# Project Status Report

## High End Computing Capability
## Strategic Capabilities Assets Program

October 10, 2012

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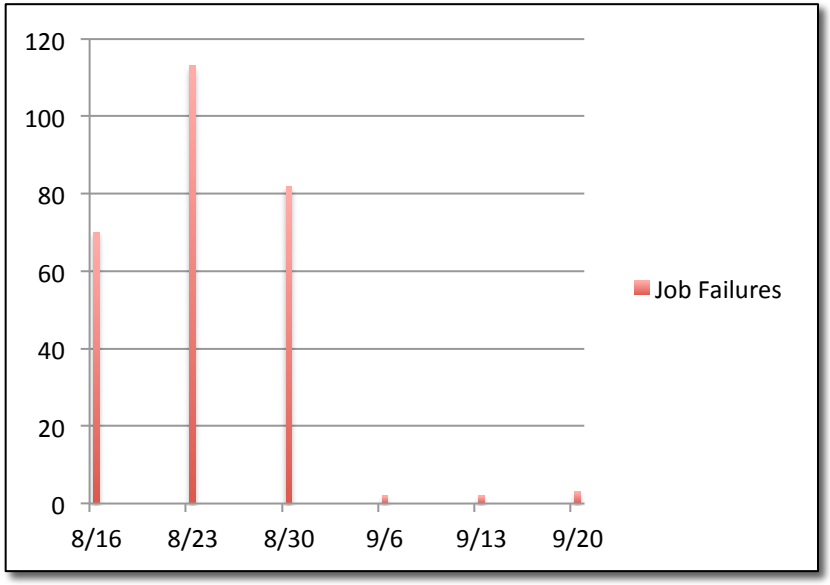
# HECC Systems Experts Resolve Pleiades Sandy Bridge InfiniBand Issues

- HECC systems engineers successfully stabilized the Sandy Bridge (SGI ICE-X) augmentation to the Pleiades supercomputer, using dedicated time to deploy new firmware on the Sandy Bridge nodes to address InfiniBand (IB) fourteen data rate (FDR) issues.
- The HECC team worked closely with Mellanox and SGI engineers, tracing the issue to a problem with buffering data across multiple switches causing one of the links to initiate a Link Level Recovery.
- The teams worked collaboratively to solve the problem—developing tools, running extensive diagnostics tests (see slide 4) and making numerous improvements to this complex system.
- After updating the firmware, job failures due to the IB issues were virtually eliminated.
- Batch jobs running on the system were suspended at the start of the dedicated time and then resumed once the work was completed—the vast majority of jobs were not impacted by the dedicated time.

**Mission Impact:** The upgraded Pleiades supercomputer is now providing scientists and engineers with a stable, productive, and much more capable computational environment.




This chart shows the number of job failures on the Sandy Bridge nodes before and after the firmware update. Note the significant reduction in the errors after the firmware was installed.

***POCs:*** *Bob Ciotti, bob.ciotti@nasa.gov, (650) 604-4408, NASA Advanced Supercomputing Division; Davin Chan, davin.chan@nasa.gov, (650) 604-3613, NASA Advanced Supercomputing Division, Computer Sciences Corp.*

# Innovative Tools, Test Methods Help Diagnose Pleiades InfiniBand Issues

- Application Performance and Productivity (APP) team members developed tools that provided valuable diagnostic information to vendors and sped up the resolution of InfiniBand (IB) issues on Pleiades' Sandy Bridge nodes (see slide 3).
- The team employed its recently developed tool called "Lumber" (which facilitates rapid analysis of individual job failures) to diagnose the IB firmware issue. APP staff also modified the tool to look across all jobs for a particular pattern of error messages appearing in the logs.
- In combination with their newly developed code "MPIcheck," which stresses the IB, the team generated several failures and then provided execution log reports to the vendors.
- The Sandy Bridge augmentation was successfully stabilized due to the close collaboration among the HECC experts and vendor teams.
- The versatility of the new tools will also help ensure future system robustness.

**Mission Impact:** Using in-house developed tools to identify and fix an intermittent issue with the InfiniBand fabric on Pleiades—NASA's largest supercomputing resource— greatly increased the reliability of the system and allows users to be more productive.

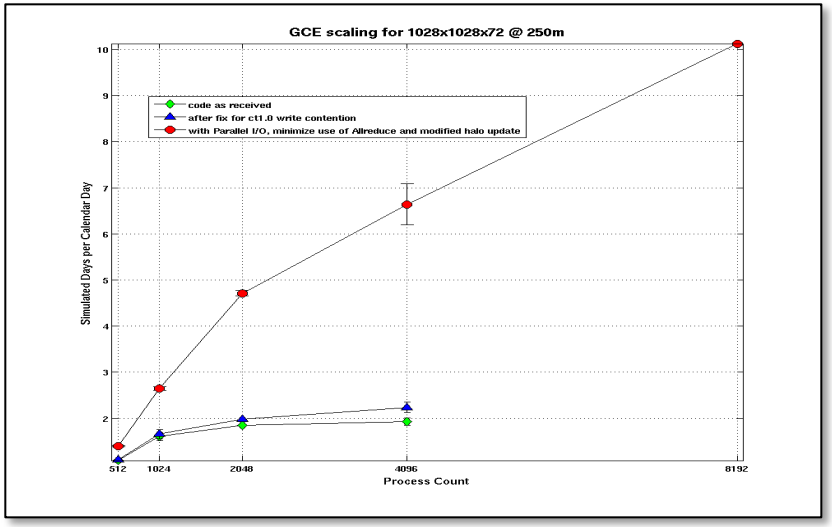
The new Sandy Bridge nodes, with Fourteen Data Rate (FDR) InfiniBand, were successfully integrated into the Pleiades supercomputer after HECC-developed tools helped diagnose and fix an InfiniBand firmware issue.

**POCs:** *Dave Barker, david.p.barker@nasa.gov (650) 604-4292, Robert Hood, robert.hood@nasa.gov, (650) 604-0740, NASA Advanced Supercomputing Division, Computer Sciences Corp.*

# APP Team Optimizes Cloud Resolving Model for Running on Pleiades

- The Application Performance and Productivity (APP) team optimized the I/O performance of the Goddard Cumulus Ensemble (GCE) code, improving it by a factor of 3 and helping the user meet the project's deadline without resorting to simulations at a lower resolution. APP analyses revealed several impediments to scaling:
  - In the higher resolution case, a subroutine had severe contention problems caused by all processes writing the same information to the same small text file;
  - The code made excessive use of MPI_Allreduce with a small message size and also had a non-optimal halo update routine;
  - Serial I/O was being used for diagnostics and checkpointing—that is, arrays were being gathered to a single process and written to disk.
- To solve these issues, the APP team made numerous code modifications to minimize the number of MPI_Allreduce calls, avoid needless waiting during non-blocking communication, and eliminate I/O bottlenecks.
- The code owner stated that the modifications *" …dramatically increased the efficiency of the GCE, making a new set of large domain, high resolution experiments feasible."*

**Mission Impact:** Identifying and fixing performance bottlenecks such as these allows NASA users to complete their computational studies more quickly and obtain higher resolution results.



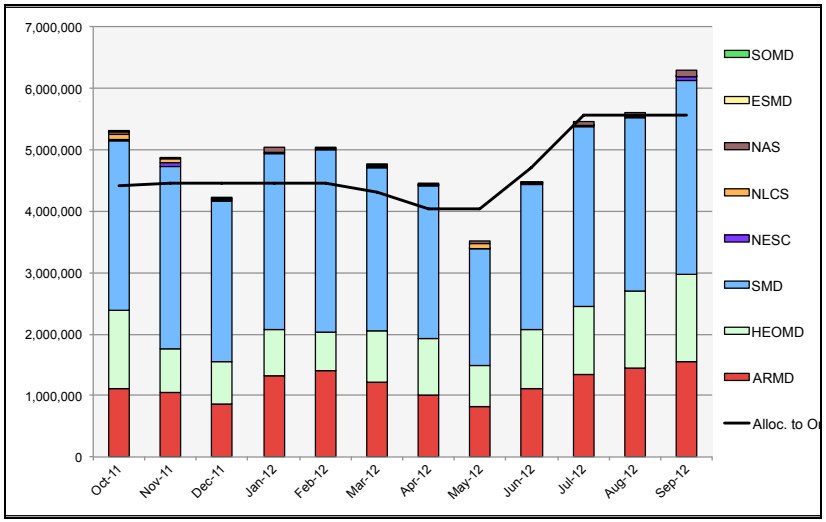

A scaling study of the effect of different optimizations for 12-hour Goddard Cumulus Ensemble (GCE) simulations at 250-meter resolution.

**POC:** *Dan Kokron, daniel.s.kokron@nasa.gov, (301) 286-3959, NASA Advanced Supercomputing Division, Computer Sciences Corp.*

# Pleiades Improvements Enable Record-High Usage Levels for NASA Missions

- September 2012 showed record-high usage of HECC's Pleiades supercomputer.
- Nearly 6.3 million Standard Billing Units (SBUs) were used by NASA's Mission Directorates (MDs) and mission support organizations—exceeding the previous record (from August 2012) of 5.6 million SBUs.
- This ~12% increase was enabled by stabilizing the Sandy Bridge nodes and by efficient operations that delivered 97% availability and 87% utilization (75% utilization is the target).
- Researchers in the Science Mission Directorate represented the largest group of users, consuming approximately 50% of all Pleiades SBUs.
- Computing resources continue to expand and are made available to users from all MDs to support their computing needs.

**Mission Impact:** Increasing Pleiades' system capacity and operational efficiency provides NASA Mission Directorates with more resources to accomplish their goals and objectives.




Utilization of Pleiades by all mission directorates and support organizations. Data is shown in Standard Billing Units (SBUs), where one SBU is equivalent to one node hour of a 12-core Westmere node of Pleiades. Data is normalized to a 30-day month.

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

# HECC Successfully Completes Triennial Equipment Inventory

- HECC staff successfully completed the Triennial Inventory for the NASA Advanced Supercomputing (NAS) facility, begun in March 2010; all but one piece of equipment was located, demonstrating our constant attention to government property management.
- Results of the three-phase process include:
  - The phase one initial scan turned up 119 missing items and 51 overages;
  - During the phase two reconciliation period, all overages and 118 missing items were identified;
  - Final phase results show that HECC equipment consisted of 1,320 items valued at approximately $88M; one display (valued at $795) was not found; no unrecorded items were found.
- Quarterly property scans continue; annual scans will replace the Triennial Inventory starting in January 2013.

**Mission Impact:** Accurate and careful stewardship of real property is integral to achieving NASA's vision and mission in science, technology, and discovery.

The Triennial Inventory includes scanning and accounting for the Pleiades supercomputer, including its continual augmentation and component replacement.

**POC**: *Judy Kohler, judy.k.kohler@nasa.gov, (650) 604-4303, NASA Advanced Supercomputing Division, Computer Sciences Corp.*

# Supercomputing Impact on Space Shuttle Program Highlighted at Ames Flyover Event

- HECC staff engaged many of the 15,000+ visitors at the NASA Ames Space Shuttle Endeavor flyover event on September 21.
- Visitors to the supercomputing booth learned how high-fidelity modeling on HECC supercomputers played a key role in supporting the Space Shuttle Program for over two decades:
  - Computational fluid dynamics (CFD) research led to improved shuttle performance, reliability, and safety, and helped engineers redesign the shuttle's main engine manifold and turbopump;
  - Critical analyses supported the Columbia (STS-107) accident investigation and NASA's subsequent Return to Flight efforts;
  - HECC resources provided debris-transport analysis, damage estimates, and other support during the Discovery (STS-114) mission.
- Participants took away information about Pleiades and overall HECC contributions to agency-wide research and development.

**Mission Impact:** After supporting the Space Shuttle Program for over two decades, NASA researchers are now using their experience, modeling tools, data, and resources to provide essential, early input into the design of next-generation spacecraft such as the new Space Launch System (SLS).

NASA Ames researcher Michael Aftosmis explains high-fidelity modeling on supercomputers to a young space shuttle fan shortly before Space Shuttle Endeavour, atop the Shuttle Carrier, flies over Ames' historic Hangar One on its way to the California Science Center on September 21, 2012.

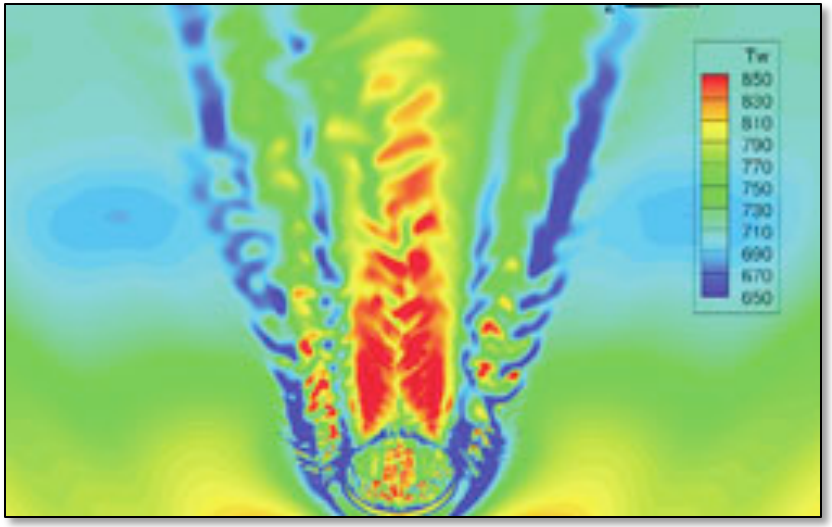
**POC**: *Gina Morello, gina.f.morello@nasa.gov, (650) 604-4462, NASA Advanced Supercomputing Division*

# High-Fidelity Simulations of Transition to Turbulence Support Mars Entry Vehicles

- To validate and improve the accuracy of aerodynamic heating predictions for large-payload Mars entry vehicles, researchers at NASA Ames performed direct numerical simulations of transition experiments utilizing the Pleiades supercomputer.
- Successful predictions of roughness-induced transition to turbulence enable the design of safe, efficient thermal protection systems for planetary exploration vehicles.
- The high-resolution simulations included high-enthalpy flows of Mars-like $CO_2$ gases over a hemisphere with an isolated roughness element at Mach 15.
- Such simulations require computational models with millions of grid points to resolve the small turbulent scales in the boundary layer, necessitating the large resources available on Pleiades.

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

**Mission Impact:** Successful prediction of roughness-induced transition to turbulence in hypersonic, reacting flow environments will enable the design of safe and efficient thermal protection systems for future missions.




Close-up view of surface temperature contours for roughness-induced transition to turbulence in Mars-like CO2 gas at Mach 15 in the NASA Ames Hypersonic Ballistic Range. Steven Yoon, Michael Barnhardt, NASA/Ames

**POC**: *Steven Yoon, s.yoon@nasa.gov, (650) 604-4482, NASA Ames Research Center*

# HECC Facility Hosts Several Visitors and Tours in September 2013

- HECC hosted five tour groups in September; guests learned about the agency-wide missions being supported by Pleiades, and viewed scientific results on the hyperwall system. Visitors this month included:
  - Stan Tieman, Division Chief at Marshall Space Flight Center, who met with staff on future collaboration with Ames on Space Launch System (SLS)-related efforts;
  - David McBride, Director, Dryden Flight Research Center;
  - A group from the NASA Advisory Committee, Commercial Space Team visited the facility as part of their quarterly review tour;
  - A technical group from Kennedy Space Center visited with staff for future collaboration on SLS and flame trench efforts.


Aerospace engineer Donovan Mathias, NASA Advanced Supercomputing Division, presents SLS engineering risk assessment findings to Stan Tieman, Division Chief, Marshall Space Flight Center.

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

# Presentations and Papers

- "**A fully coupled 3D wave-current interaction model on unstructured grids**," A. Roland, et al, Journal of Geophysical Research, Volume 117, C00J33, September 29, 2012.*
  *http://www.agu.org/journals/jc/jc1209/2012JC007952/*
- "**(Mis)interpreting supernovae observations in a lumpy universe**," C. Clarkson, et al, Monthly Notices of the Royal Astronomical Society, Volume 426, Issue 2: 1121-1136, October 2012 (published online September 26, 2012).*
  *http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2966.2012.21750.x/full*
- "**Numerical Simulations of the Dark Universe: State of the Art and the Next Decade**," M. Kuhlen, M. Vogelsberger, R. Angulo, arXiv:1209.5745 [astro-ph.CO], September 25, 2012.*
  *http://arxiv.org/abs/1209.5745*
- "**Large Scale Aeroelastic Data for Design of Rotating Blades using Navier-Stokes Equations**," G. Guruswamy, presented at 12th AIAA Aviation Technology, Integration, and Operations (ATIO) Conference and 14th AIAA/ISSM, Indianapolis, Indiana, September 17-19, 2012.
  *http://arc.aiaa.org/doi/pdf/10.2514/6.2012-5629*

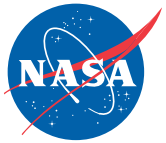
** HECC provided resources and services in support of this work.*

# Presentations and Papers (cont.)

- "**Investigating the Reliability of Coronal Emission Measure Distribution Diagnostics Using Three-Dimensional Radiative Magnetohydrodynamic Simulations**," P. Testa, et al, The Astrophysical Journal, Volume 758, Number 1, October 2012 (published online September 25, 2012).*
  *http://iopscience.iop.org/0004-637X/758/1/54/fulltext/*
- "**Gamma-ray burst afterglow light curves from a Lorentz-boosted simulation frame and the shape of the jet break**," H. van Eerten, A. MacFadyen, arXiv:1209.1985 [astro-ph.HE], September 10, 2012.*
  *http://arxiv.org/abs/1209.1985*
- **18th AIAA International Space Planes & Hypersonic Systems and Technologies Conference**, September 24-28, 2012, Tours, France.
  - "Water Injection Pre-Compressor Assist Space Access," U. Mehta.*
  - "Stage Separation from Shuttle Carrier Aircraft for Space Access," U. Mehta.*
- "**Performance of NASA Applications on Modern Accelerator Technologies,**" H. Jin and P. Mehrotra, MAT4GIScience Workshop, September 18, 2012, Columbus, Ohio.

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

# News and Events

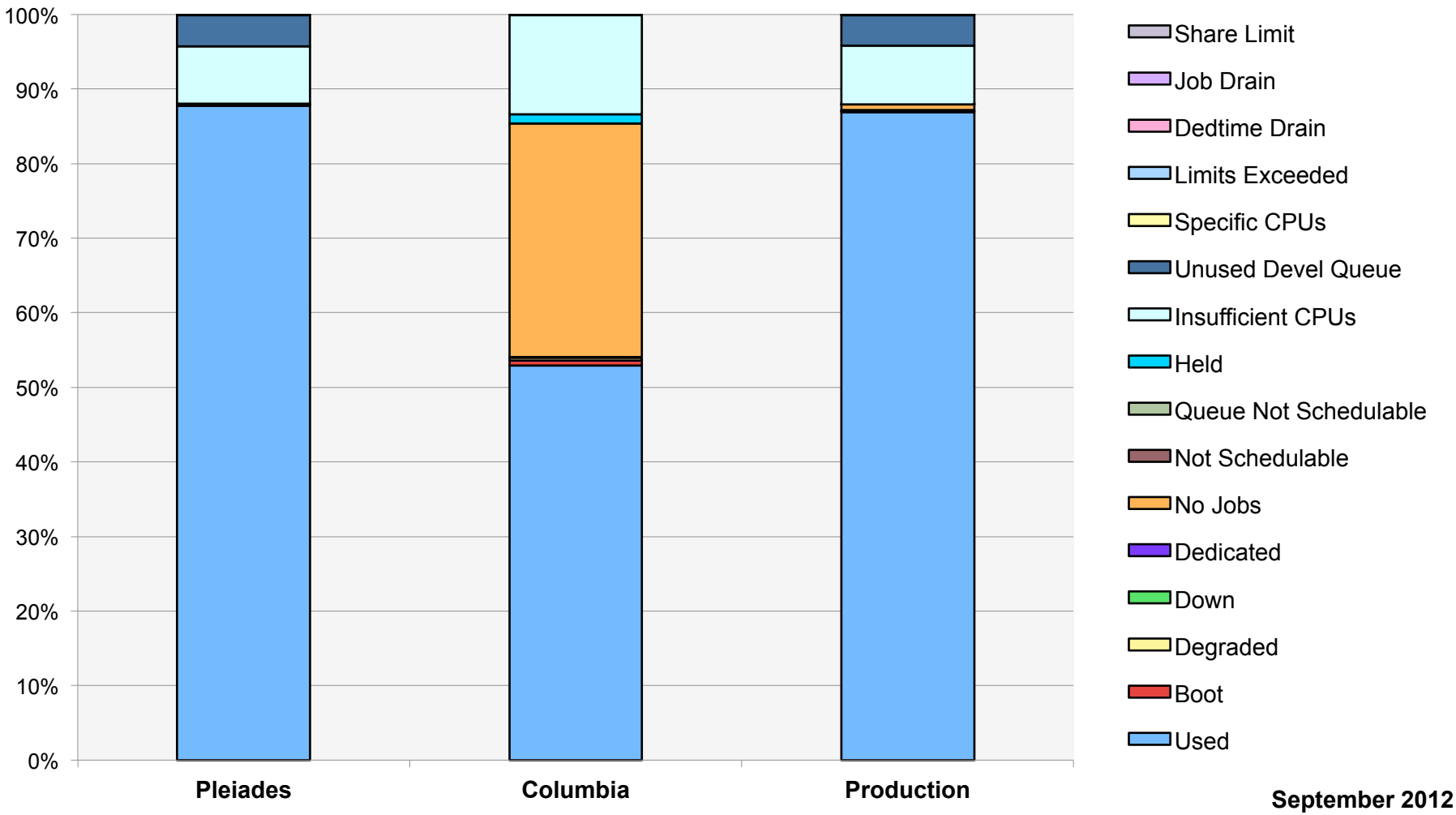



- **Simulations Uncover 'Flashy' Secrets of Merging Black Holes,** *NASA feature article,* September 27, 2012 – Video created by NASA Goddard's Scientific Visualization Studio uses two black hole merger simulations run on Pleiades. *http://www.nasa.gov/topics/universe/features/black-hole-secrets.html*

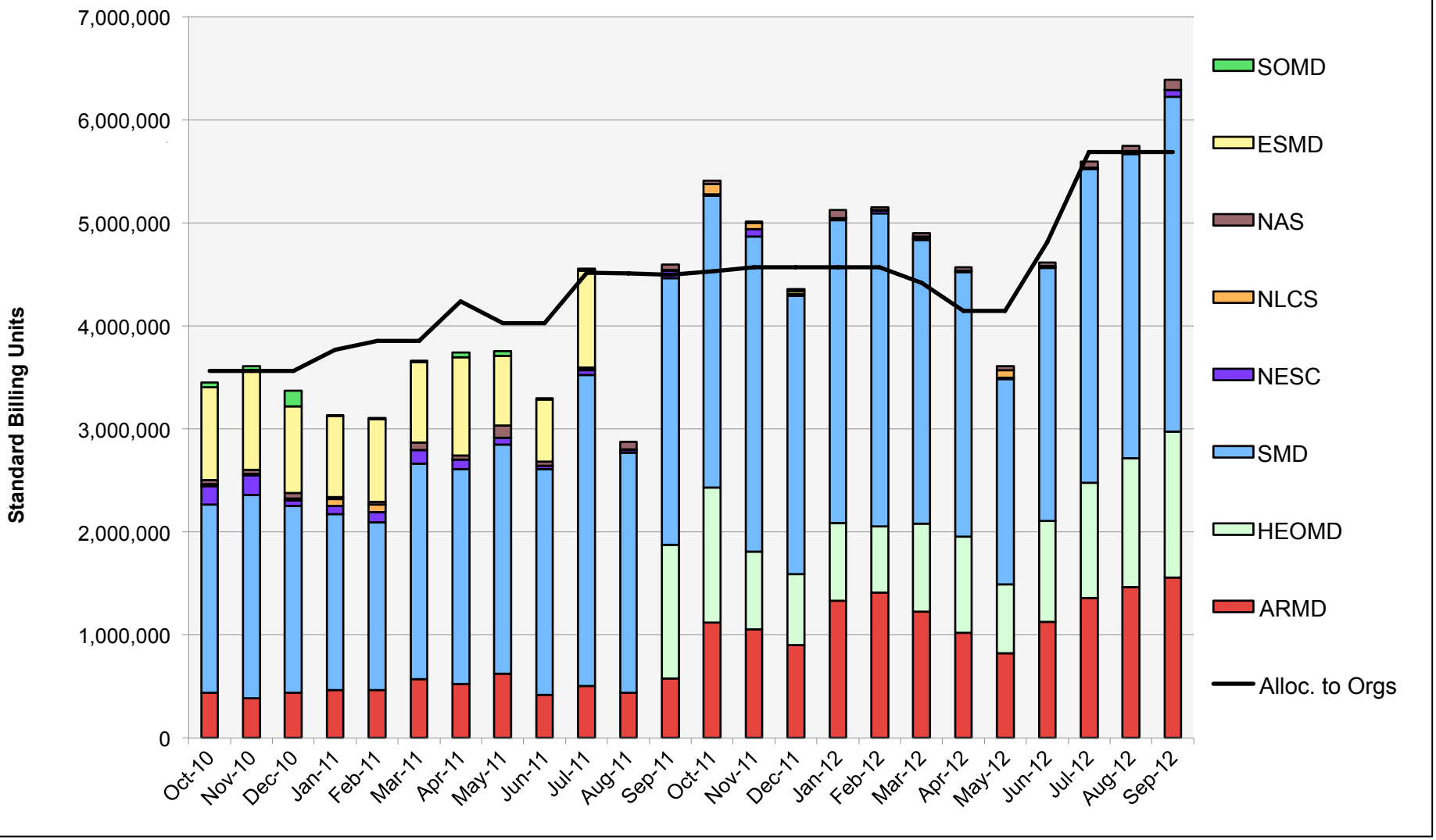
- **High-Res Simulations Help Solve Missing Massive Satellites Problem,** *Featured science article from the Department of Astronomy at University of Wisconsin-Madison*, September 18, 2012 – HECC provided resources supporting dark matter and galaxy formation research toward understanding how galaxies like the Milky Way form and what forces create the satellite galaxies around it. *http://www.astro.wisc.edu/news-events/featured-science/*

- **Ames Shuttle Flyover Event,** September 21, 2012 – Visitors to the supercomputing booth learned from researchers how high-fidelity modeling on HECC supercomputers played a key role in supporting the Space Shuttle Program for over two decades (see slide 9).

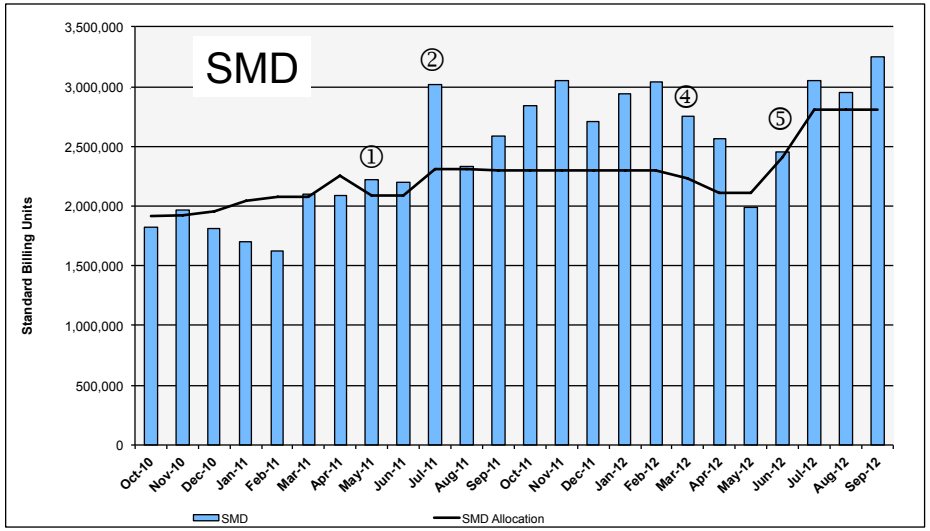
# HECC Utilization

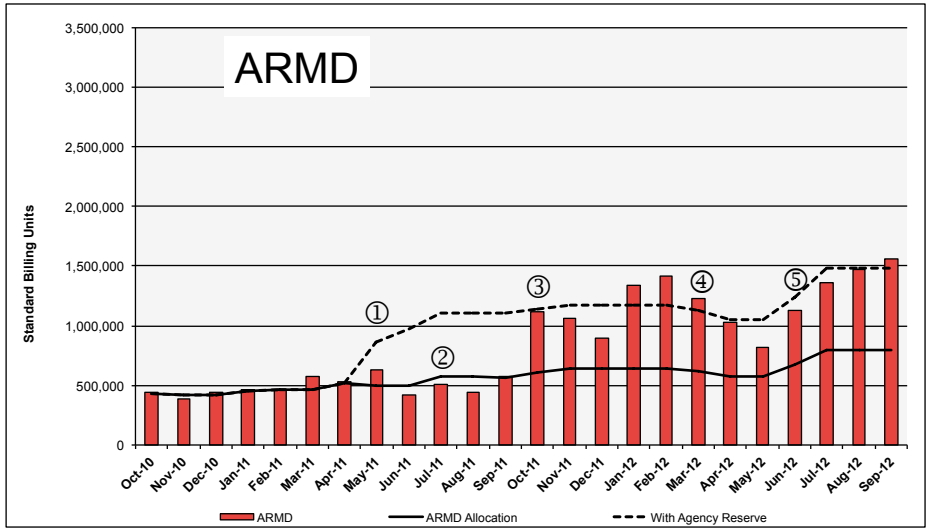


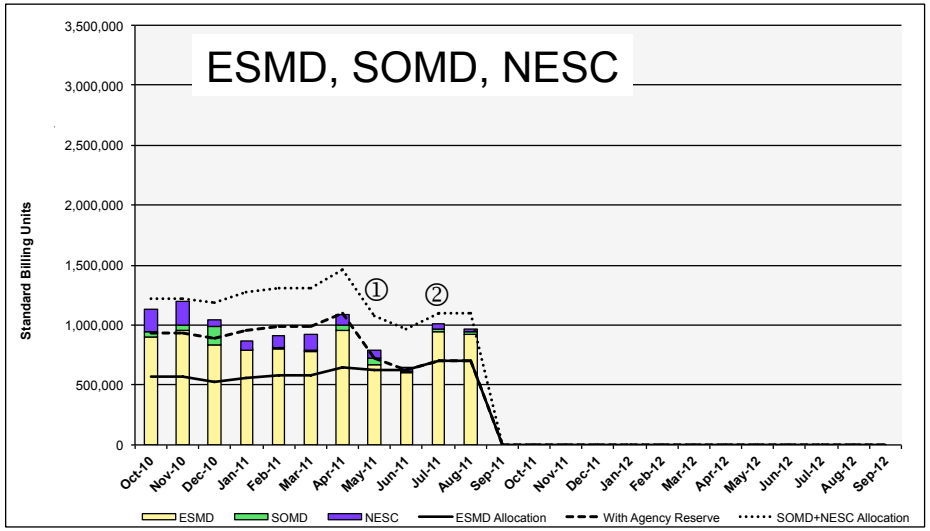
# HECC Utilization Normalized to 30-Day Month

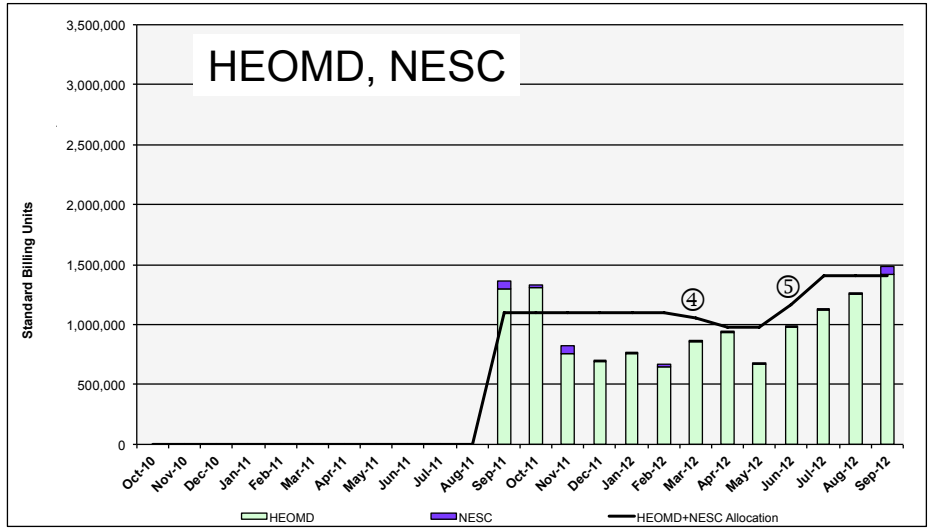


# HECC Utilization Normalized to 30-Day Month



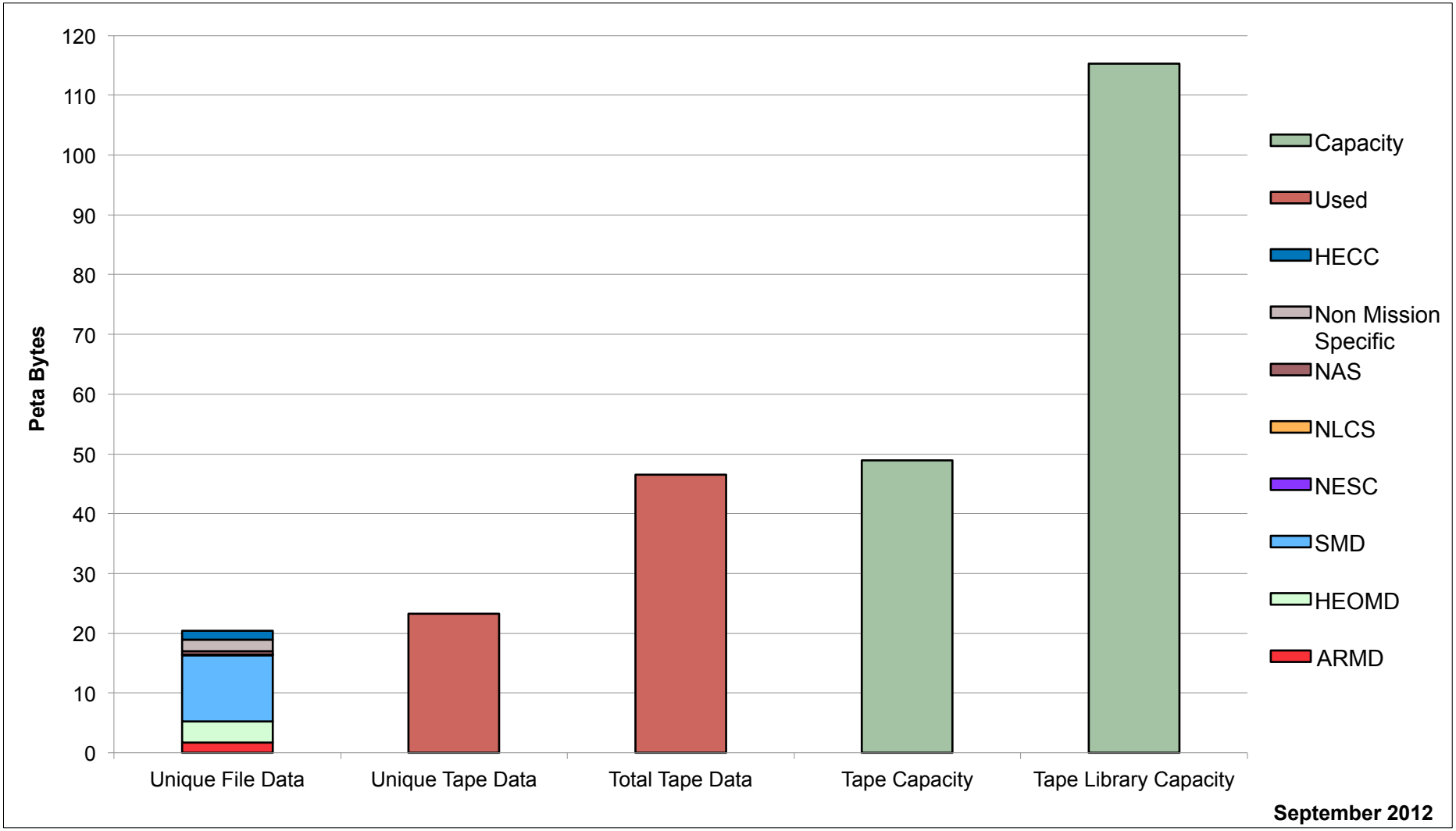



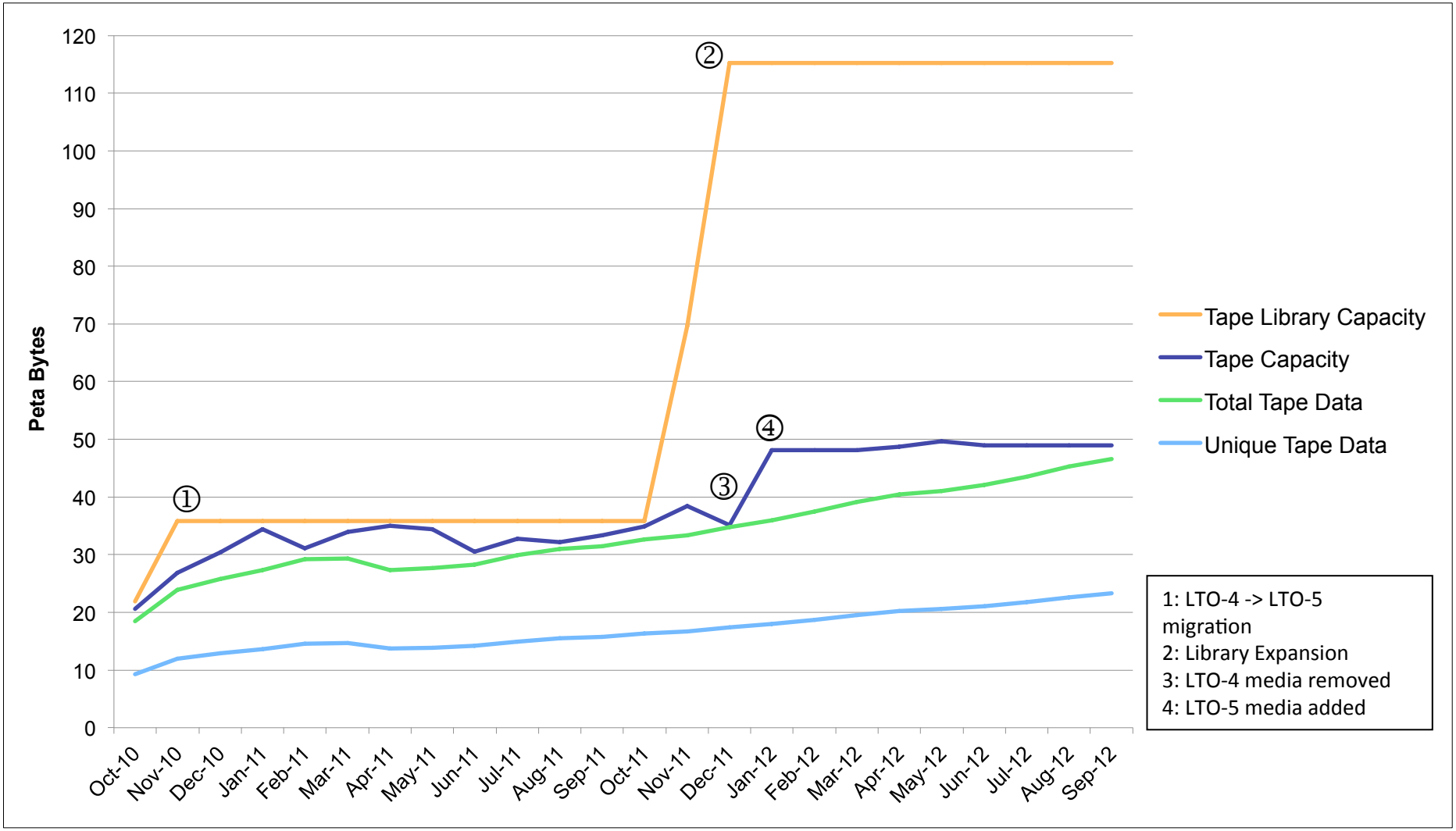




① Allocation to orgs. decreased to 75%, Agency reserve shifted to ARMD ② 14 Westmere racks added
③ 2 ARMD Westmere racks added ④ 28 Harpertown racks removed ⑤ 24 Sandy Bridge racks added

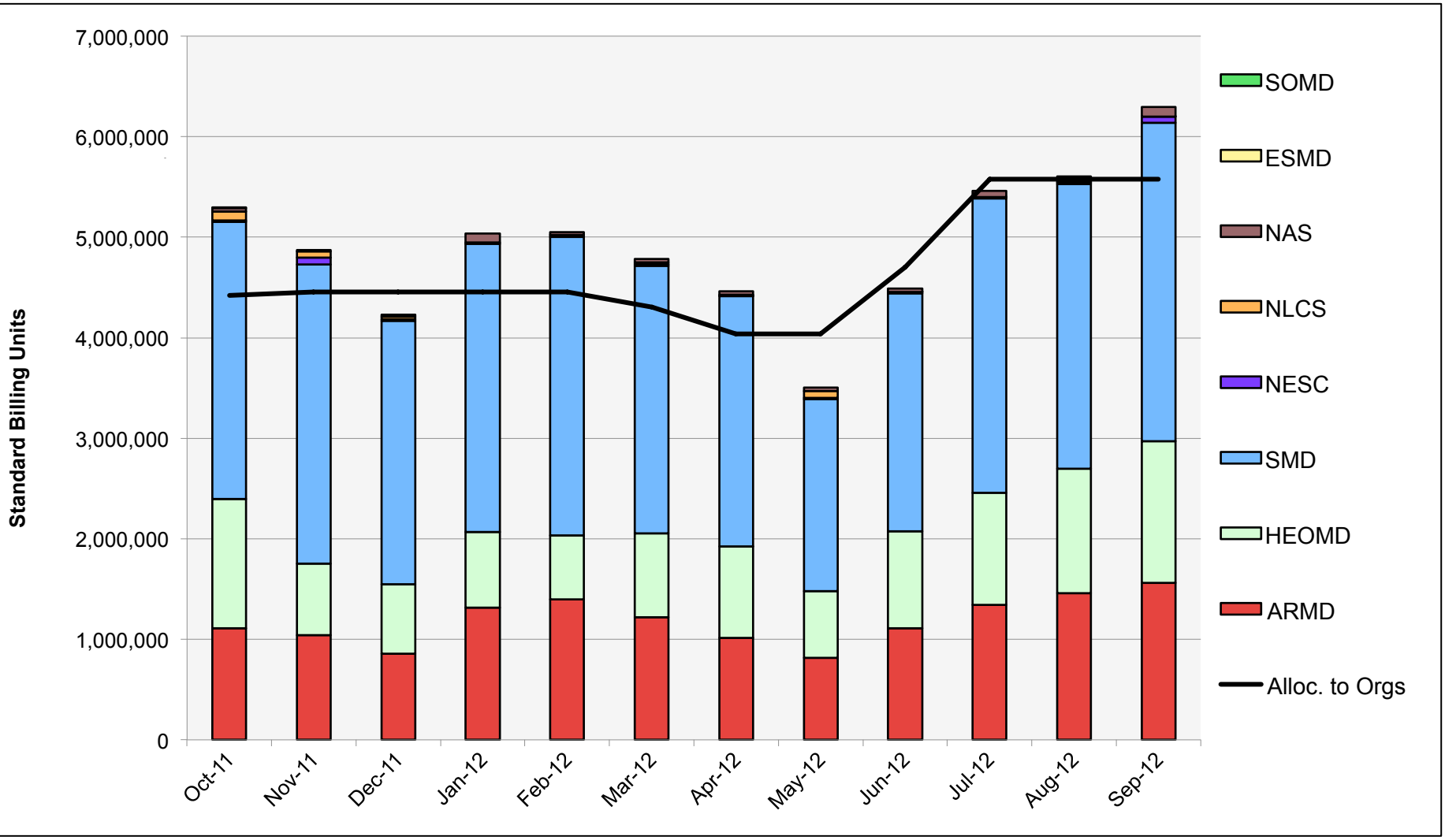
# Tape Archive Status



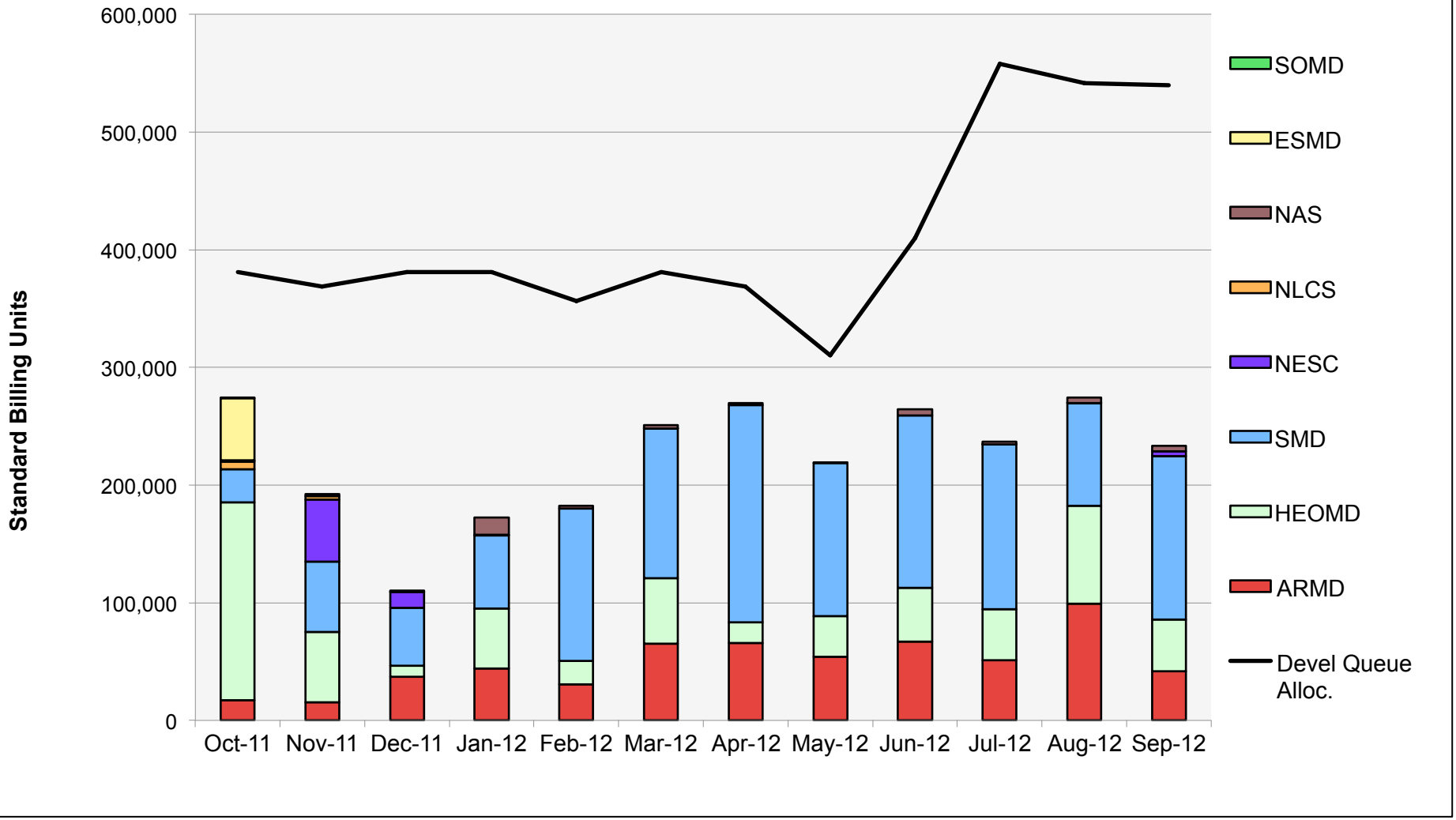
# Tape Archive Status



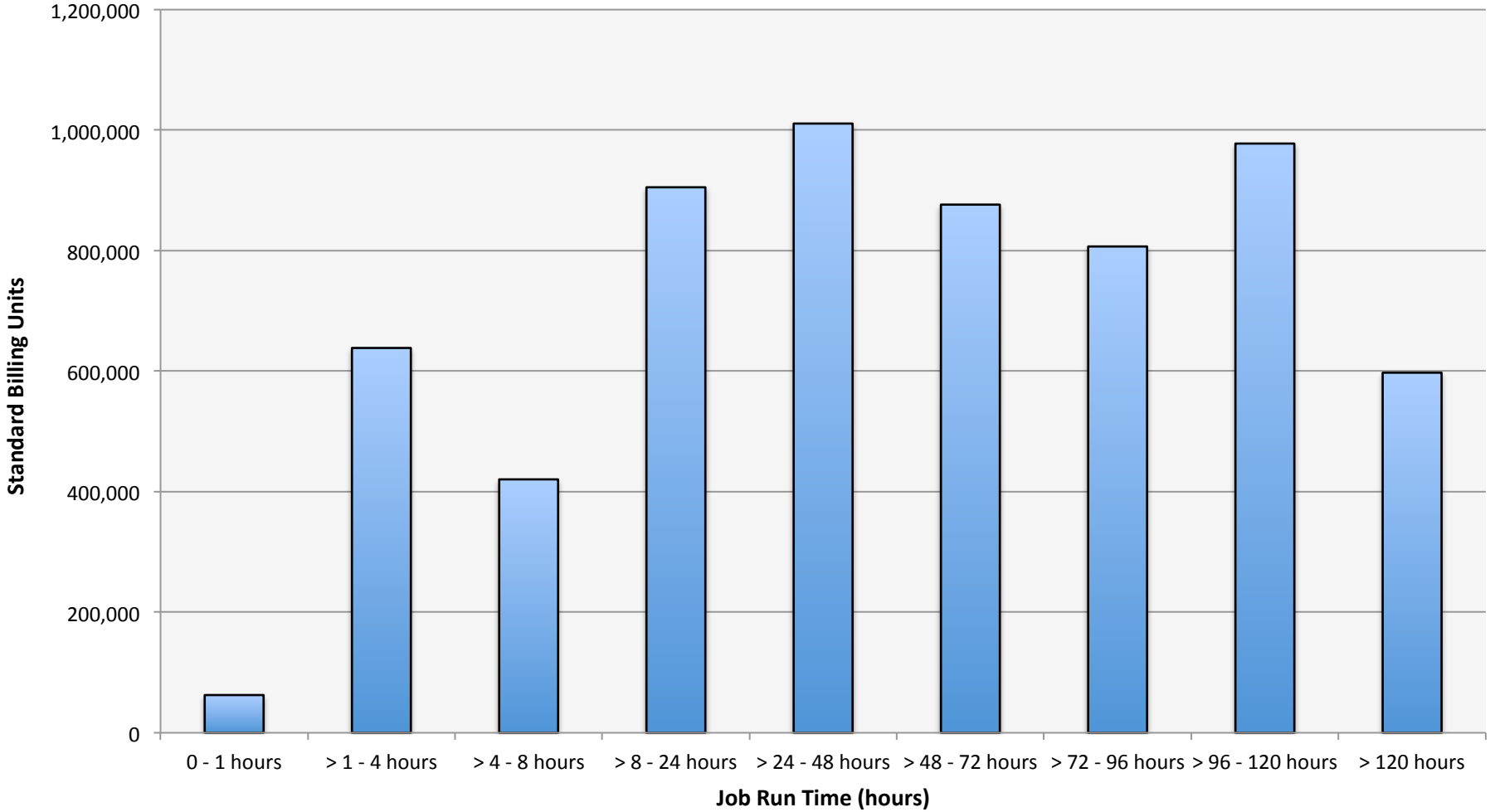
# Pleiades:
# SBUs Reported, Normalized to 30-Day Month



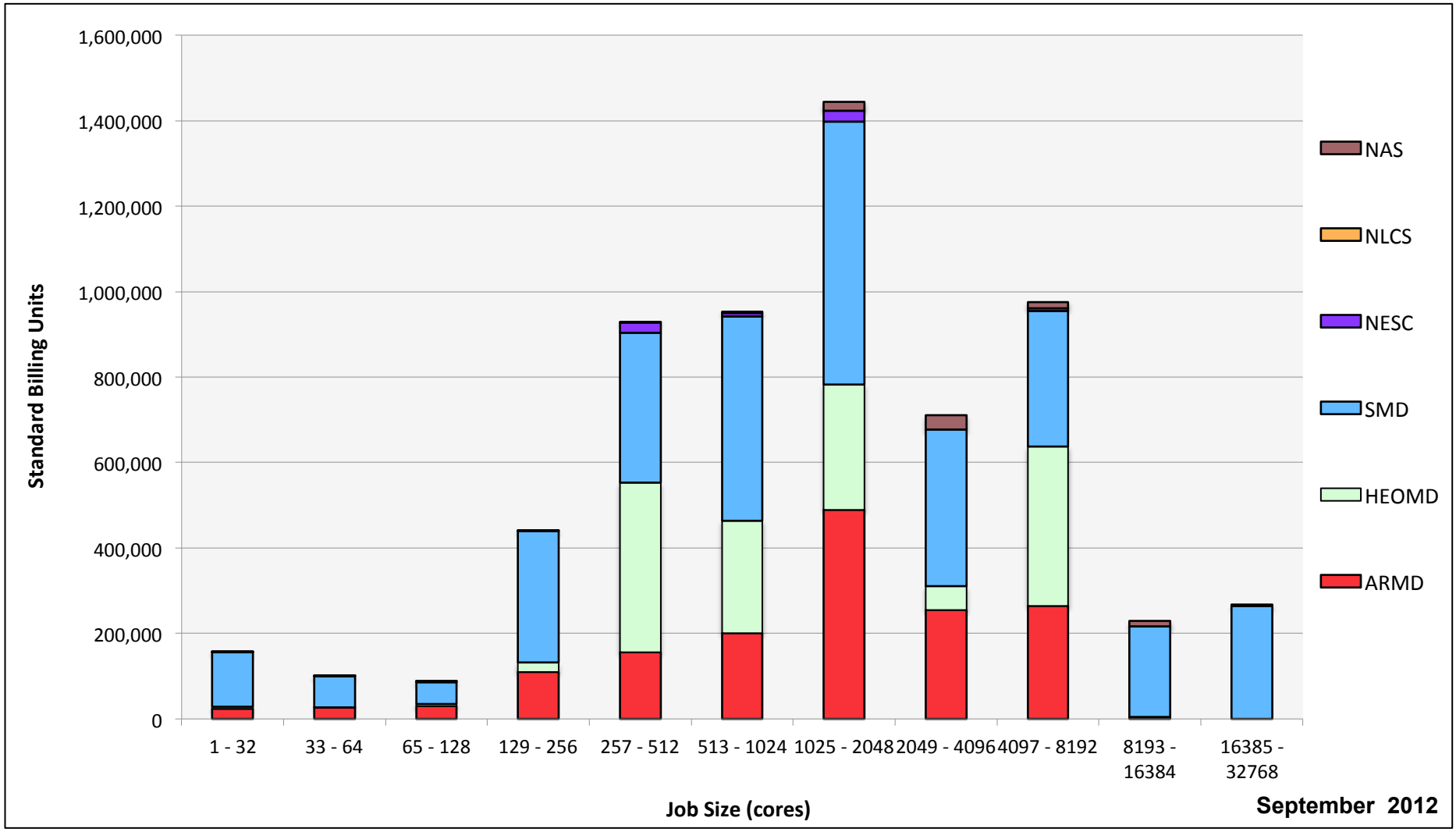
# Pleiades:
# Devel Queue Utilization



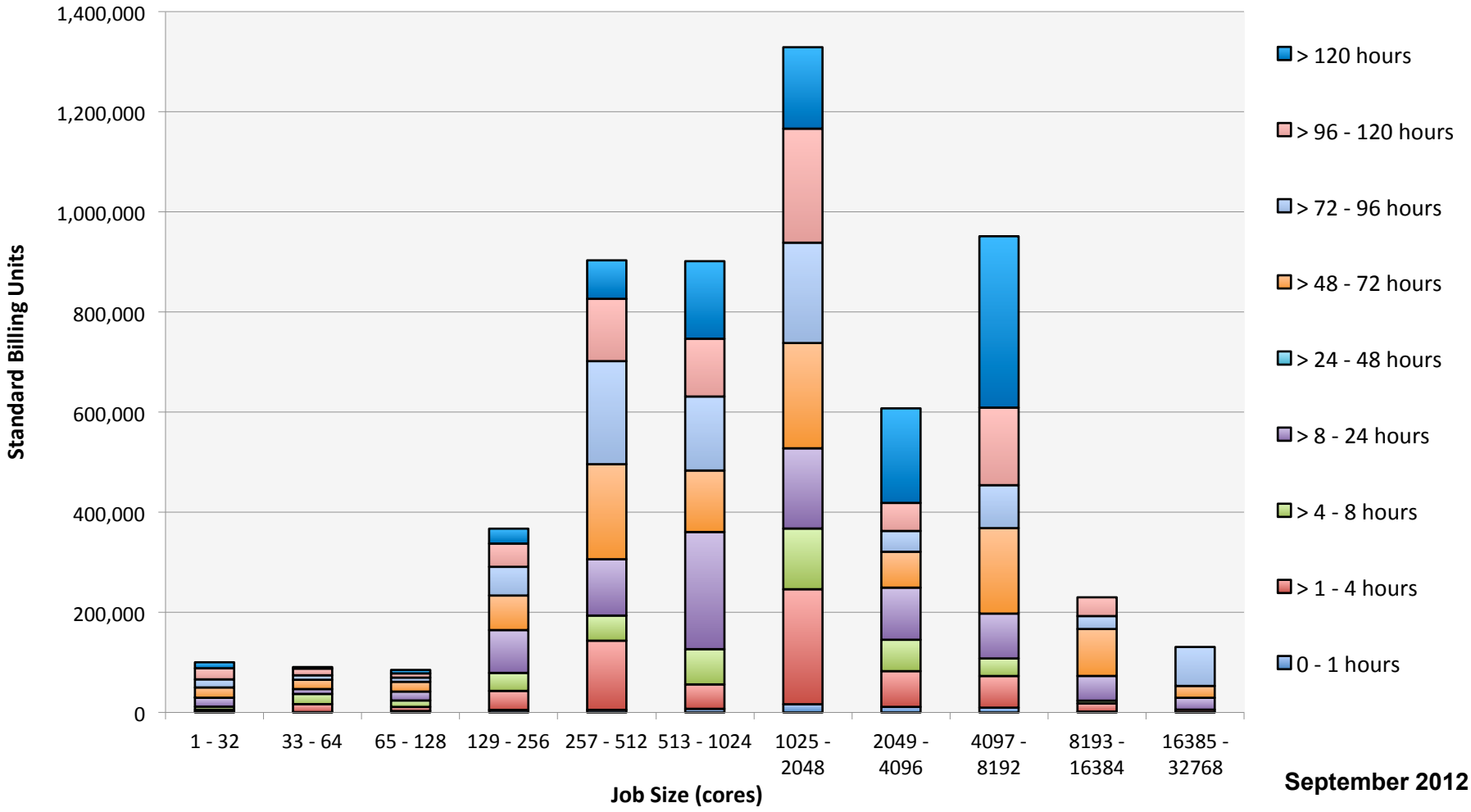
# Pleiades:
# SBUs Reported, Normalized to 30-Day Month



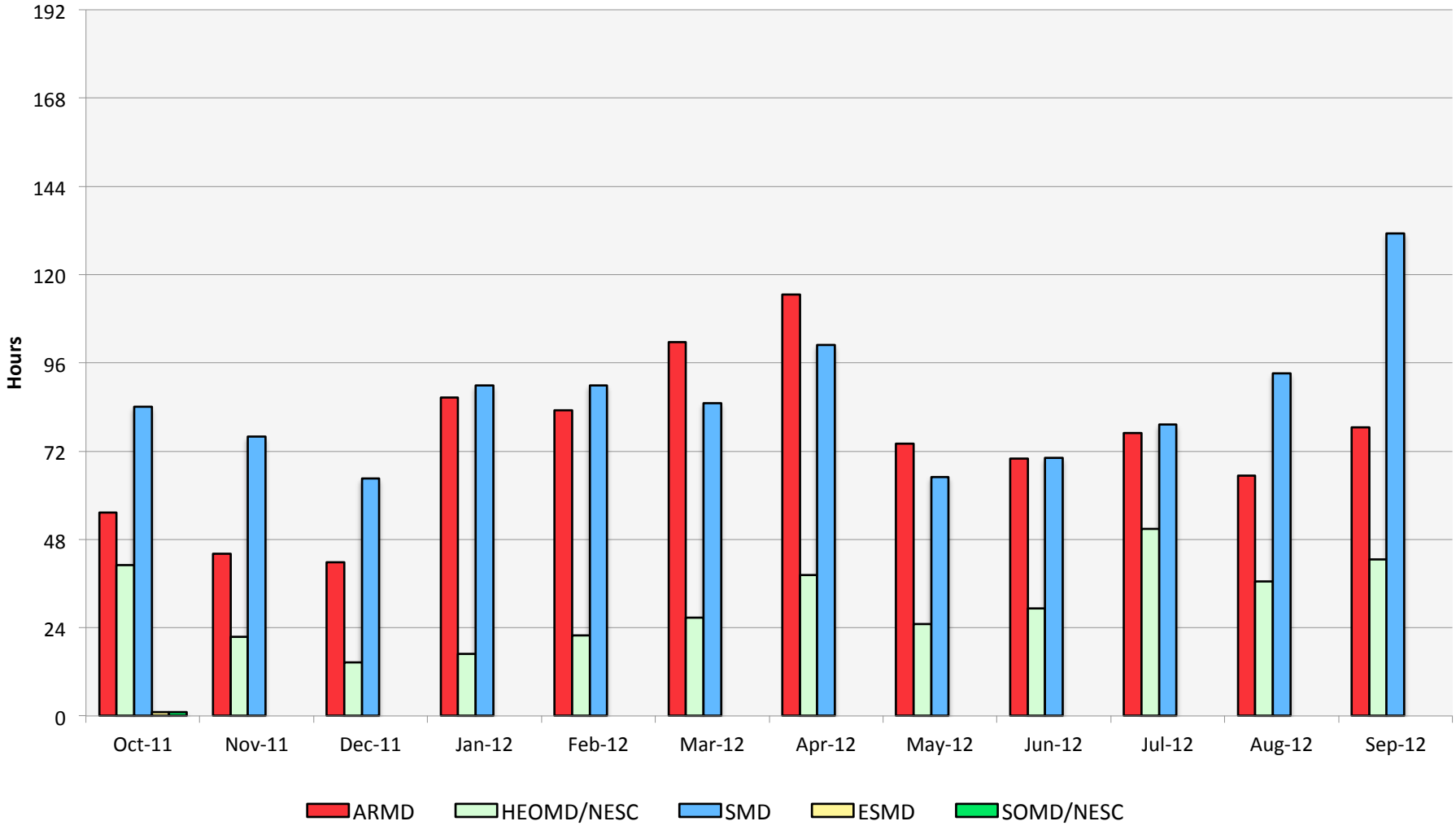
# Pleiades:
# Monthly Utilization by Size and Mission



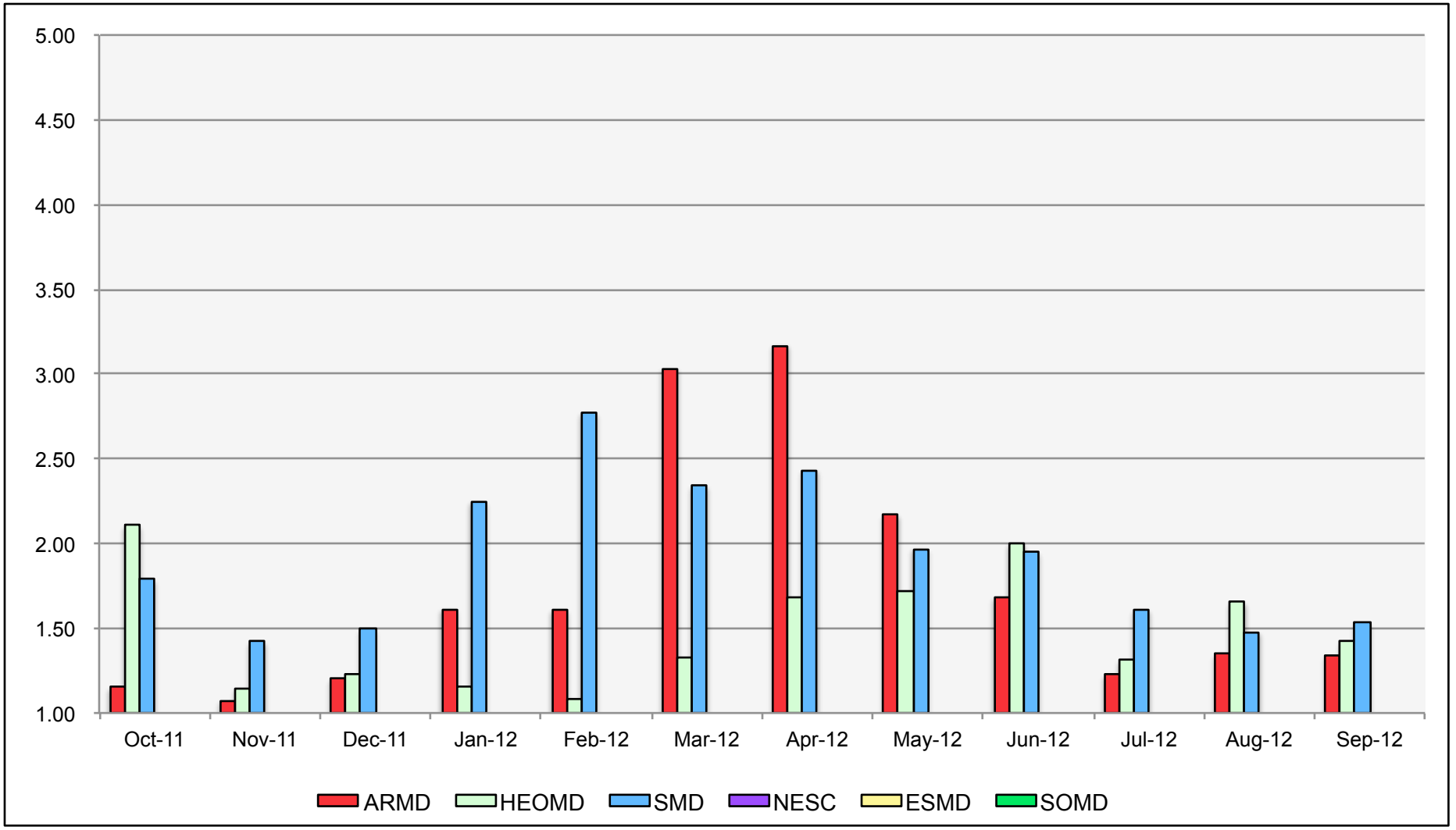
# Pleiades:
# Monthly Utilization by Size and Length



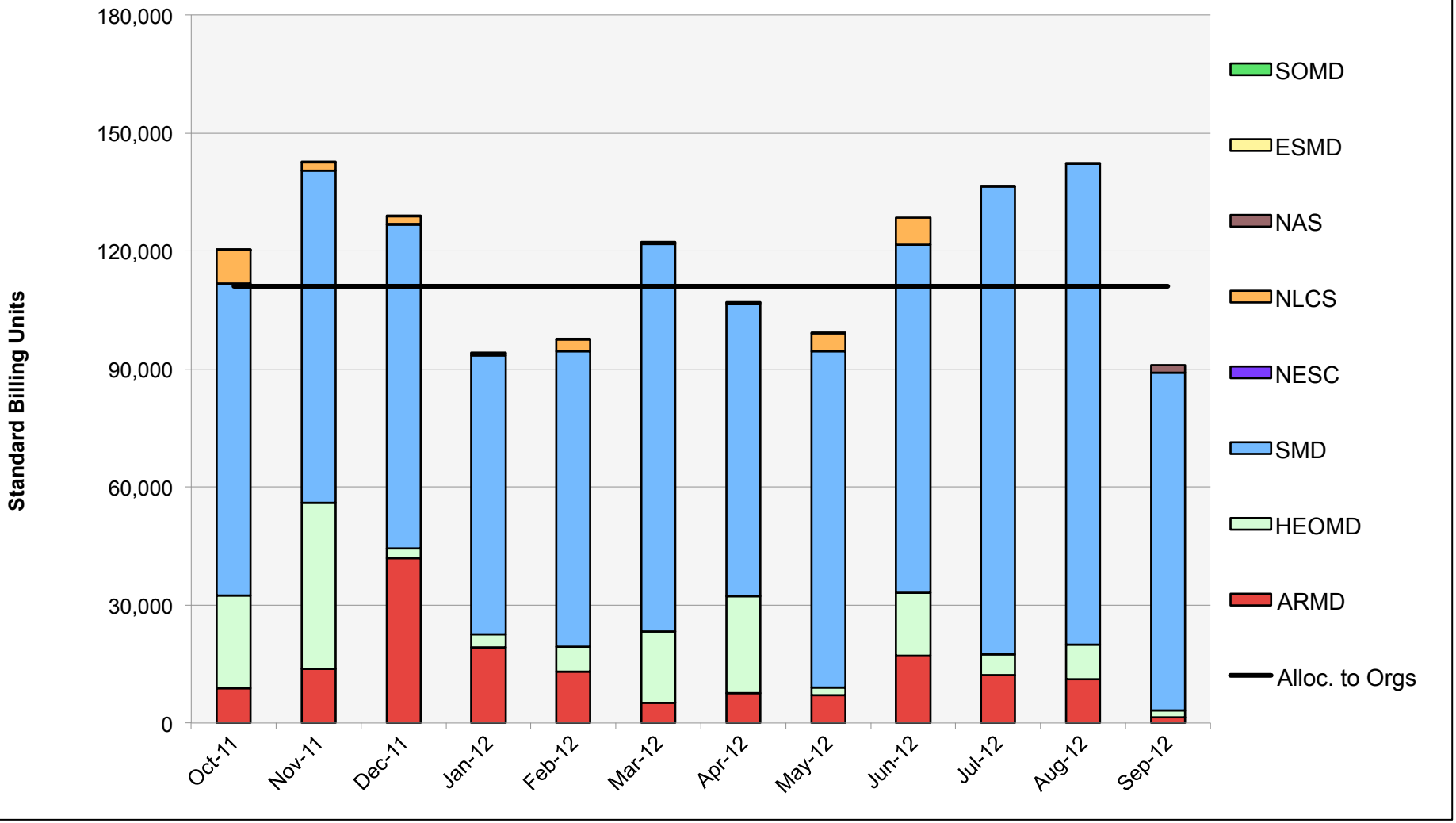
# Pleiades:
# Average Time to Clear All Jobs



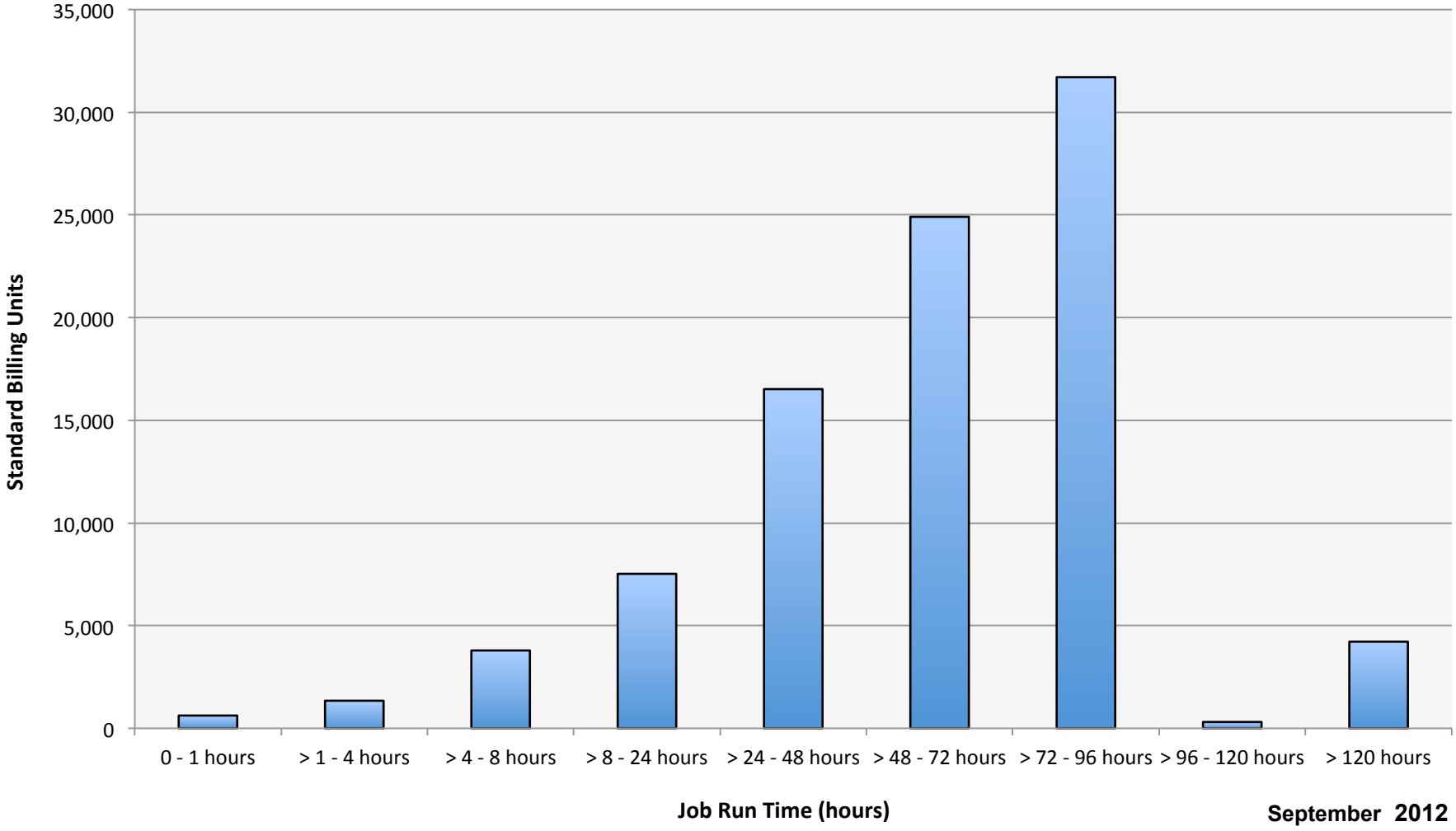
# Pleiades:
# Average Expansion Factor



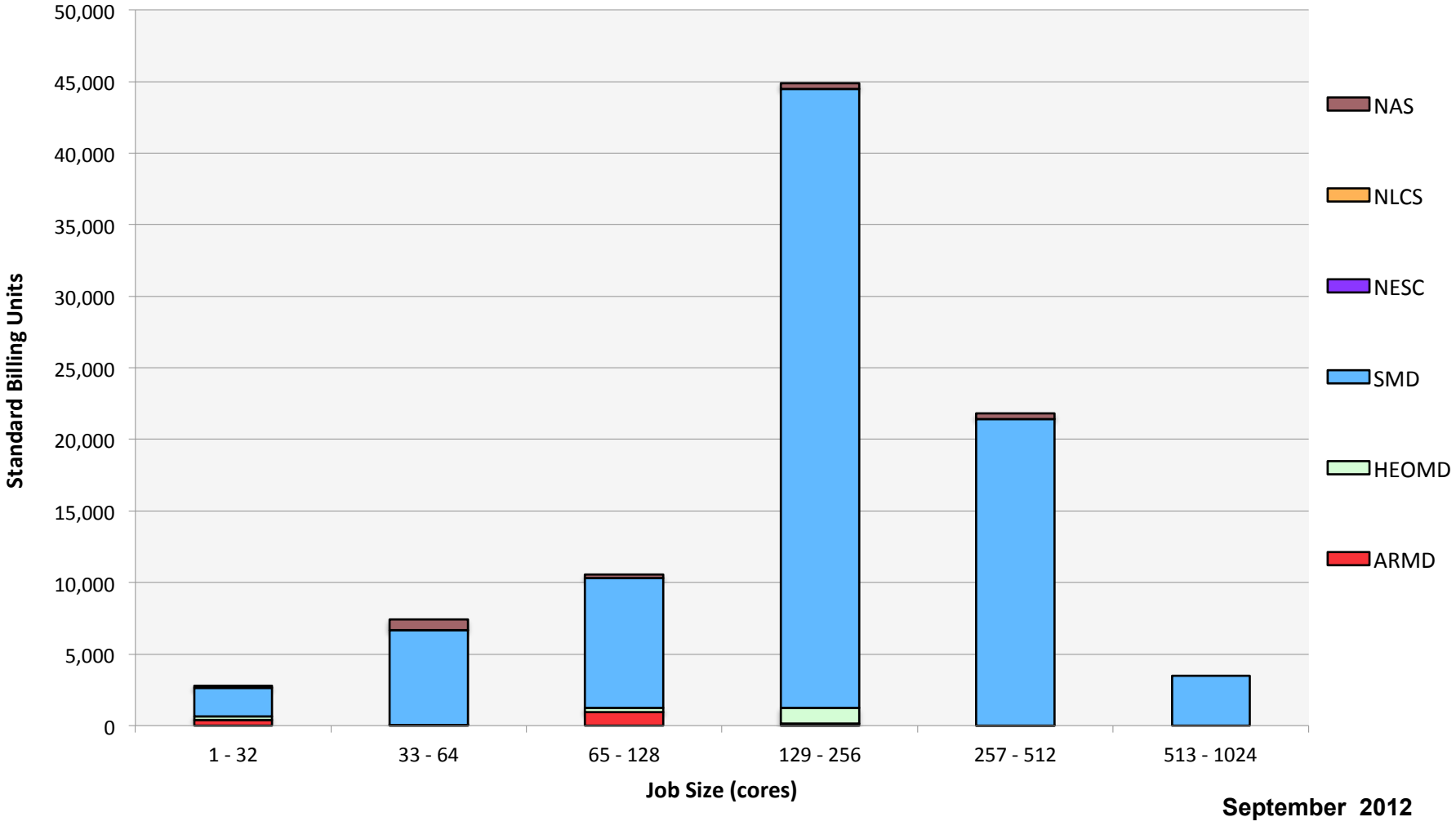
# Columbia:
# SBUs Reported, Normalized to 30-Day Month



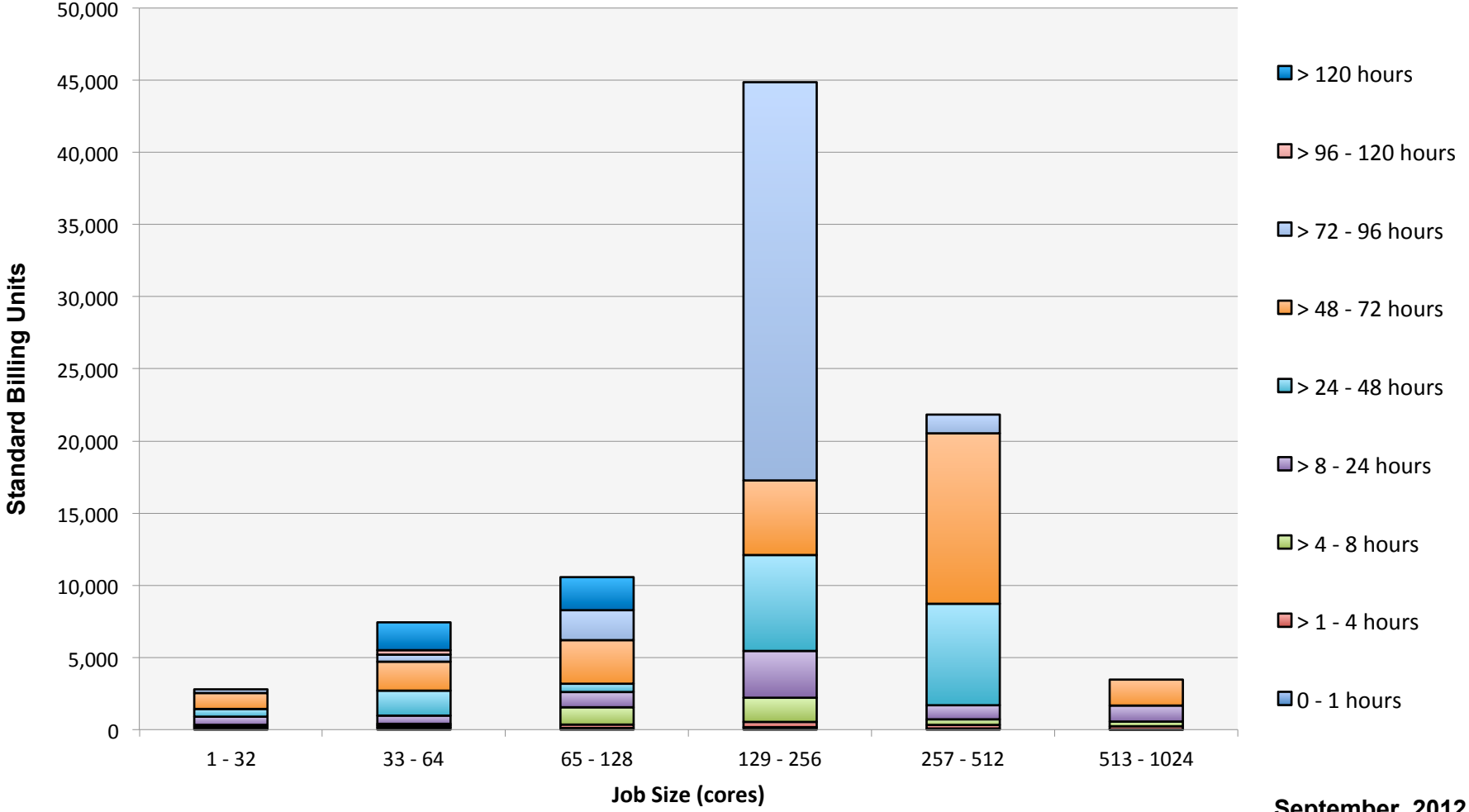
# Columbia:
# SBUs Reported, Normalized to 30-Day Month



# Columbia:
# Monthly Utilization by Size and Mission



# Columbia:
# Monthly Utilization by Size and Length



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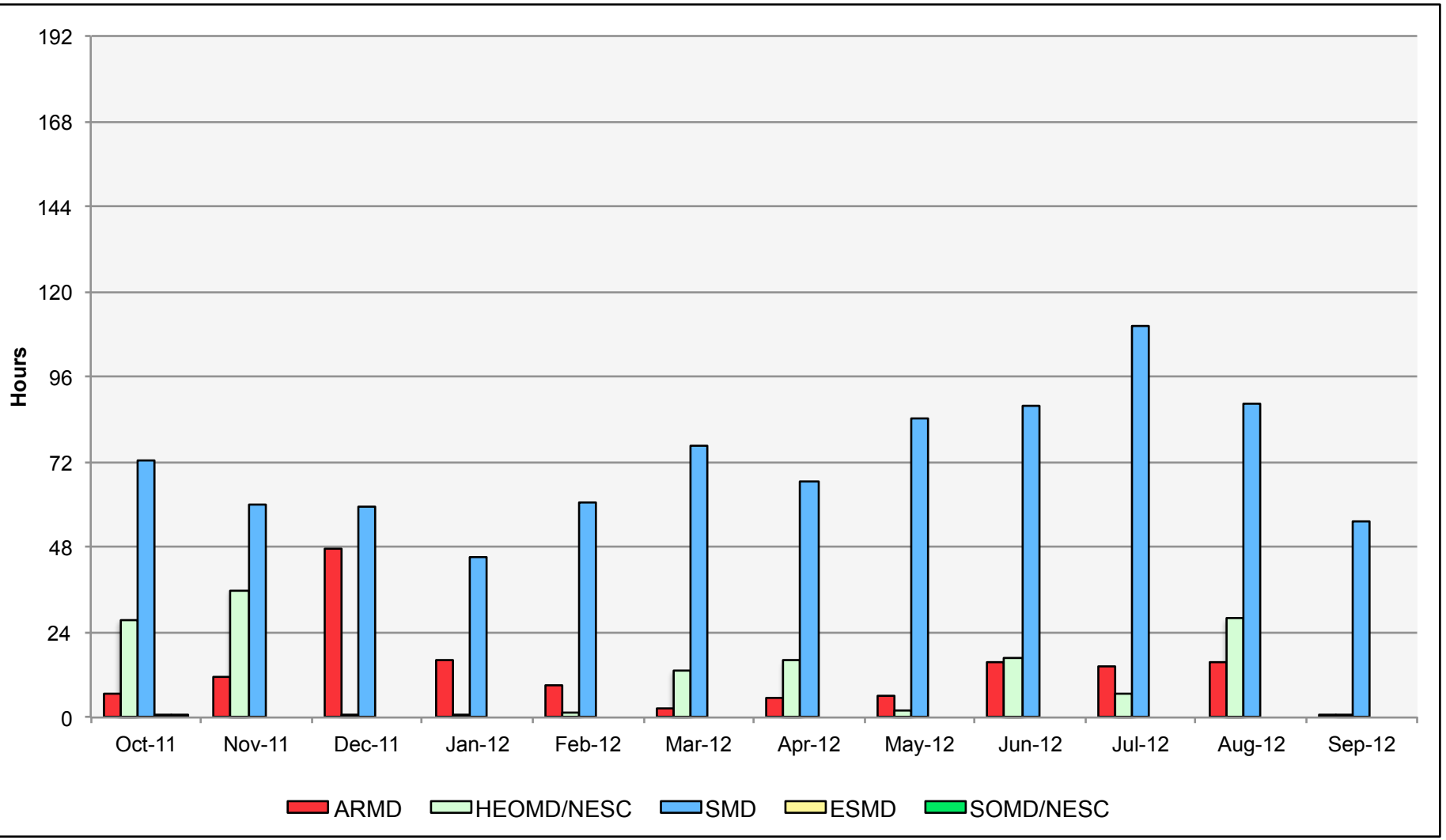

# Columbia:
# Average Expansion Factor