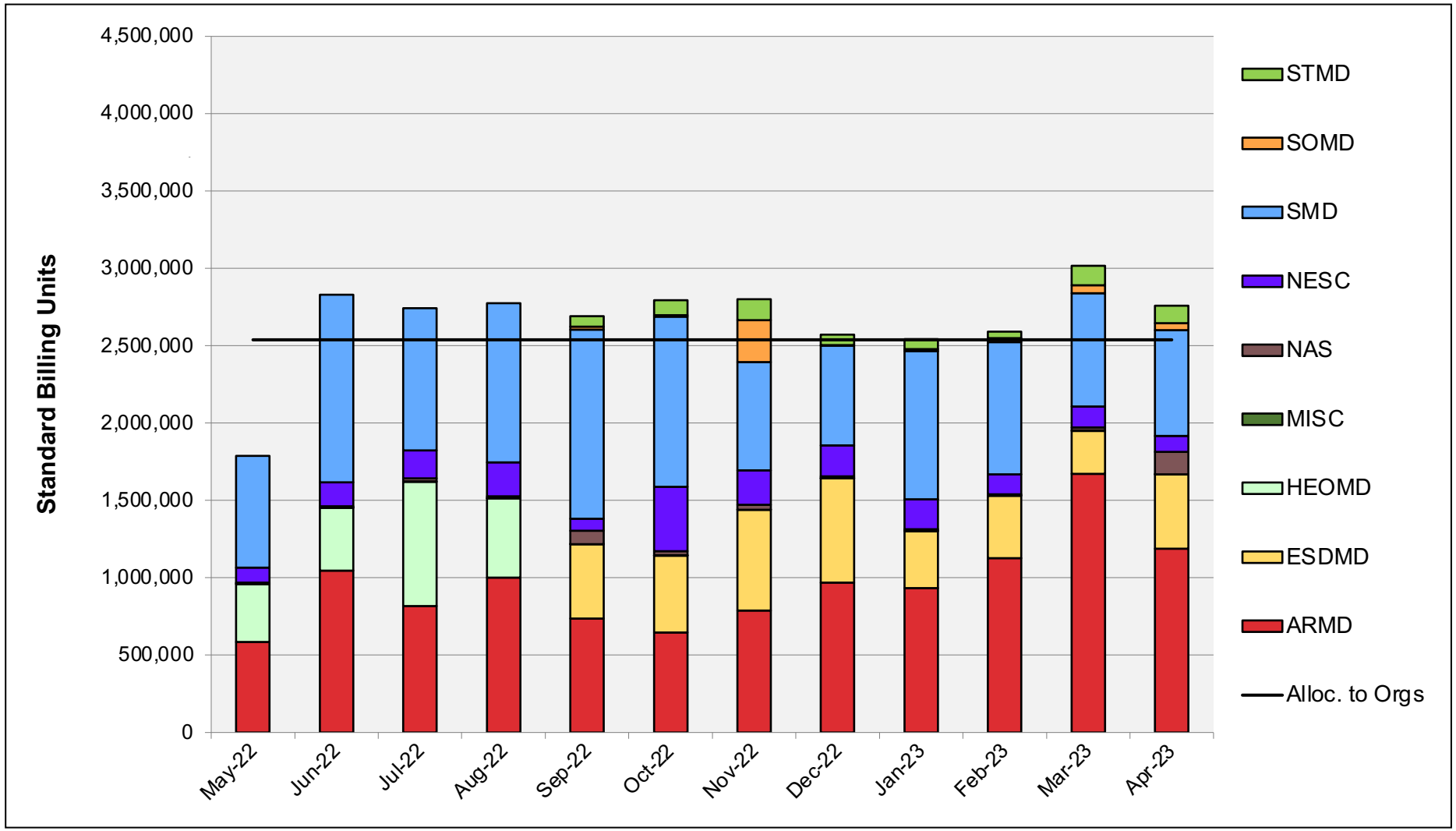
Pleiades: Average Time to Clear All Jobs



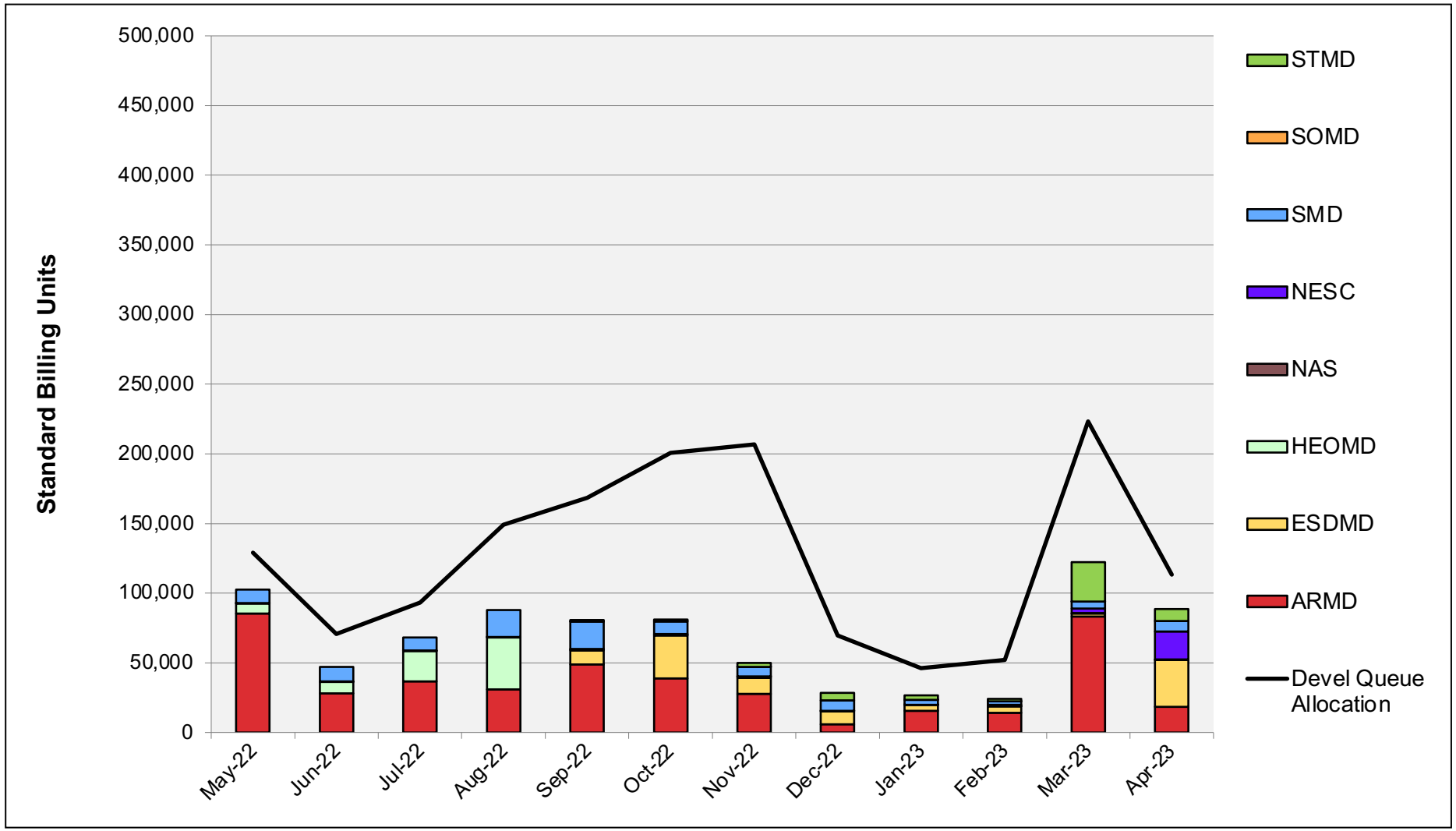
Pleiades: Average Expansion Factor



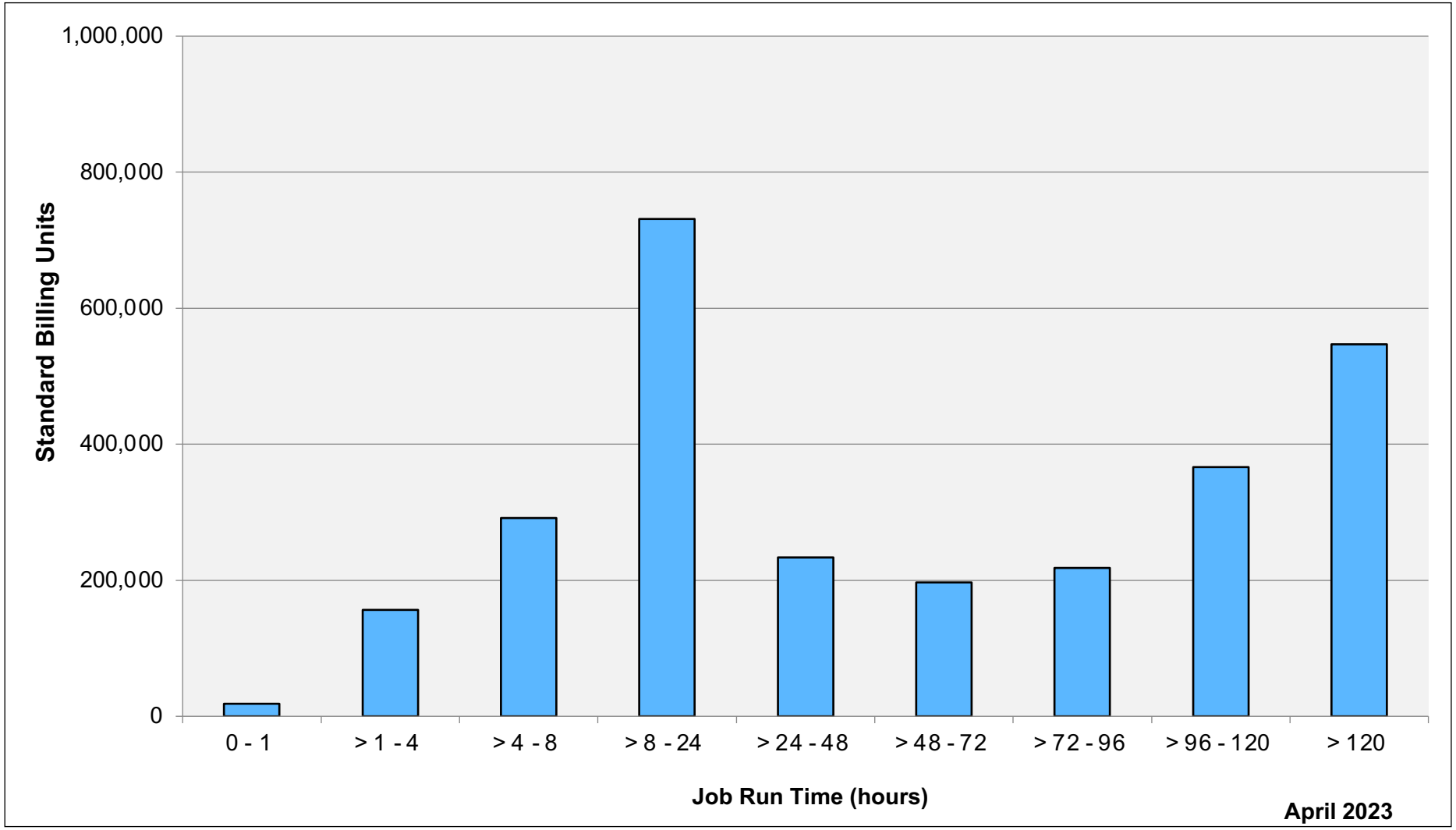
Electra: SBUs Reported, Normalized to 30-Day Month



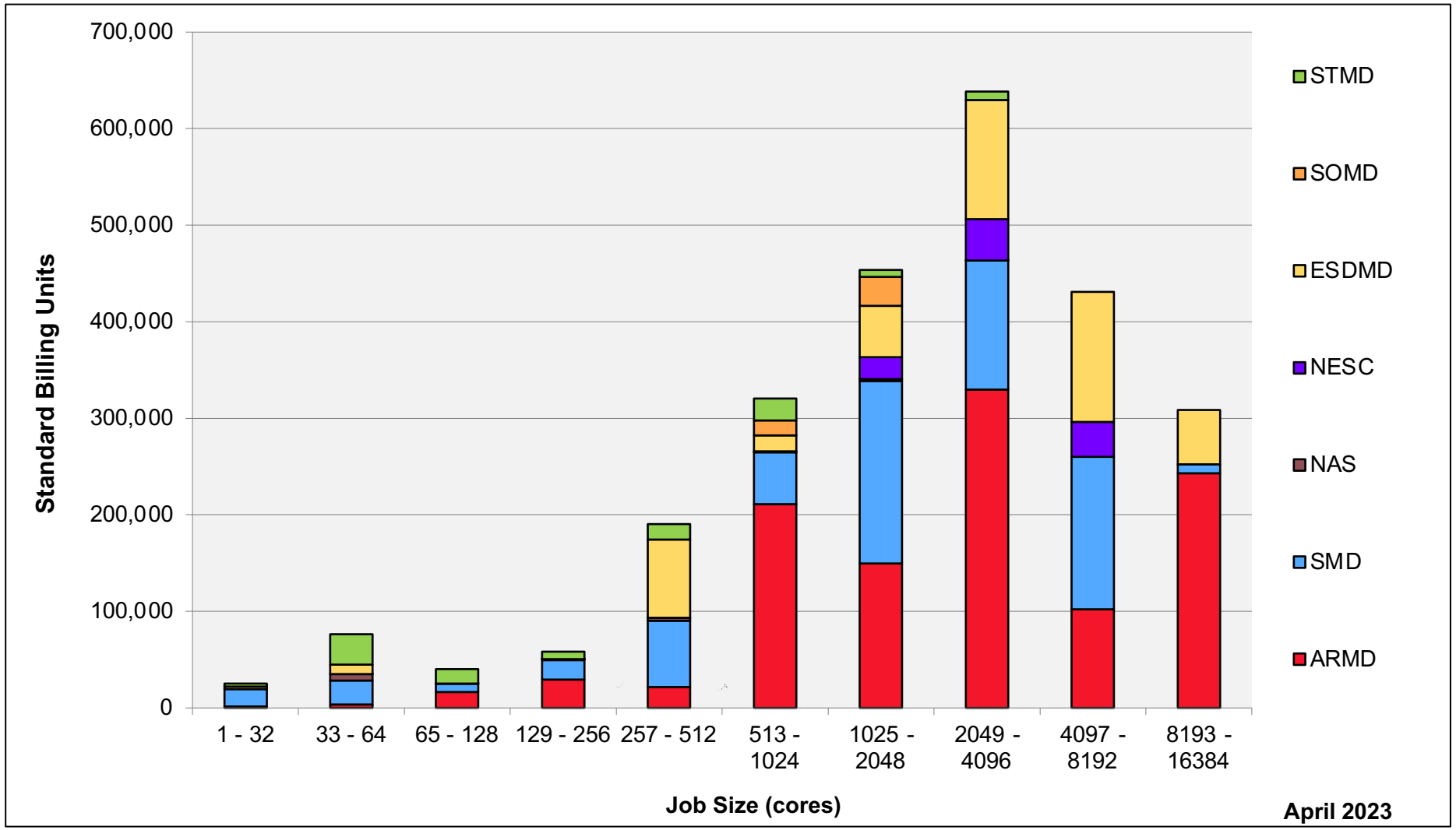
Electra: Devel Queue Utilization



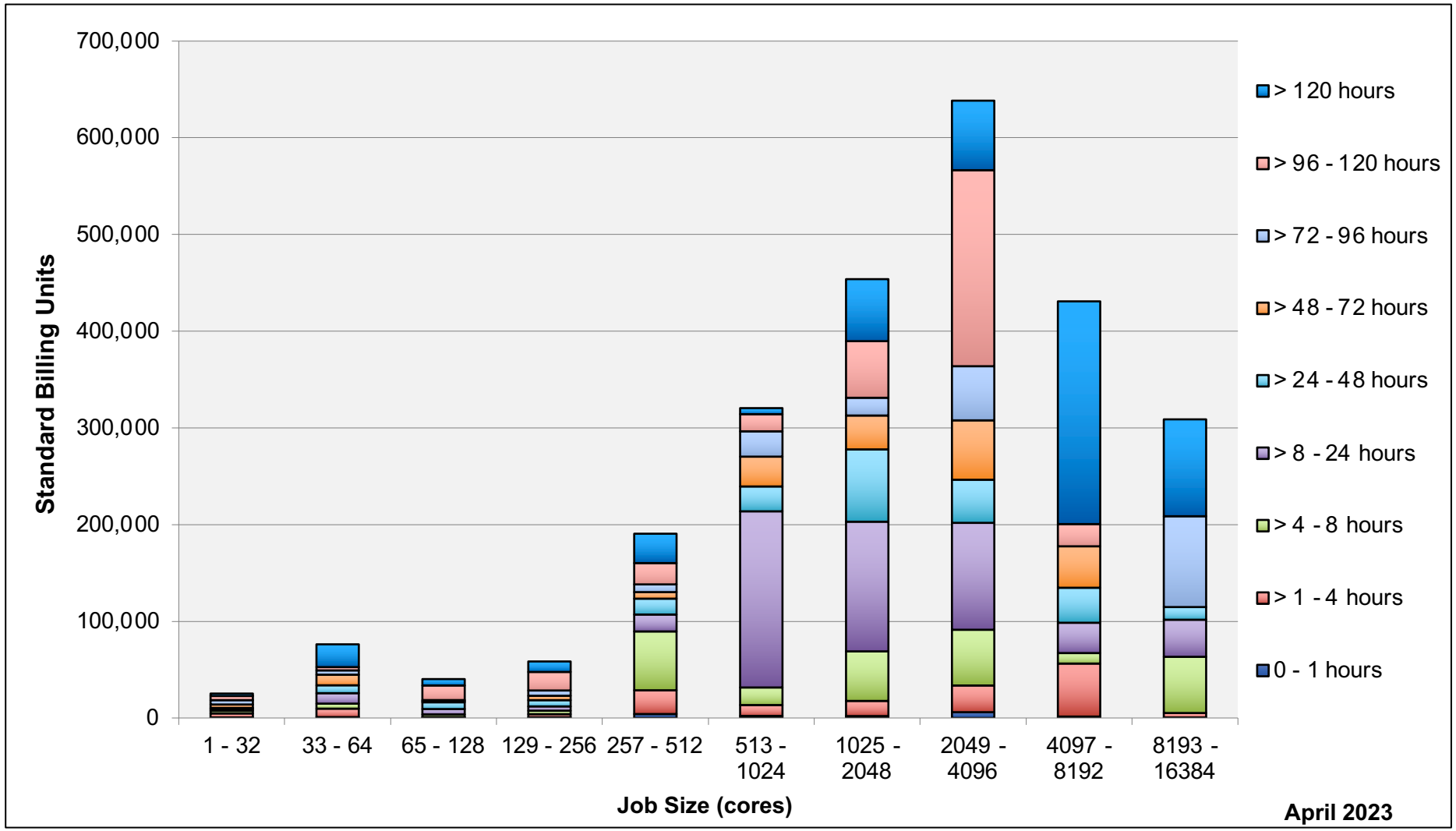
Electra: Monthly Utilization by Job Length



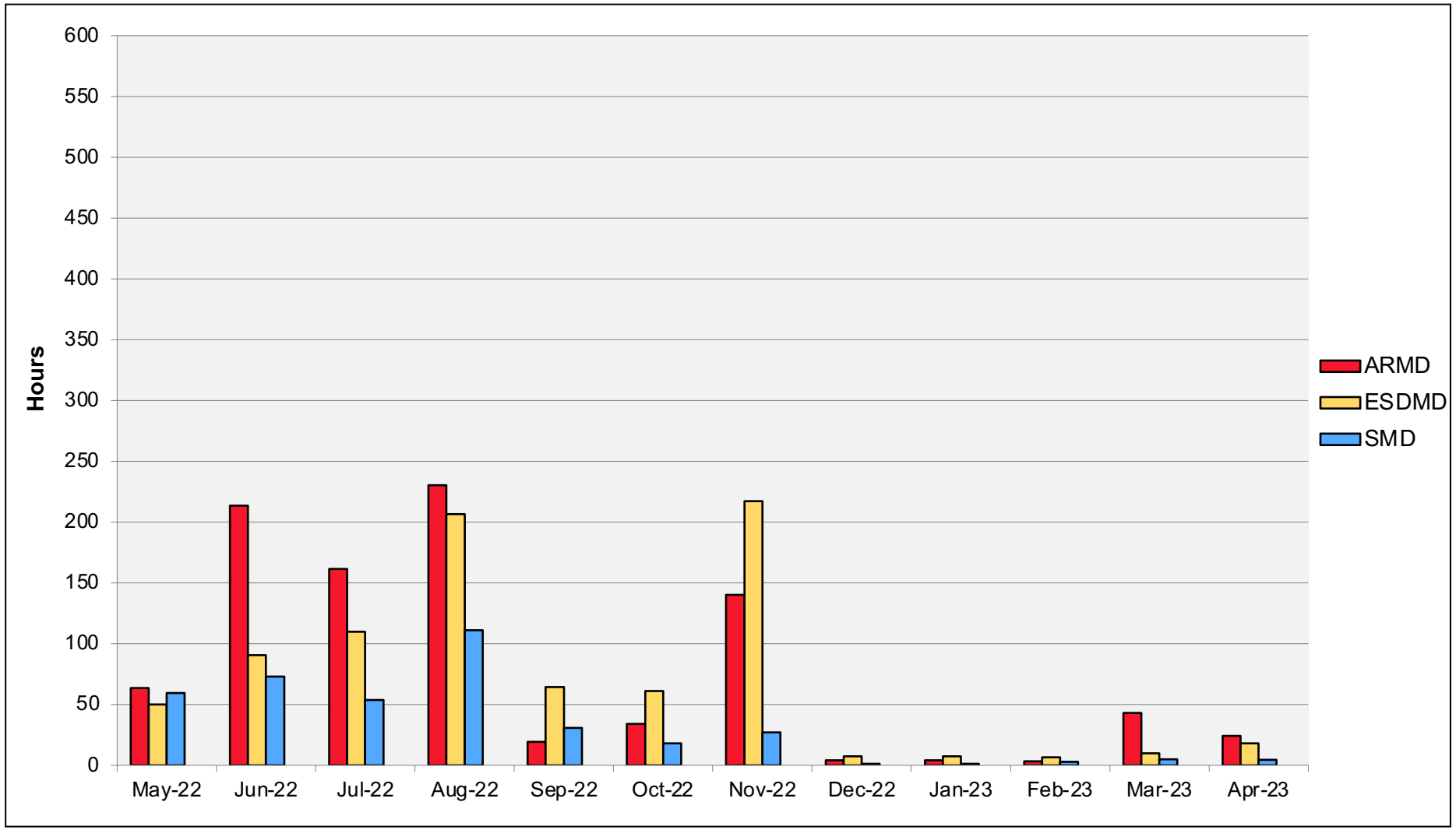
Electra: Monthly Utilization by Job Size



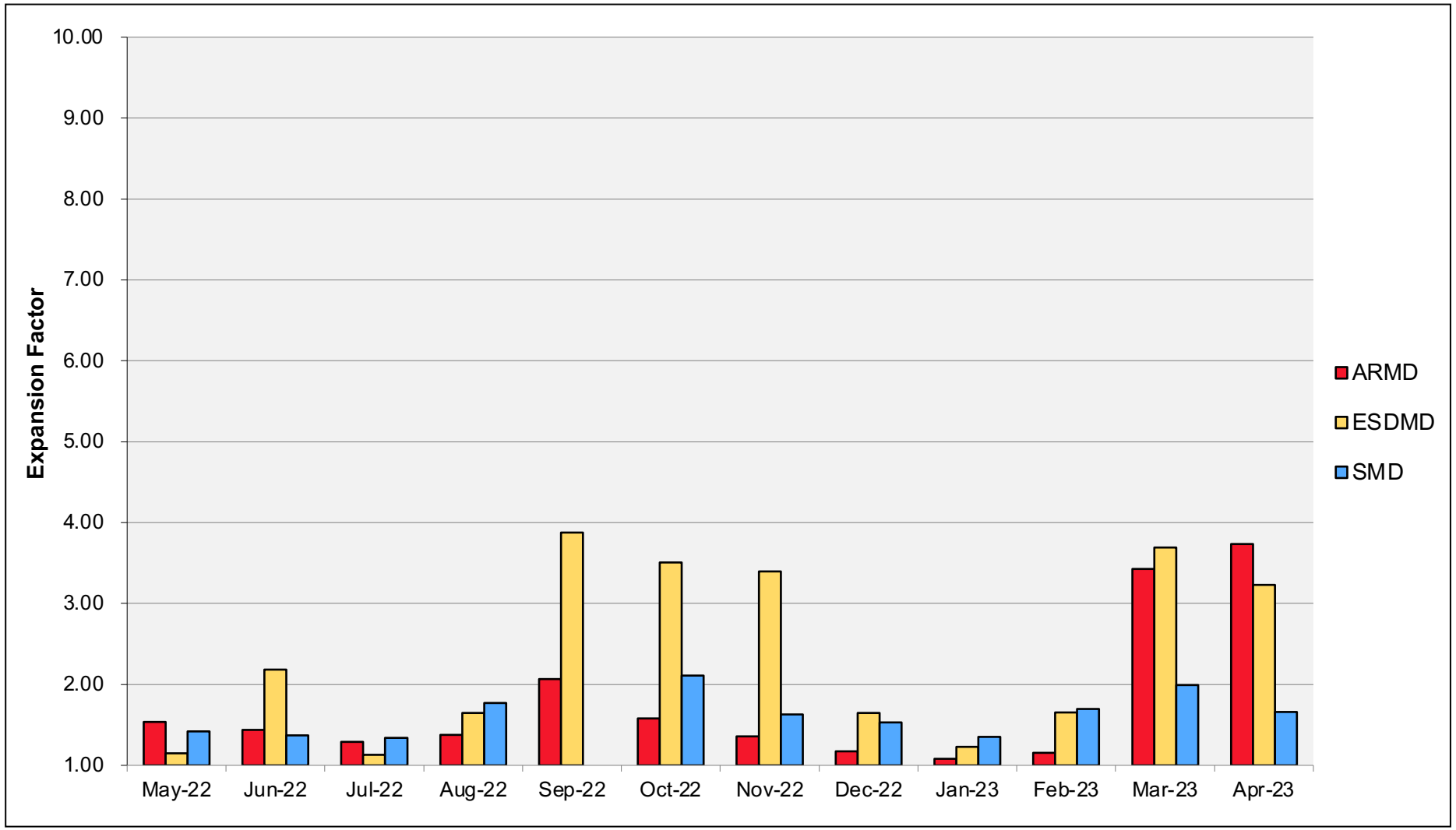
Electra: Monthly Utilization by Size and Length



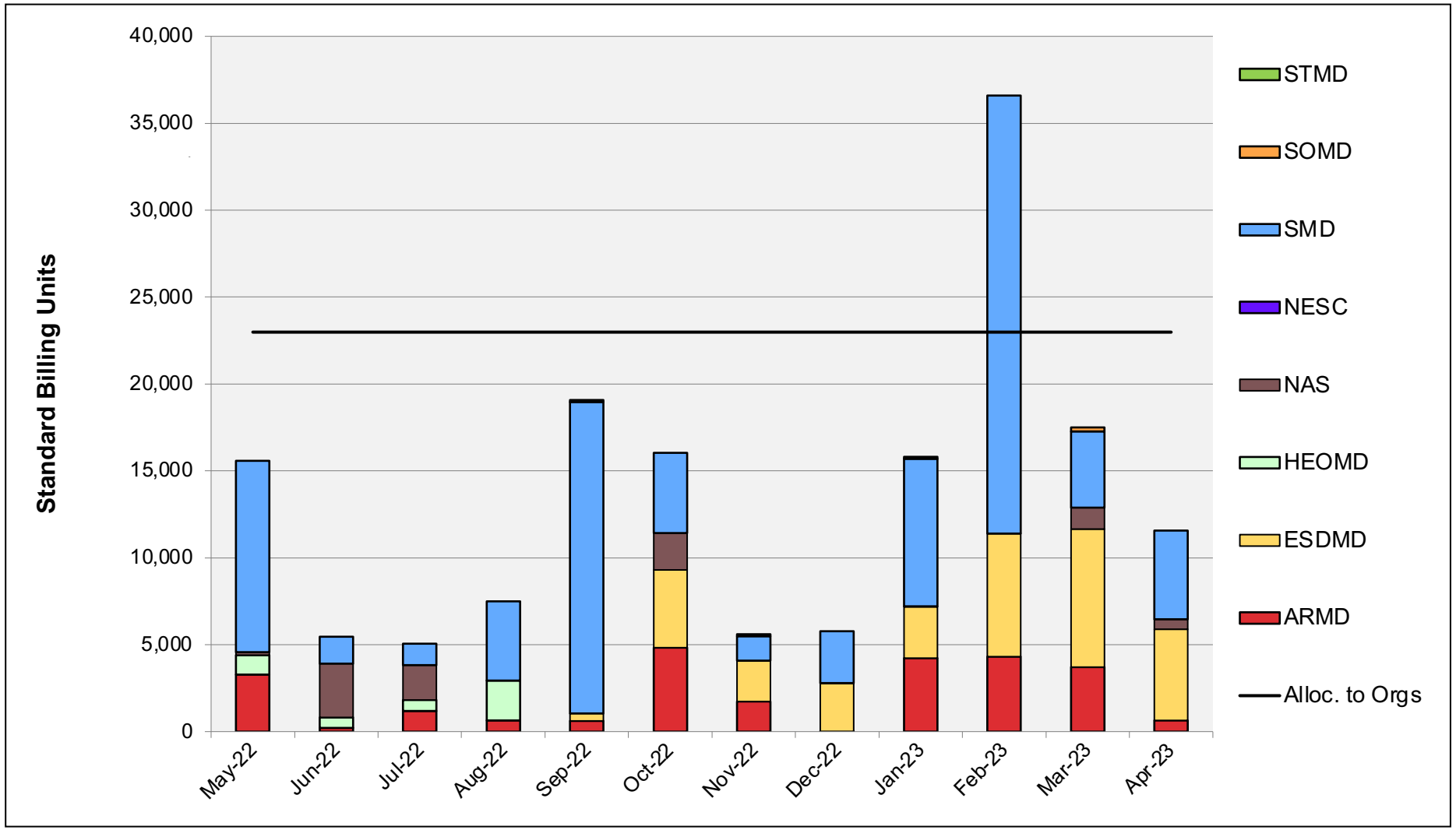
Electra: Average Time to Clear All Jobs



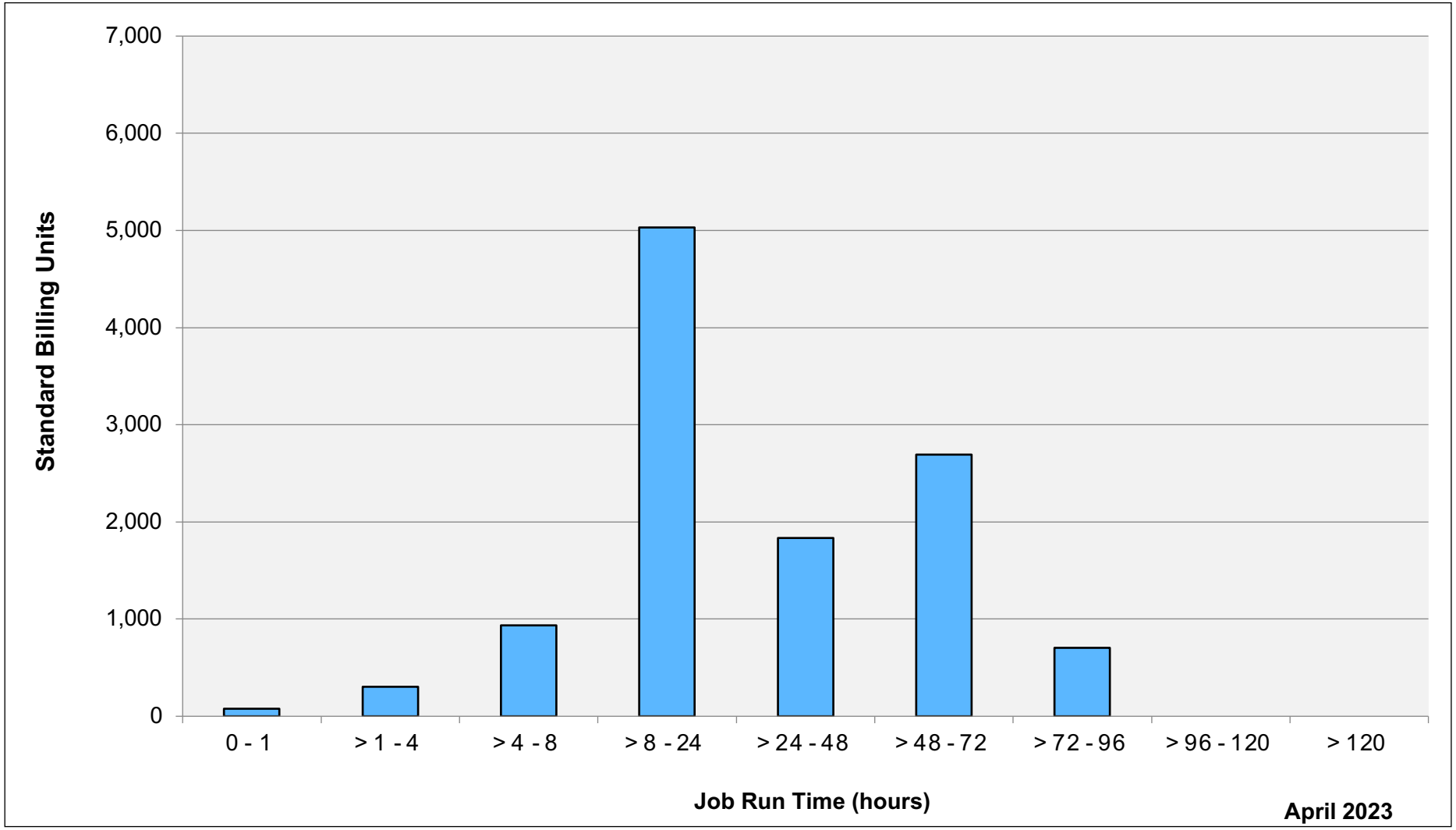
Electra: Average Expansion Factor



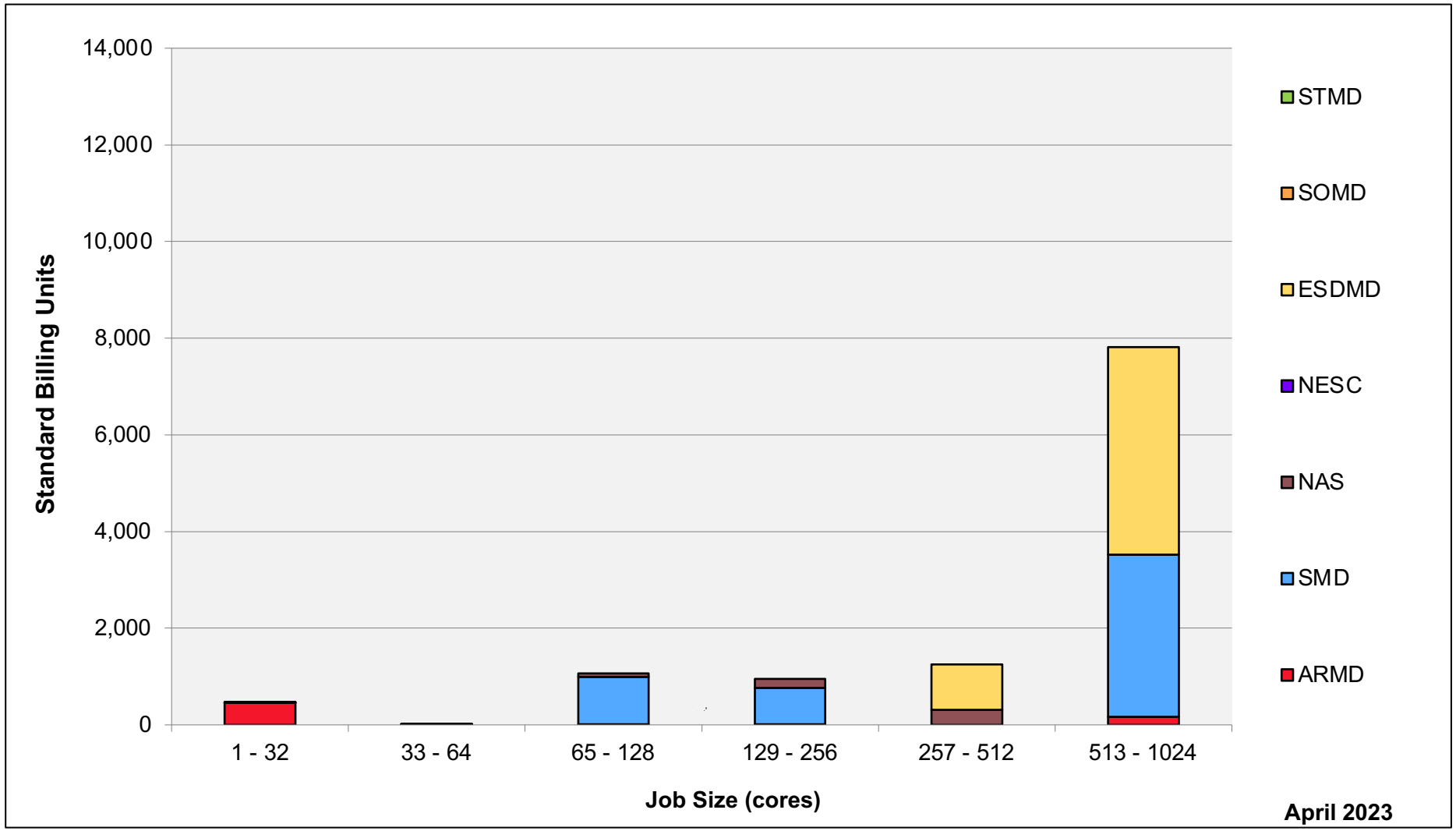
Endeavour: SBUs Reported, Normalized to 30-Day Month



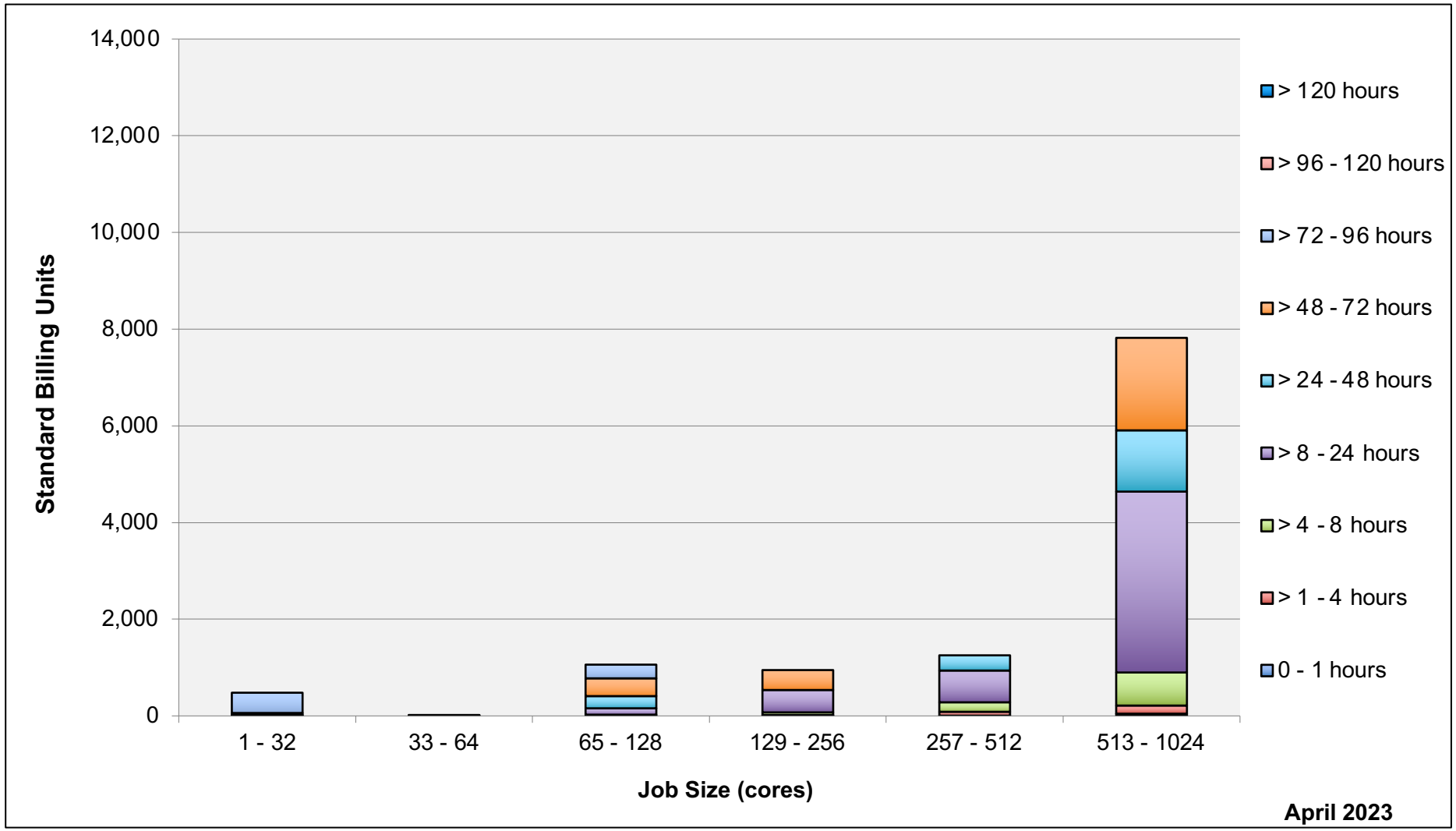
Endeavour: Monthly Utilization by Job Length



Endeavour: Monthly Utilization by Job Size



Endeavour: Monthly Utilization by Size and Length



Endeavour: Average Expansion Factor

