Project Status Report

High End Computing Capability
Strategic Capabilities Assets Program

11 September 2011

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Aerodynamic Analyses of the SpaceX Dragon Rider Crew Capsule

- Computational fluid dynamics (CFD) experts from the NASA Advanced Supercomputing (NAS) Division's Applied Modeling & Simulation Branch have performed aerodynamic simulations of the Dragon Rider crew capsule being designed by Space Exploration Technology Corporation (SpaceX) for NASA's Commercial Crew Development Program.
- Using NASA's OVERFLOW CFD code, the team simulated the aerodynamic airflow around the capsule at three different Mach numbers.
- For each Mach number, the team ran simulations using a range of computational grid resolutions, two different turbulence models, and two far-field boundary conditions to determine which produced the best results and quantify the sensitivity of the results to these factors.
- These analyses will help SpaceX assess and develop the aerodynamic criteria and abort capabilities for their Dragon Capsule, and will help provide validation and verification for the company's own CFD simulations.

Mission Impact: HECC is supporting NASA's Commercial Crew Development Program by providing expert modeling and simulation support for candidate commercial crew vehicle designs.

Figure: Rendering of the SpaceX Dragon Capsule. Image courtesy of SpaceX.

POC: *Ted Manning, ted.a.manning@nasa.gov, (650) 604-2285, NASA Advanced Supercomputing Division*

Large-Scale Launch Environment Simulations for Future HLLV Missions

- Computational fluid dynamics (CFD) experts in the NASA Advanced Supercomputing (NAS) Division are running simulations on Pleiades of the launch environment for future heavy lift launch vehicle (HLLV) missions. Results include:
  - Simulation of the ignition overpressure (IOP) phenomenon to predict pressure loads on the vehicle and launch pad trench walls.
  - Establishing computational methodologies to predict acoustic noise sources and sound propagation during during liftoff
- CFD simulations have yielded IOP and acoustic level results in agreement with flight data and empirical prediction methods, validating the approach's accuracy for future vehicles.
- These simulations require large computational resources to accurately resolve the physics, which can only be run on supercomputer systems.
- HECC's parallel visualization tools are essential to examine the results of the simulations; researchers use up to 512 processors of the hyperwall-2 to investigate the results with much faster turnaround.

Mission Impact: These CFD simulations, enabled by HECC resources and services, help assess the suitability of existing launch facilities for larger vehicles, and will help ensure successful HLLV launches.

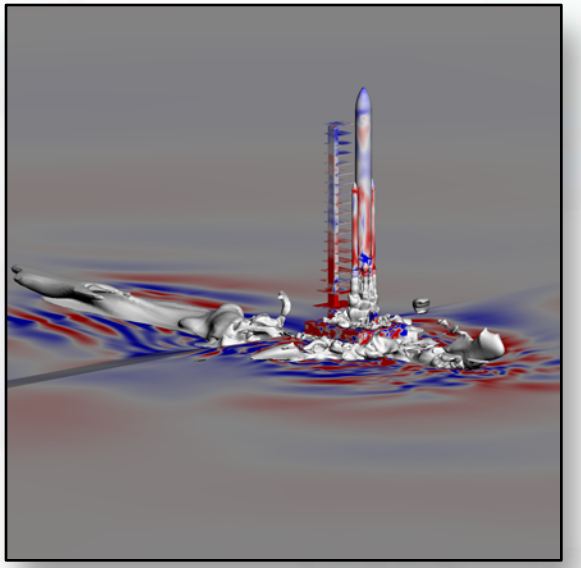


***Figure**: Gauge pressure contours are shown on the Ares V vehicle (now the Space Launch System); surrounding structures, and exhaust gases are depicted by an isocontour at 5% concentration. Note that acoustic pressure waves radiate predominantly in the direction of the flame trench. Jeffrey Housman, NASA/Ames*

***POCs:** Cetin Kiris, cetin.c.kiris@nasa.gov, (650) 604-4485,*
Jeffrey Housman, jeffrey.a.housman@nasa.gov, (650) 604-5455,
NASA Advanced Supercomputing Division

Advanced Simulations Provide New Views of the Solar Atmosphere

- In support of NASA's IRIS mission, researchers at Lockheed Martin and the University of Oslo are running advanced magnetohydro-dynamic (MHD) simulations on Pleiades to improve understanding of the Sun's atmosphere, including:
  - The role of chromospheric heating and dynamics in the solar atmosphere.
  - Mass and energy transfer from the convection zone into the solar corona and solar wind.
  - Complex interactions of magnetic fields, hydrodynamics, and radiation fields, which presents one of the great astrophysics challenges.
- HECC supercomputing resources are required to handle the numerical modeling of these complex radiative transfer and physical processes, and the large contrasts of density, temperature and magnetic field. As the physical complexity of the simulations increases, so do the processor requirements—on the order of 1-5 million processor hours for 1 hour of solar time.

Mission Impact: HECC supercomputing resources enable crucial numerical simulation and modeling in support of the upcoming Interface Region Imaging Spectrograph (IRIS) mission.

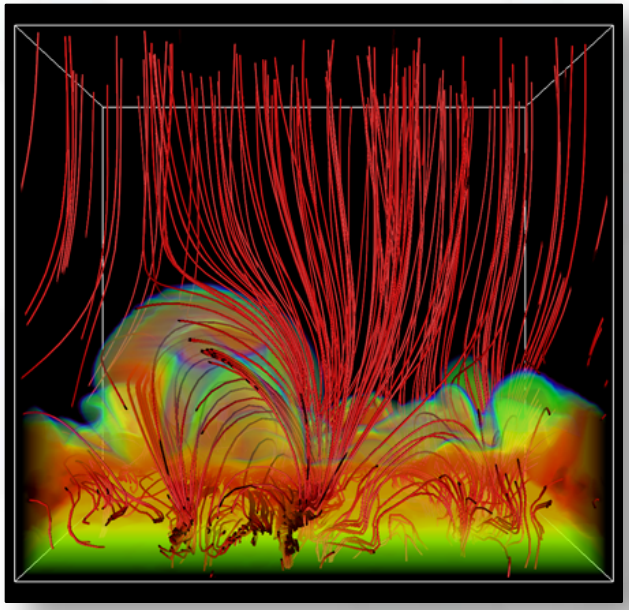


Figure: MHD simulation from the convection zone (bottom) through the transition region (yellow-blue) to the corona. The atmosphere is permeated by magnetic fields (red lines) that sway back and forth, carrying enough energy from the engine of the convection to accelerate the solar wind. Mats Carlsson, University of Oslo

POC: *Mats Carlsson, mats.carslon@astro.uio.no, +47 99032357, University of Oslo*

Modeling of Solar and Stellar Dynamos Supports SMD Studies

- Researchers at the National Center for Atmospheric Research (NCAR) are modeling solar and stellar dynamos to address such specific questions as:
  - How are coherent, large-scale magnetic flux structures, such as those underlying sunspots and coronal loops, formed amid the intense turbulence of the solar convection zone?
  - How do such flux structures destabilize, rise, and emerge from the solar interior, through the surface, and into the solar atmosphere?
  - Why does solar activity rise and fall with a period of about 11 years (polarity changes yield a net period of 22 years)?
- HECC's Pleiades supercomputer, mass storage, and network resources enable these high-resolution models and accommodate the hundreds of terabytes of data that they generate.
- In addition, HECC experts provide visualization services that are essential to properly analyzing this data and maximizing scientific impact.

Mission Impact: HECC resources and services are essential to supporting Science Mission Directorate studies aimed at understanding the origins of solar magnetism—key to understanding solar-terrestrial connections and the Sun's influence on other planets.

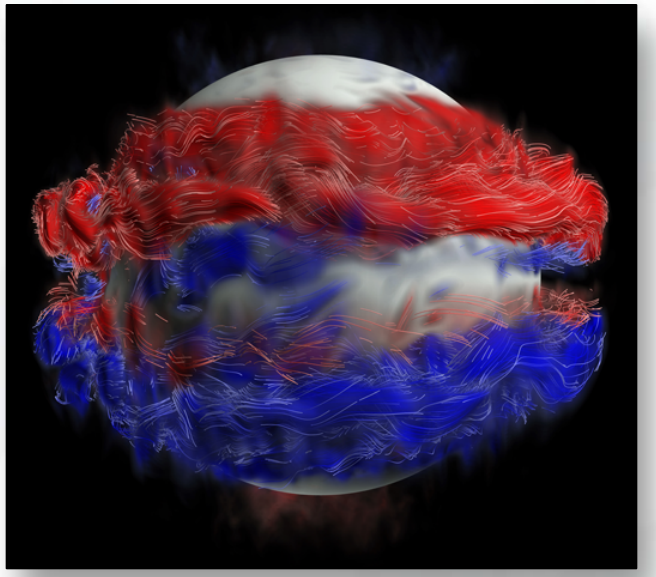


Figure: Wreathes of magnetism in a star rotating five times faster than the Sun. Color indicates magnetic polarity, which reverses sign every few years. Observations of young stars confirm that turbulent convection and rapid rotation breed vigorous magnetic activity. Benjamin Brown, University of Wisconsin; Timothy Sandstrom, NASA/Ames

POC: *Mark S. Miesch, miesch@ucar.edu, 303-497-1582, High Altitude Observatory, National Center for Atmospheric Research*

Second Pleiades Filesystem Deployed with 10x IOPS Performance

- A second Pleiades Lustre filesystem, named nobackupp2, has been deployed to replace nobackupp20/40.
- The new filesystem has double the disk capacity and will provide 10x the Input/ Output Operations Per Second (IOPS) performance of the old filesystem.
- The 10-fold improvement in IOPS addresses a deficiency in the previous RAID controller, and will provide better interactive filesystem performance to researchers.
- The remaining filesystems on Pleiades will also be upgraded to attain a 10x improvement in IOPS.
- The next two new filesystems, named nobackupp3/4, are in the process of being configured and installed, and will serve users currently using nobackupp50/60.

Mission Impact: Along with the increased computational capability of Pleiades, faster and larger temporary storage space enables researchers to more fully utilize HECC resources.

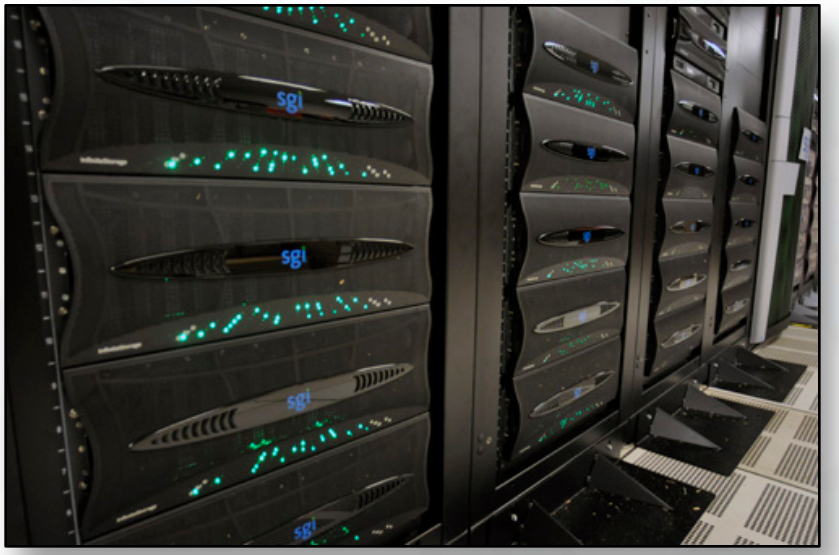


Figure: The new Data Direct Networks (DDN) RAID controllers provide a 10x improvement in IOPS performance, which, combined with increased hard drive storage density, substantially enhances HECC filesystem capabilities.

POC: *Bob Ciotti, bob.ciotti@nasa.gov, (650) 604-4408, NASA Advanced Supercomputing Division*

HECC Completes Annual Facility Maintenance

- HECC's annual two-day shutdown for major facility maintenance was successfully completed August 20-21.
- The primary work involved cleaning the cooling tower of a year-long accumulation of dirt and debris, to assure proper operation.
- Facility engineers also inspected the cooling tower to assure structural integrity, and to prepare for an upcoming test to increase in tower cooling water flow capacity.
- Additional work included installing conduit on the 13,800-volt transformers in advance of the 2012 installation of a reliable uninterruptible power supply (RUPS).
- The shutdown also allowed HECC Systems, Network, and other technical teams to perform maintenance tasks that must be accomplished during non-production hours in order to reduce the impact on users.

Mission Impact: While the facility maintenance shutdown temporarily interrupts system availability, it assures that needed maintenance, inspection, and repairs can be completed, which improve overall systems reliability.

Figures: One of four below-ground pumps (left) inside the cooling tower (right) that return cooled water to the building, which removes heat from the computer floor and other areas of the facility.

POC: *John Parks, john.w.parks@nasa.gov, (650) 604-4225, NASA Advanced Supercomputing Division*

Dedicated Time Activities Improve Systems Reliability

- The HECC Systems team made several improvements to Pleiades, Columbia, and the archive storage systems during a dedicated period scheduled to take advantage of facility maintenance downtime (see slide 8). Improvements include:
  - Reconfigured the Fibre Channel tape library infrastructure to optimize performance and decrease the time to retrieve/store user data.
  - Installed and deployed new NFS file servers for Columbia, in order to retire the IRIX NFS file servers (see slide 11).
  - Deployed a new PBS server to improve the responsiveness of the batch scheduler for interactive usage.
  - Updated the InfiniBand Subnet Manager to incorporate bug fixes.
  - Replaced failing hardware components in the systems.

Mission Impact: The improved system reliability and performance gained from regular upgrades provides HECC users with a more usable computational capability.

Figure: Dedicated time on the Pleiades supercomputer (above) enabled essential changes to improve ongoing operations of HECC resources.

POC: *Bob Ciotti, bob.ciotti@nasa.gov, (650) 604-4408, NASA Advanced Supercomputing Division*

Network Upgrades Ensure More Secure Environment

- The HECC Network team capitalized on facility maintenance downtime (see slide 8) to complete several maintenance activities, including:
  - Upgraded the operating system on all Cisco network devices to the latest version and security patches.
  - Staggered the network ports in subfloor enclosure boxes, and eliminated high-density problems; modular design of the network infrastructure enabled the network team to complete this work quickly and easily.
  - Swapped all patch cables in the high-end computing network infrastructure with cables designed for high-density environments, for ease in troubleshooting problems—a major effort.
  - Replaced old network cabinet housing fiber channel switches, allowing equipment to be mounted safely and securely.

Mission Impact: These upgrades provide a more manageable and secure network environment for HECC resources. Performing this work during facility maintenance time avoided incurring additional impact to users.

Figure: New patch cables in network racks and subfloor enclosures located in the HECC main computer room.

POC: *Chris Buchanan, chris.buchanan@nasa.gov, (650) 604-4308, NASA Advanced Supercomputing Division*

Retirement of Last Production IRIX System Marks the 'End of an Era'

- During the recent facility maintenance downtime (see slide 8), the last production SGI IRIX system was retired—marking the end of 15 years of IRIX/MIPS (Microprocessor without Interlocked Pipeline Stages) computing architecture at the NASA Advanced Supercomputing facility.
- The IRIX platform was first scaled to 64 processors (CPUs) in 1997, and eventually scaled to 128, 256, 512, and finally 1024 CPUs in 2001; each of these were the first systems to scale to that size on a single system image (SSI) system.
- The knowledge and experience gained from scaling these systems provided HECC staff with the foundation to build on the success of the IRIX/MIPS platform in the next-generation system, Columbia, in 2004.

Mission Impact: The scaling of the IRIX/MIPS architecture pushed the boundaries of supercomputing and provided unique computing resources to Mission Directorates, enabling cutting edge science.

Figure: *From top left: chapman, a 1024-processor Origin 3000 SSI system; turing, a 64-CPU Origin 2000 SSI system; and lomax, a 512- CPU Origin 2000 SSI. Each was a first-of-a-kind system pushing the boundaries of supercomputing.*

POC: *Bob Ciotti, bob.ciotti@nasa.gov, (650) 604-4408, NASA Advanced Supercomputing Division*

HECC Facility Hosts Several Visitors and Tours in August 2011

- HECC hosted 17 tour groups in August; guests received an overview of the HECC Project, demonstrations on the hyperwall-2 visualization system, and tours of the computer room floor:
  - Ed Weiler, SMD Associate Administrator, viewed NEX results on the hyperwall-2; he suggested that Paul Hertz, SMD Chief Scientist, also visit the facility.
  - Several groups from the NASA Advisory Council (NAC), including Administrator Bolden, Ames Center Director Pete Worden, and Bette Siegel, ESMD Executive Secretary for the Space Exploration Subcommittee and Audit, Finance & Analysis Subcommittee.
  - A Discovery Science Channel crew filmed Kepler images on the hyperwall-2 for an upcoming story.
  - Hena Kazmi, Project Manager for the NASA Technical Capabilities Task, SMD.
  - Jens Feeley, Senior Policy Analyst, SMD, brought J. K. Kundu, OMB Budget Analyst, to visit the facility.
  - 14 students of the NASA Ames Academy for Space Exploration, including 3 international students from France, the Netherlands, and Australia.
  - 40 U.S. Army staff from the Presidio of Monterey.

Figure: Students from the NASA Ames Academy for Space Exploration watch intently as HECC visualization staff explain scientific animations shown on the hyperwall-2 system.

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

Presentations and Papers

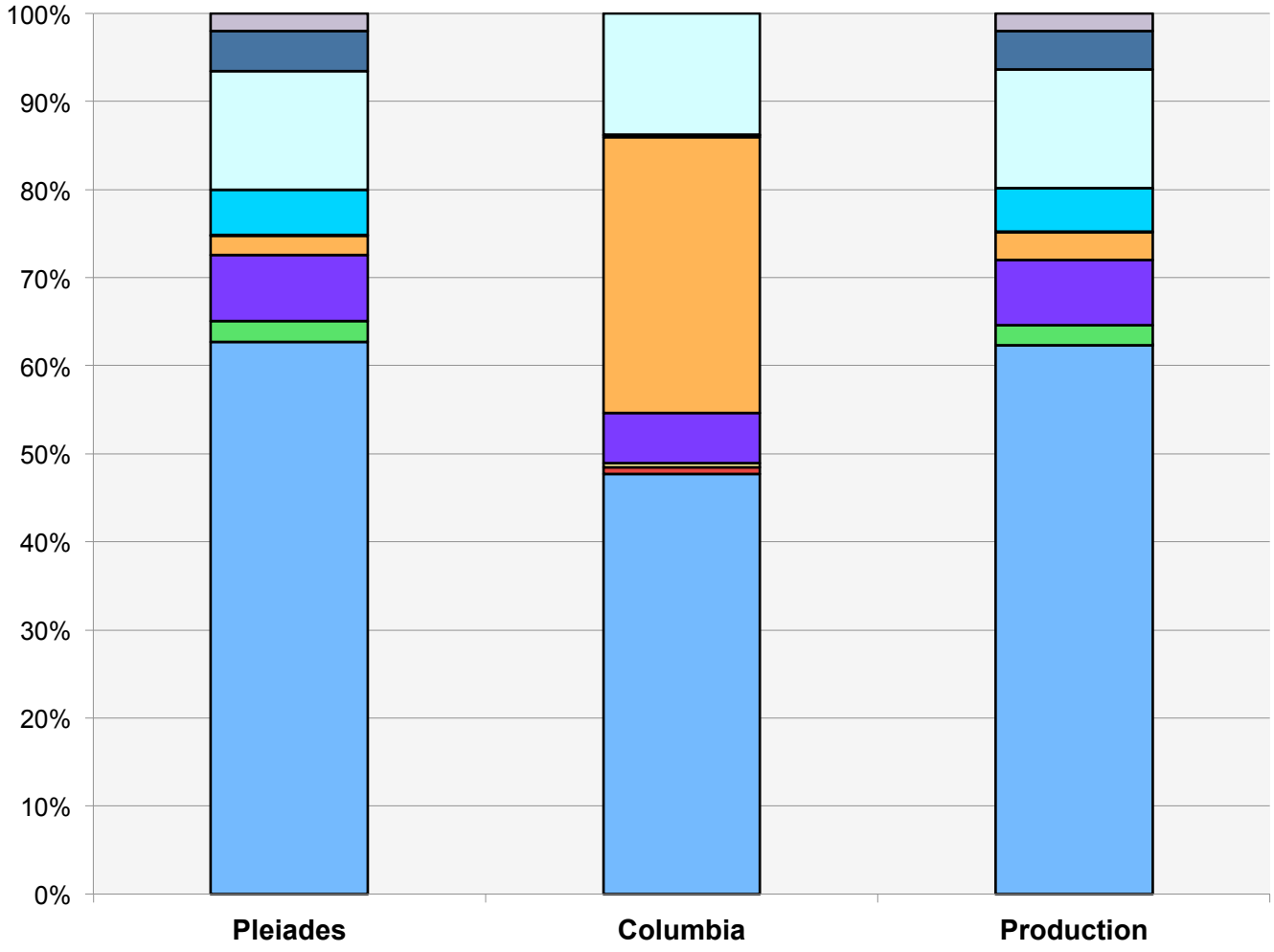
- **NASA IT Summit,** August 15–19, San Francisco, CA
  - "NASA Supercomputing and Its Impact on Agency Missions," R. Biswas
  - "Reducing False-Positives and False-Negatives in Security Event Data Using Context," D. Shaw
  - "High End Computing Capability to meet NASA's Engineering and Scientific Needs," W. Thigpen
- **Space Mission Challenges for IT (SMC-IT) Conference**, August 2, Palo Alto, CA
  - "Addressing the Deceleration Challenge: Drag Augmentation for Atmospheric Entry," N. Bakhtian*
  - "Challenges and Progress in Aerodynamic Database Generation for Booster Separation from a Heavy Lift Launch Vehicle," M. Barad, M. Gusman, C. Kiris*
  - "Space-Time Accuracy Assessment of CFD Simulations for the Launch Environment," J. Housman, M. Barad, C. Kiris*

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

News and Events

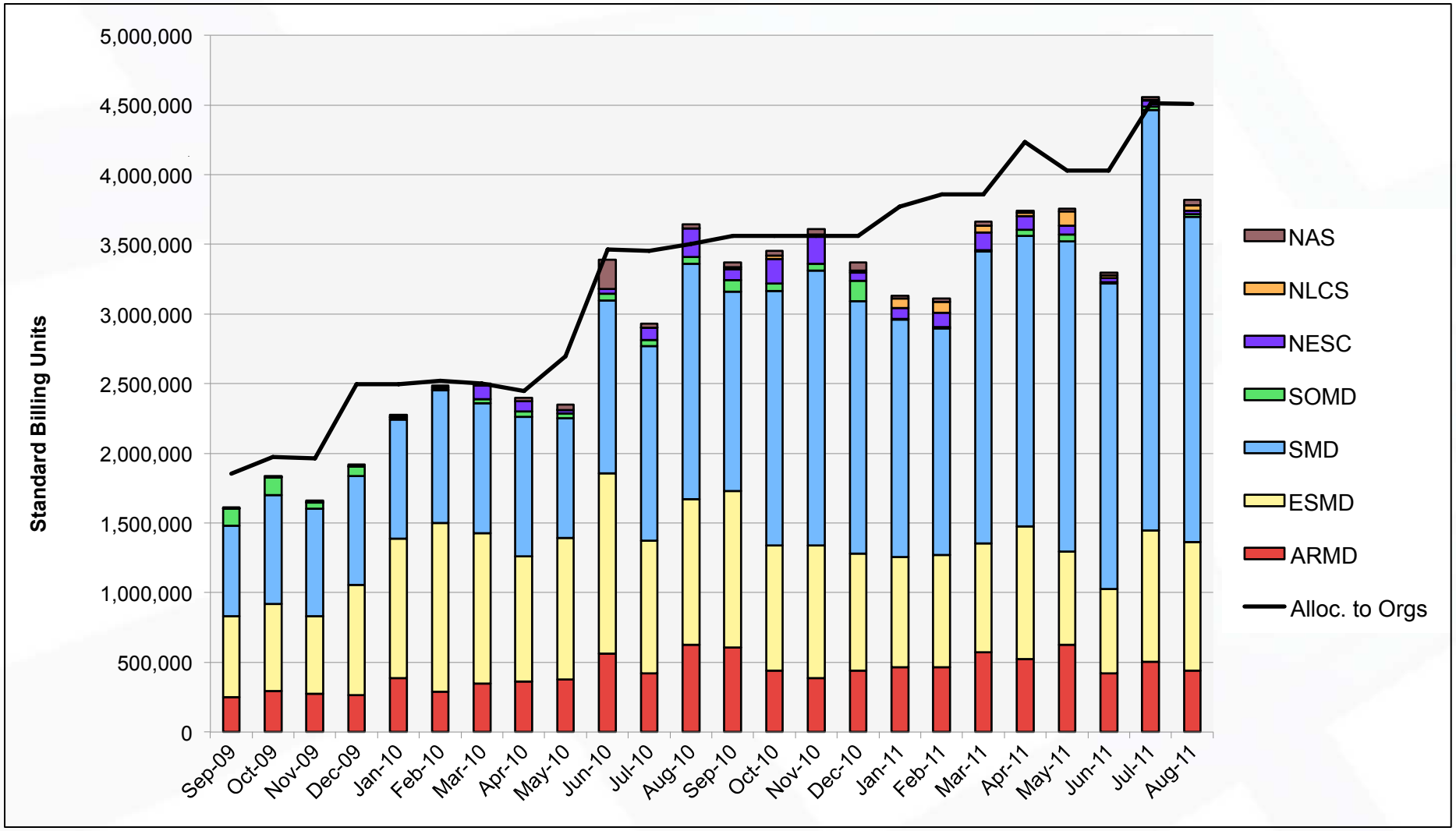
- **First glimpse into birth of the Milk Way**, *press release, University of Zurich,* August 25, 2011 – A large simulation performed on Pleiades by researchers at UCSC and the Institute for Theoretical Physics in Zurich solves a longstanding problem that had led some to question the prevailing cosmological model of the universe. Story picked up by many media outlets, including MSNBC and Popular Science.
  http://www.mediadesk.uzh.ch/articles/2011/erstmals-einblick-in-die-geburt-der-milchstrasse_en.html
- **Astrophysicists report first simulation to create a Milky Way-like galaxy**, *press release University of California, Santa Cruz,* August 29, 2011 – UCSC's version of the above press release, with more information on the importance of supercomputing.
  http://www.eurekalert.org/pub_releases/2011-08/uoc--arf082911.php
- **Supercomputers Allow First Detailed Milky Way Simulation**, *International Business Times,* August 30, 2011 – Shows video of simulation related to above press release.
  http://www.ibtimes.com/articles/206146/20110830/milky-way-galaxy-model-eris-supercomputer-spiral-galaxy-simulation.htm
- **Kepler Mission Manager Update - Closing Quarter Nine, Onto Quarter 10**, *NASA Kepler Mission News*, August 12, 2011 – Covers multi-quarter transit search and data validation tests now run on Pleiades system at NASA Ames Research Center for vastly improved throughput. Picked up by SpaceRef and other media outlets.
  http://www.nasa.gov/mission_pages/kepler/news/keplerm-20110811.html

NAS Utilization

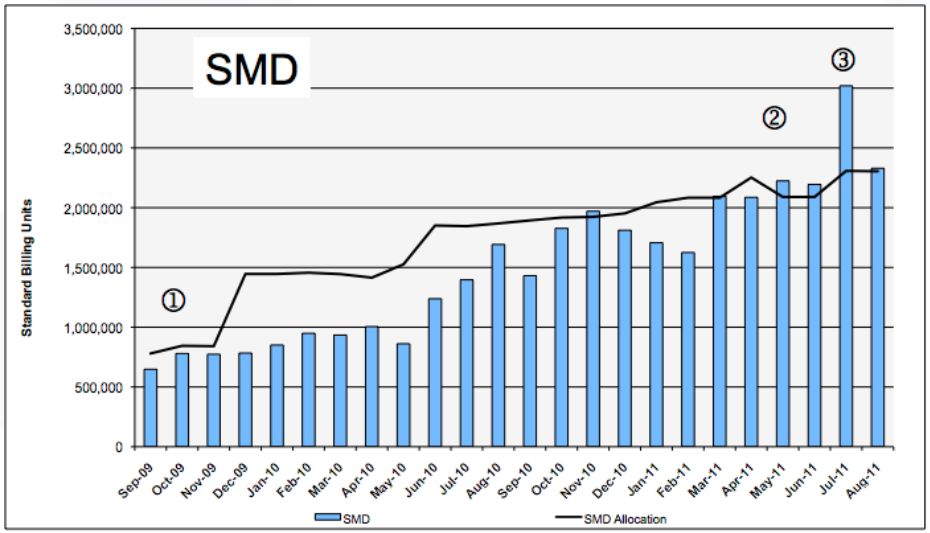


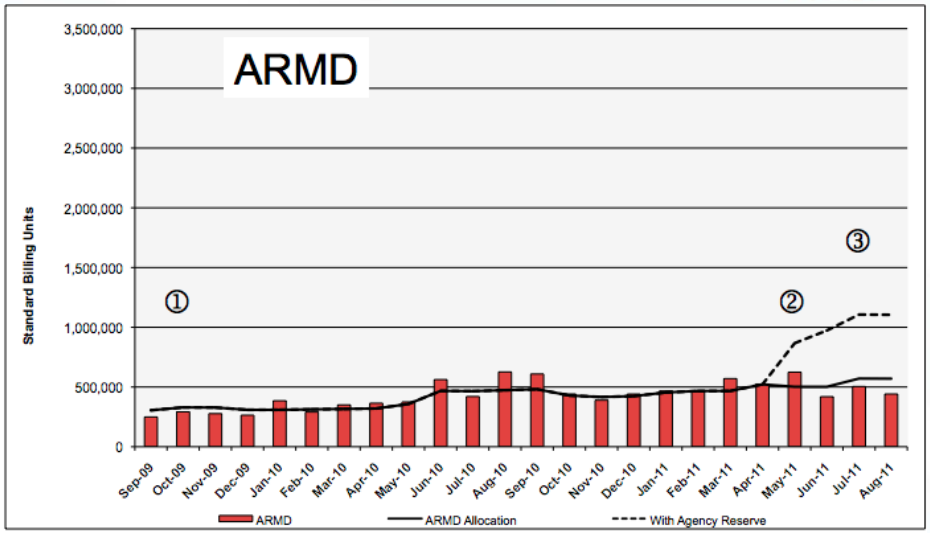
August 2011

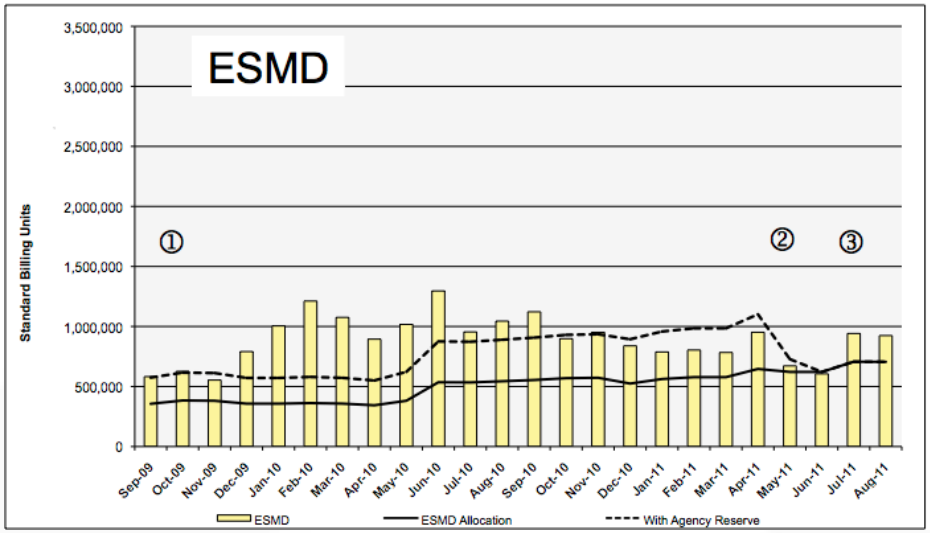
NAS Utilization Normalized to 30-Day Month

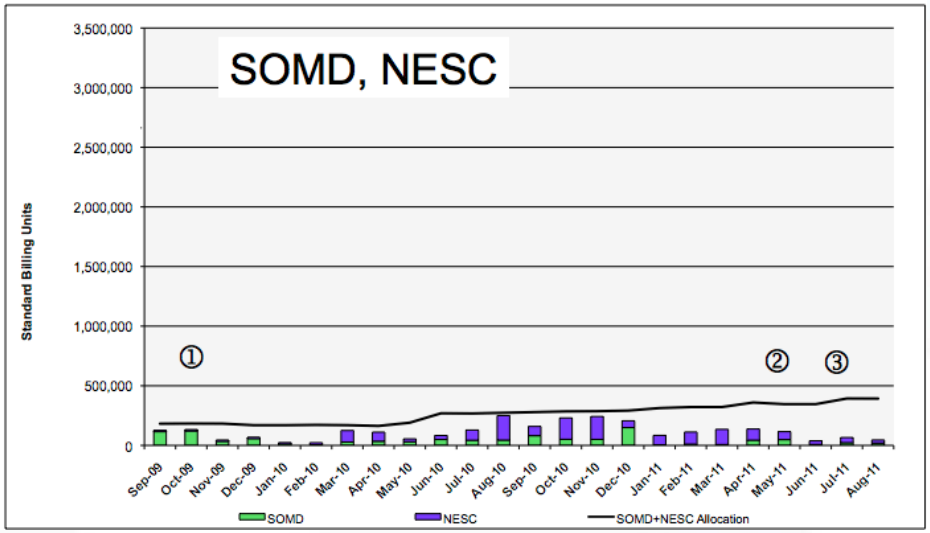


NAS Utilization Normalized to 30-Day Month



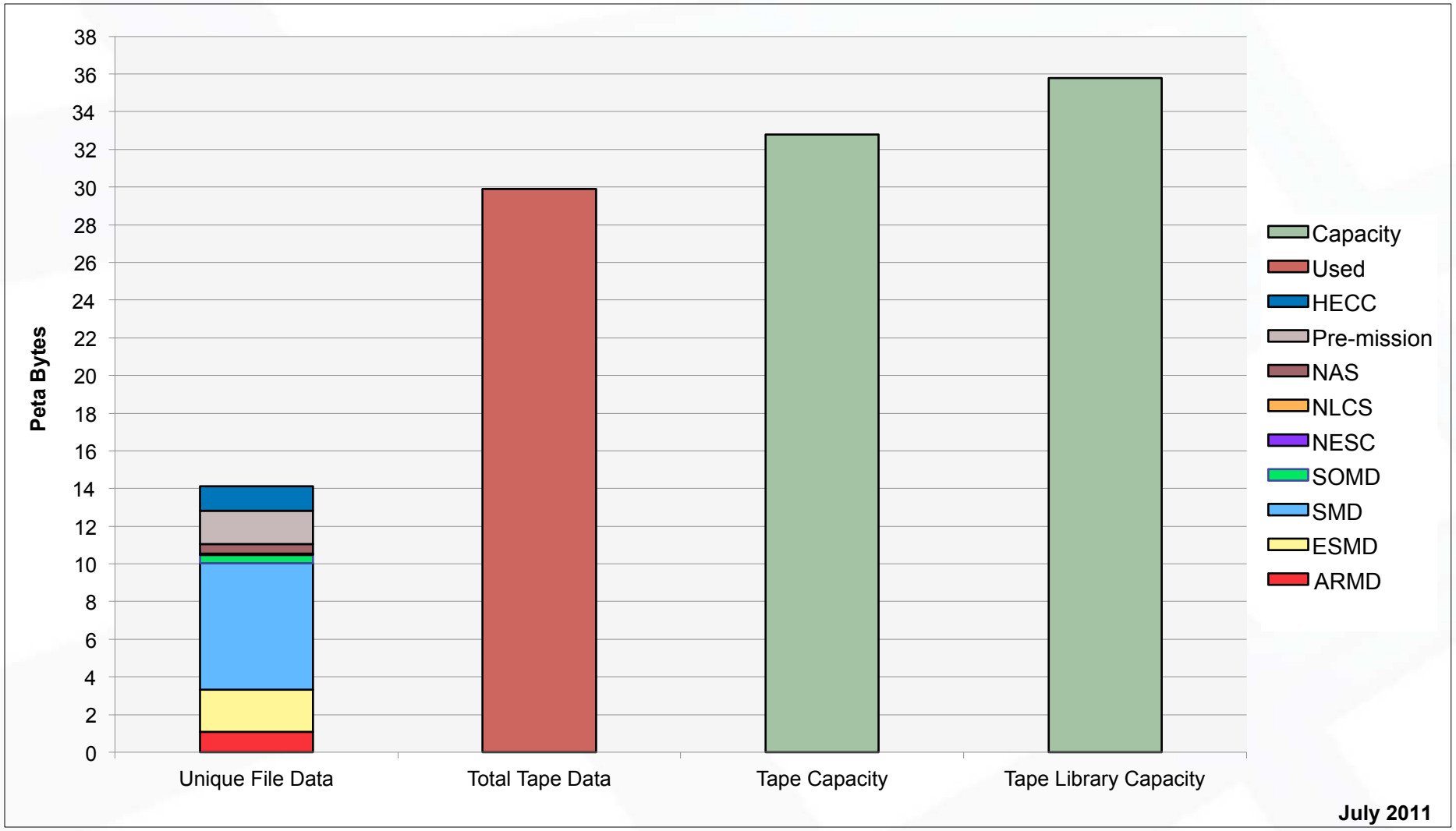




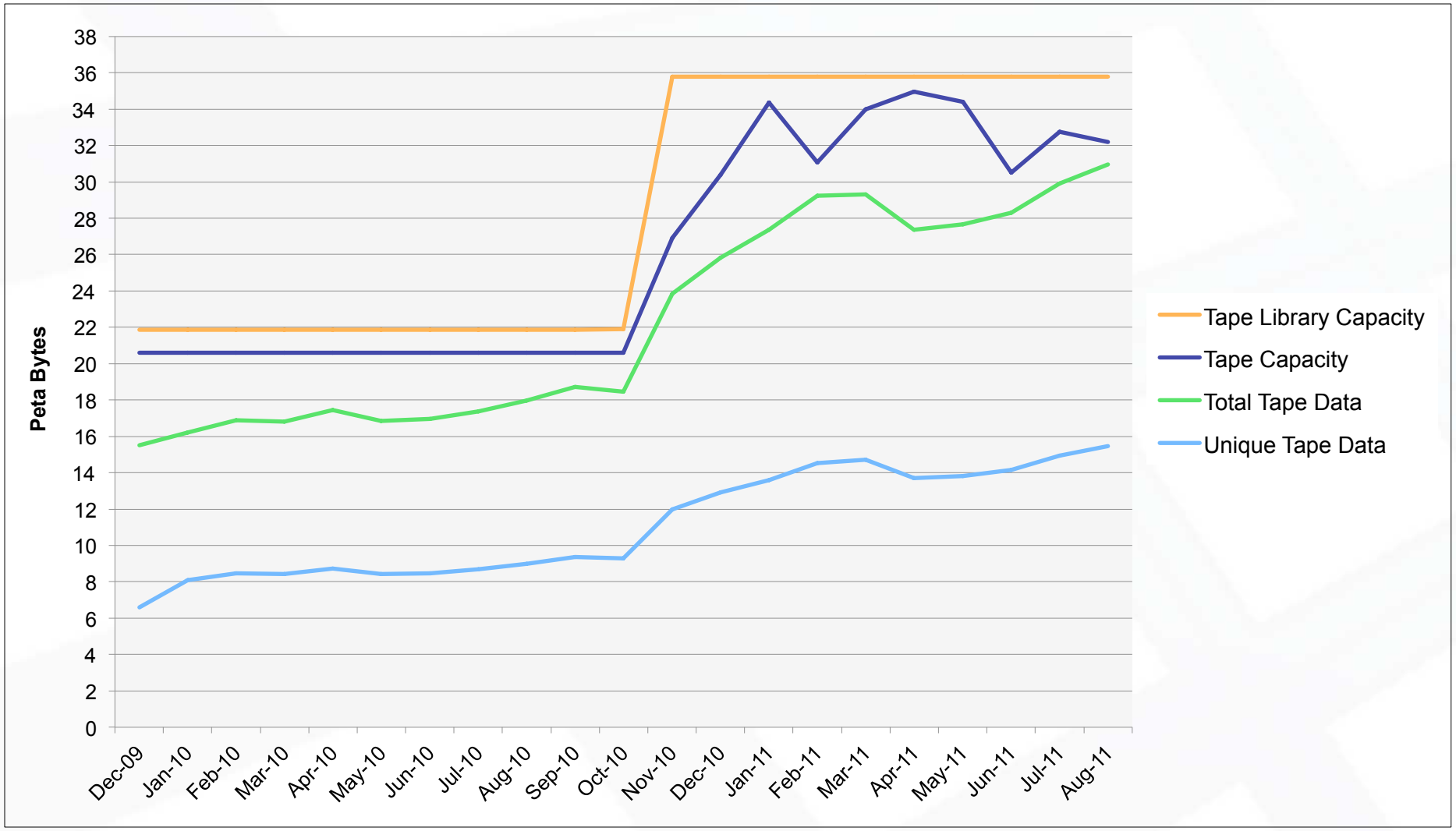


① Allocation to orgs. increased to 80% ② Allocation to orgs. decreased to 75%, Agency reserve shifted to ARMD
③ 14 Westmere racks added

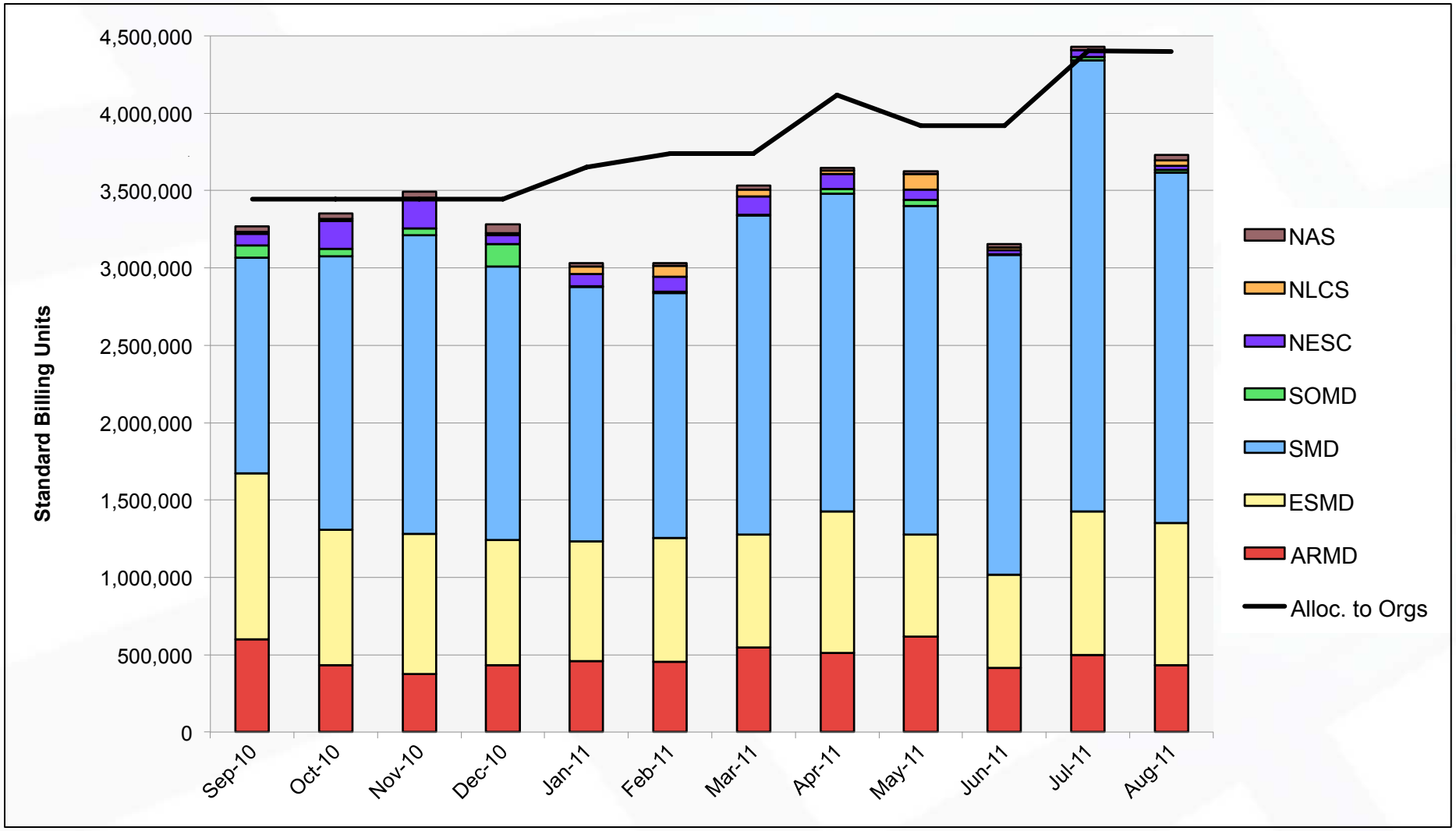
Tape Archive Status



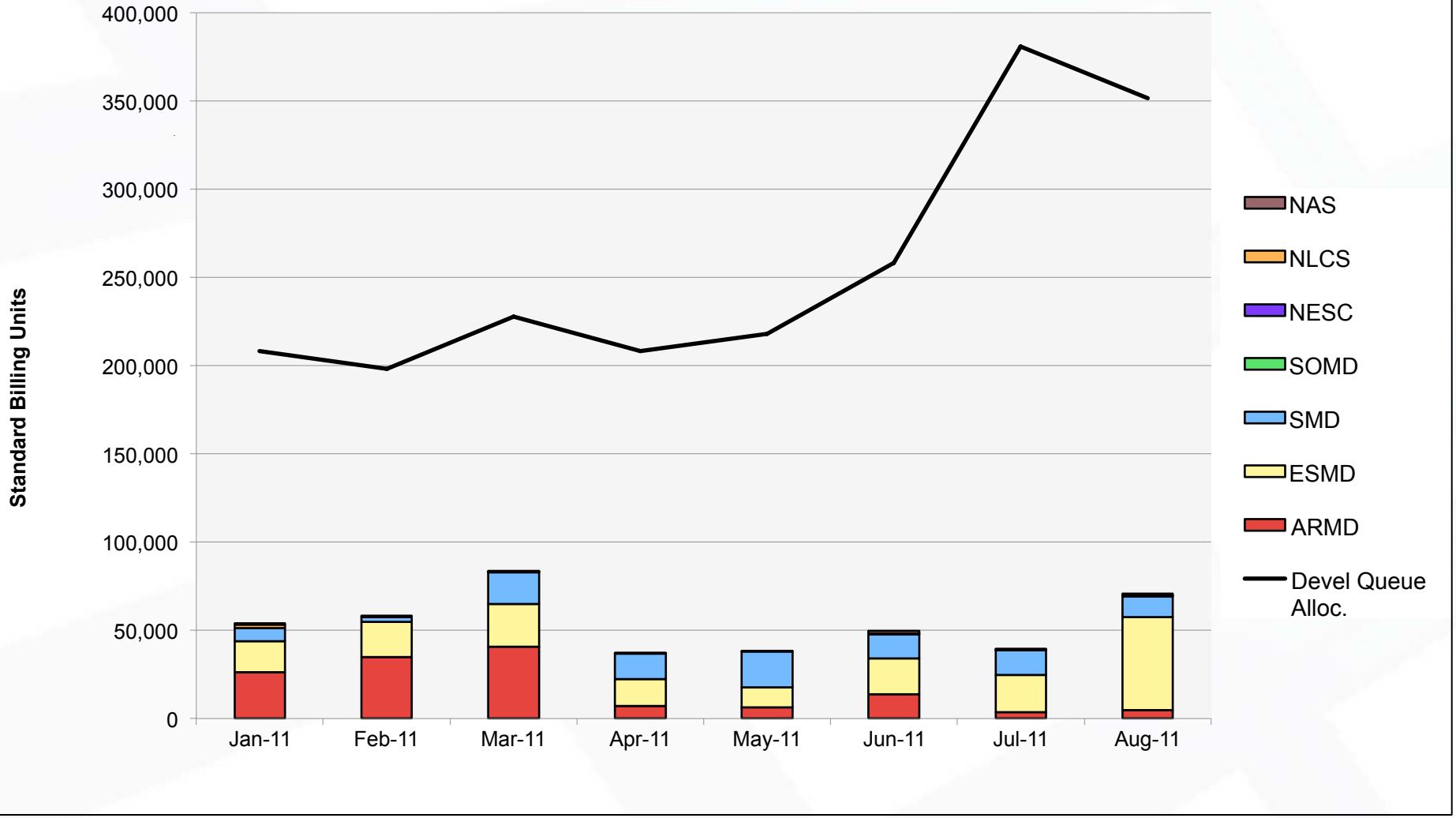
Tape Archive Status



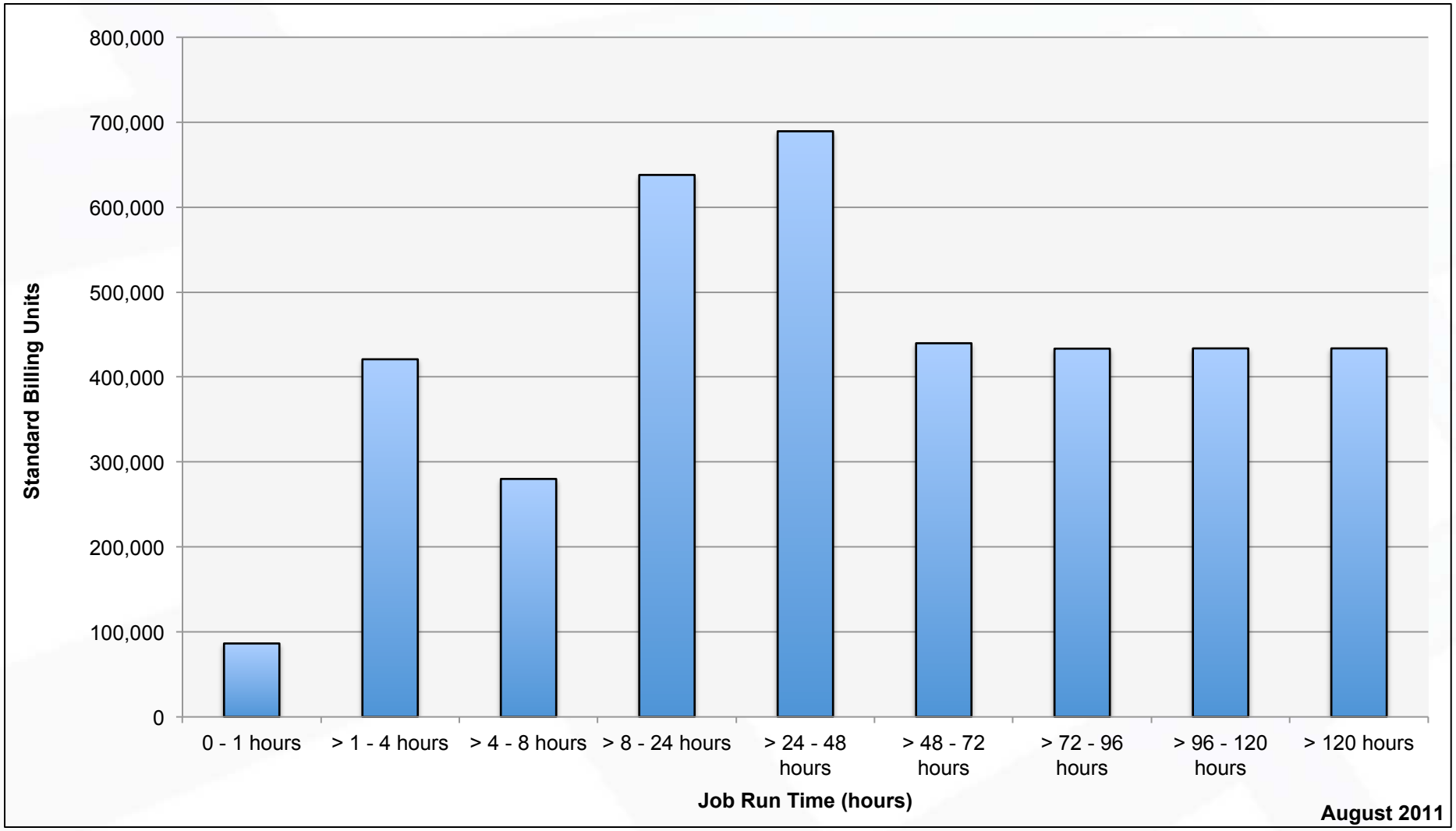
Pleiades:
SBUs Reported, Normalized to 30-Day Month



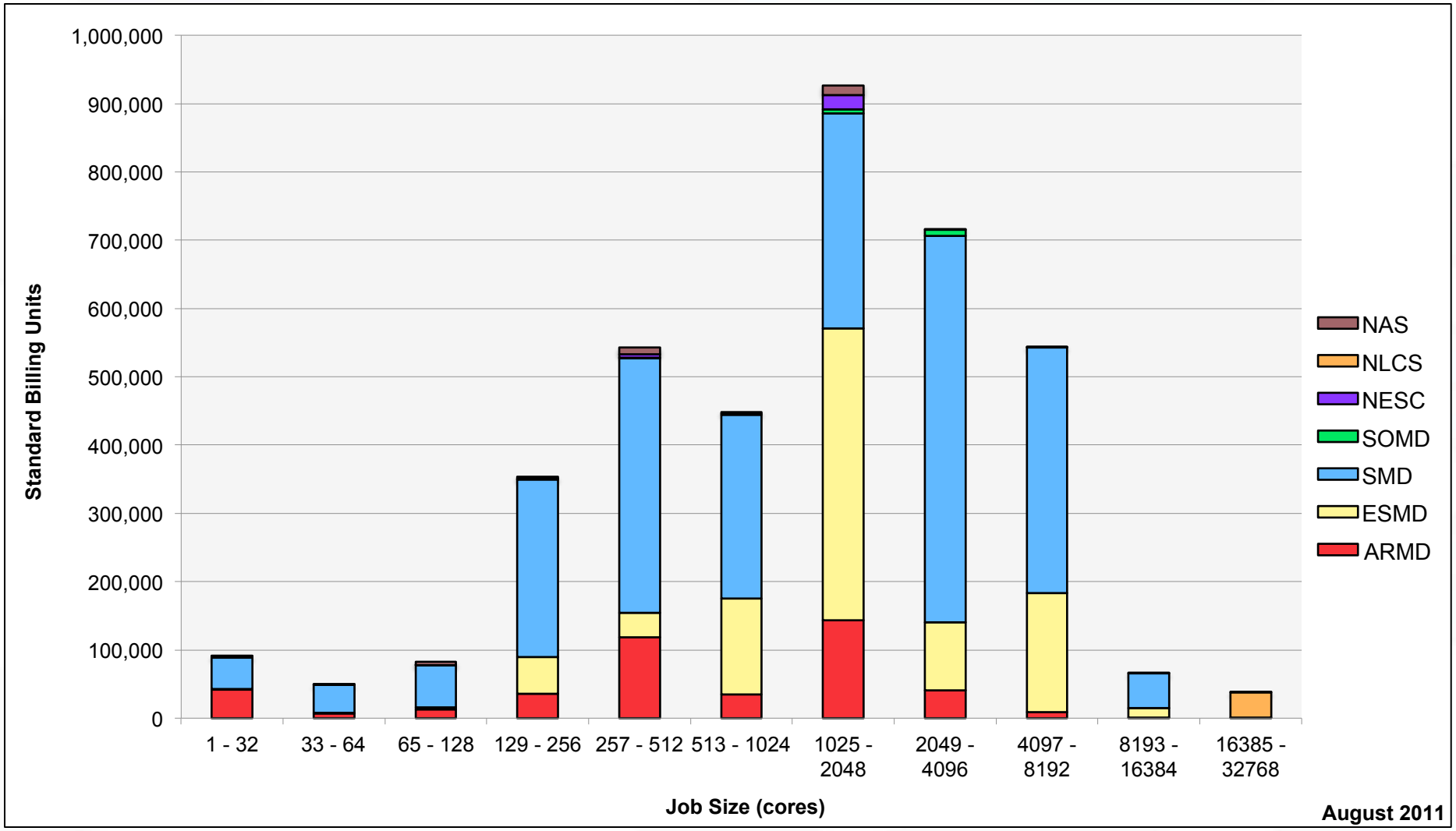
Pleiades:
Devel Queue Utilization



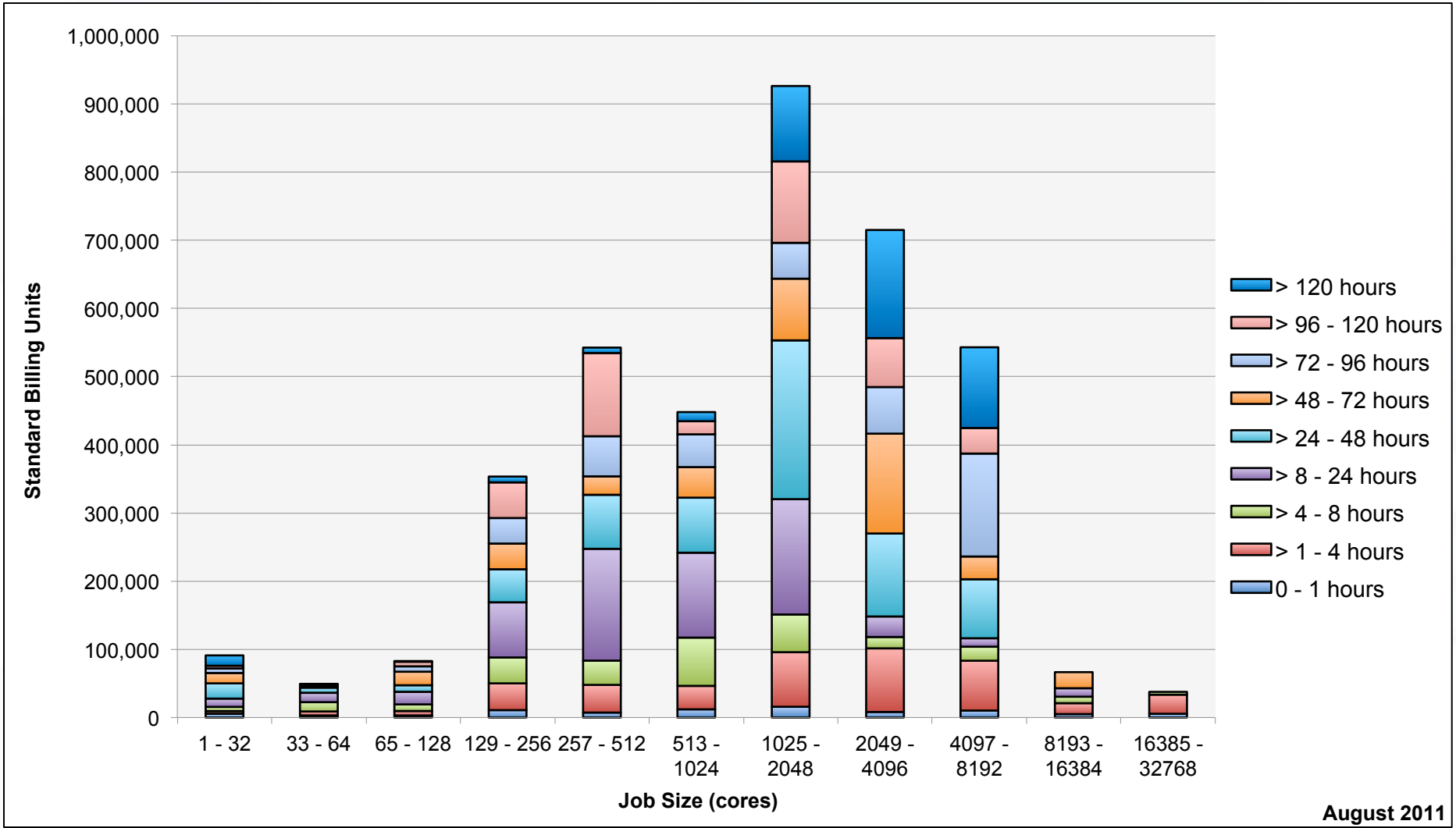
Pleiades:
Monthly SBUs by Run Time



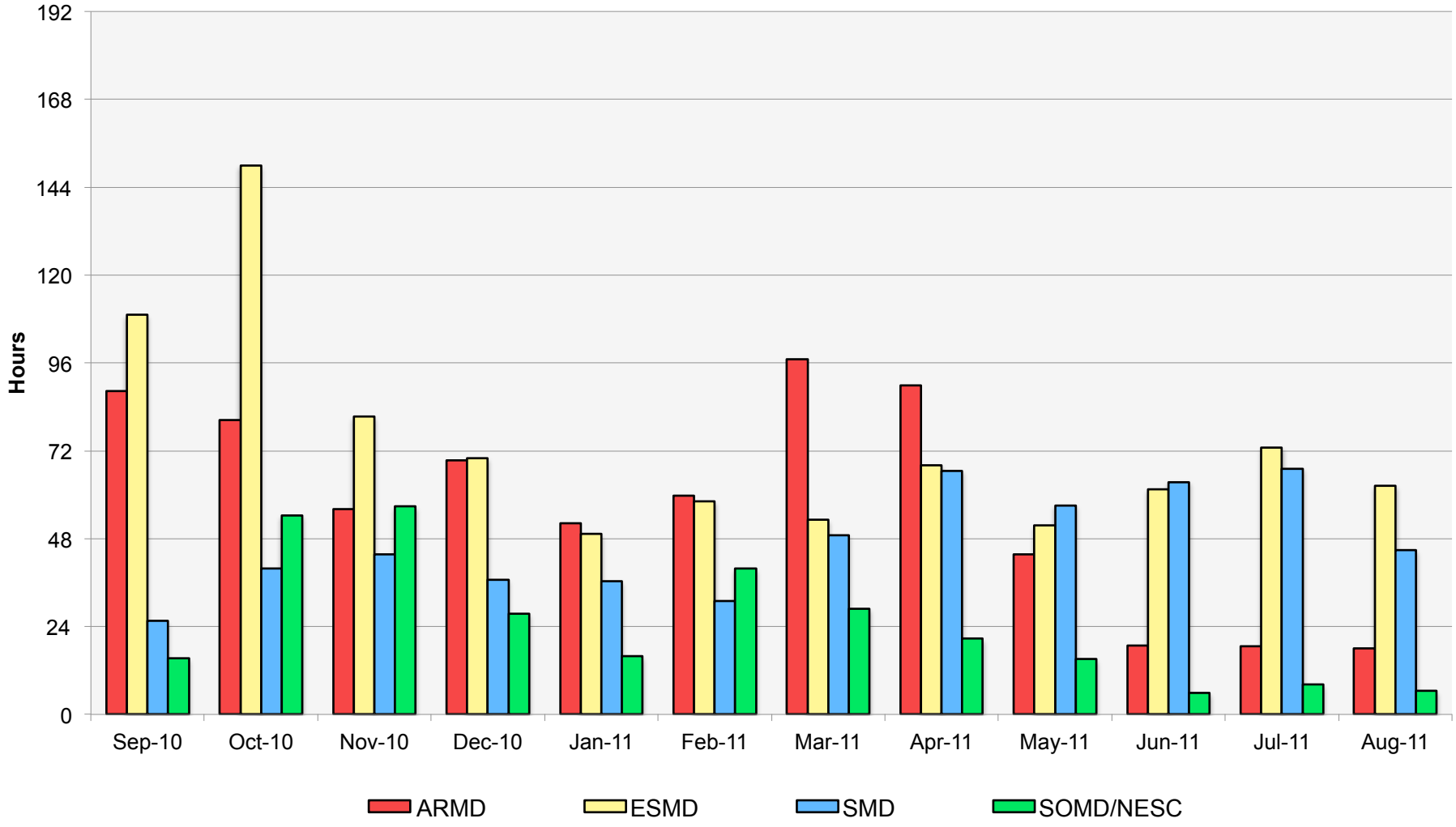
Pleiades:
Monthly Utilization by Size and Mission



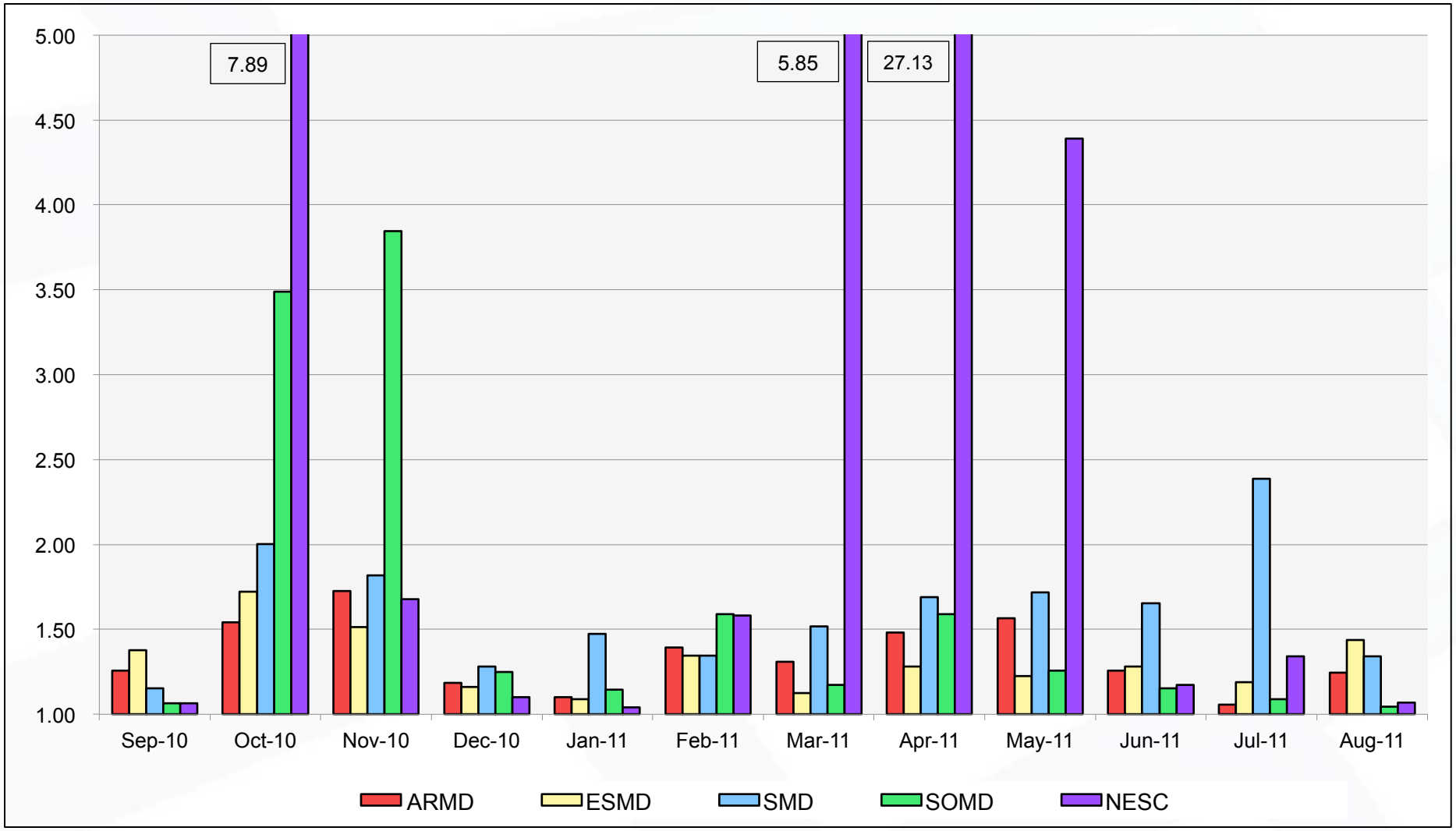
Pleiades:
Monthly Utilization by Size and Length



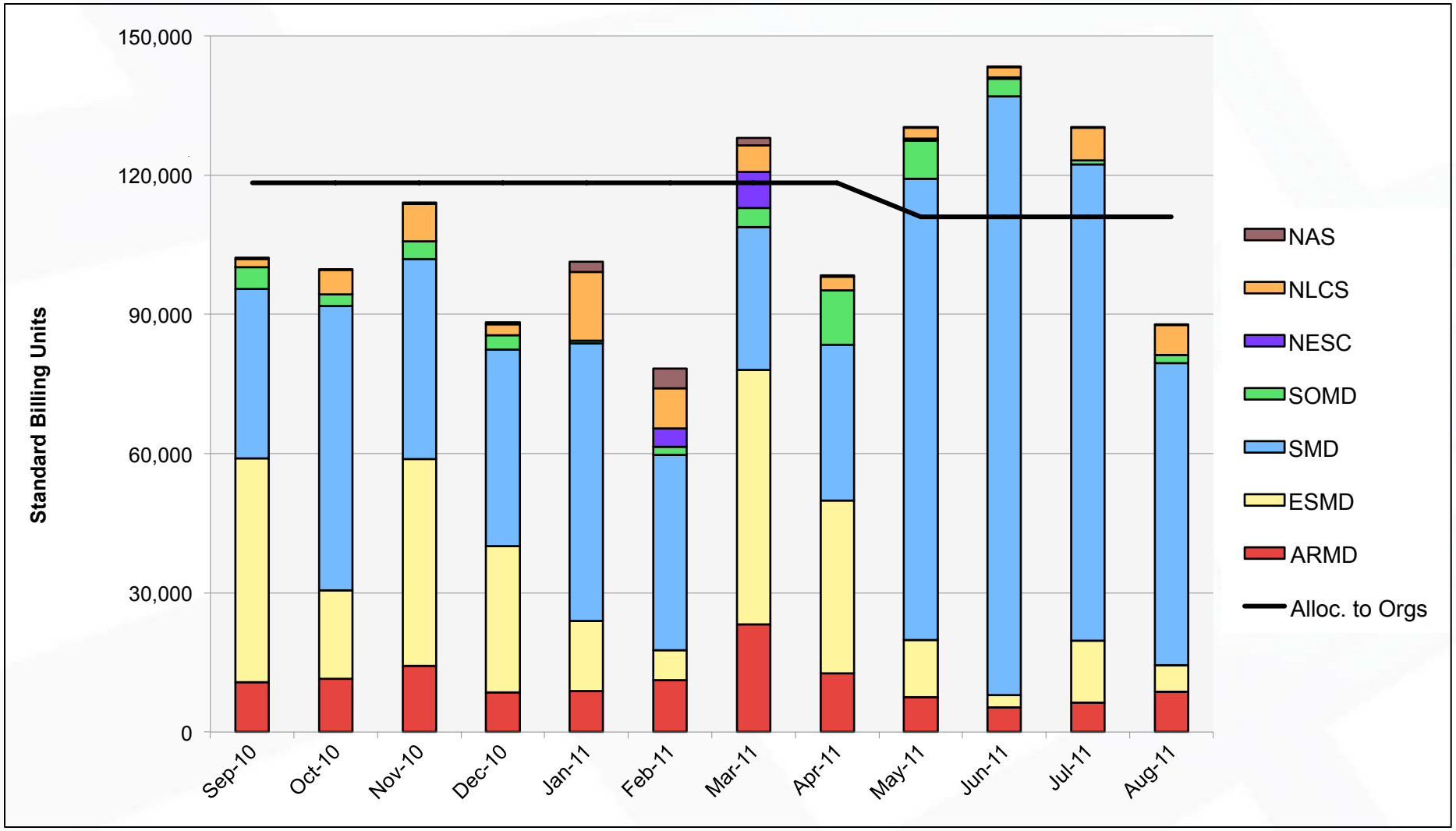
Pleiades:
Average Time to Clear All Jobs



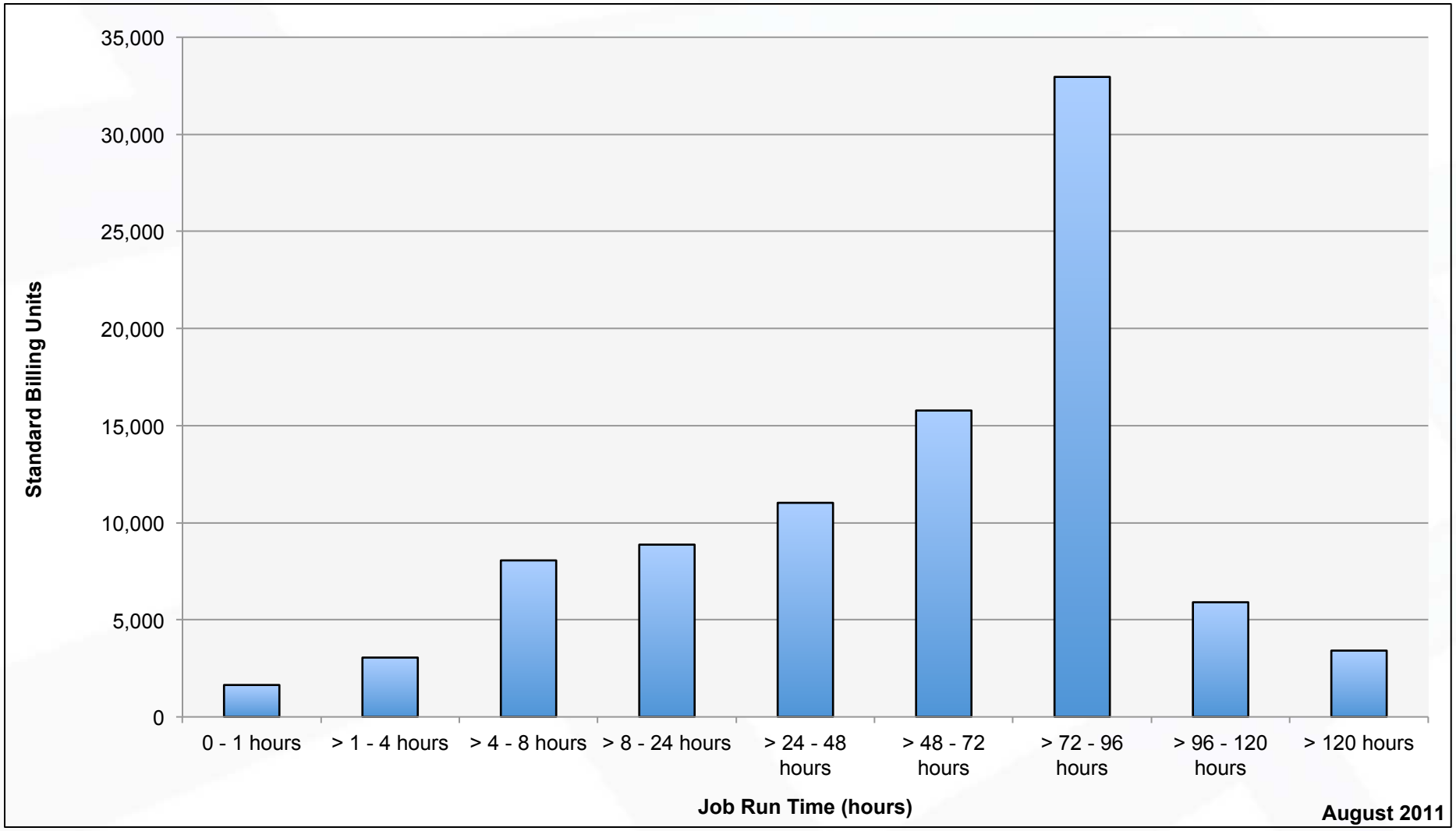
Pleiades:
Average Expansion Factor



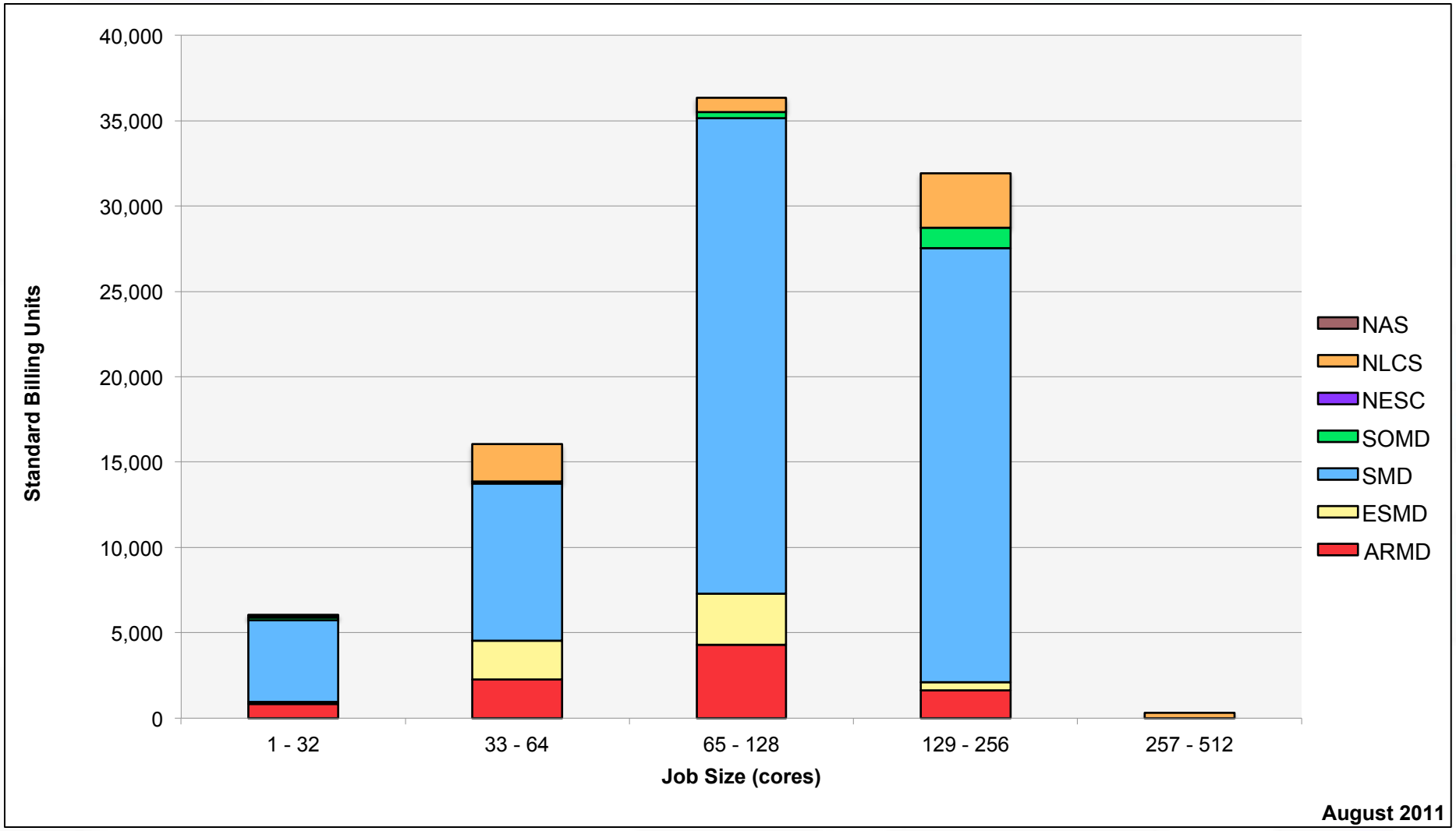
Columbia:
SBUs Reported, Normalized to 30-Day Month



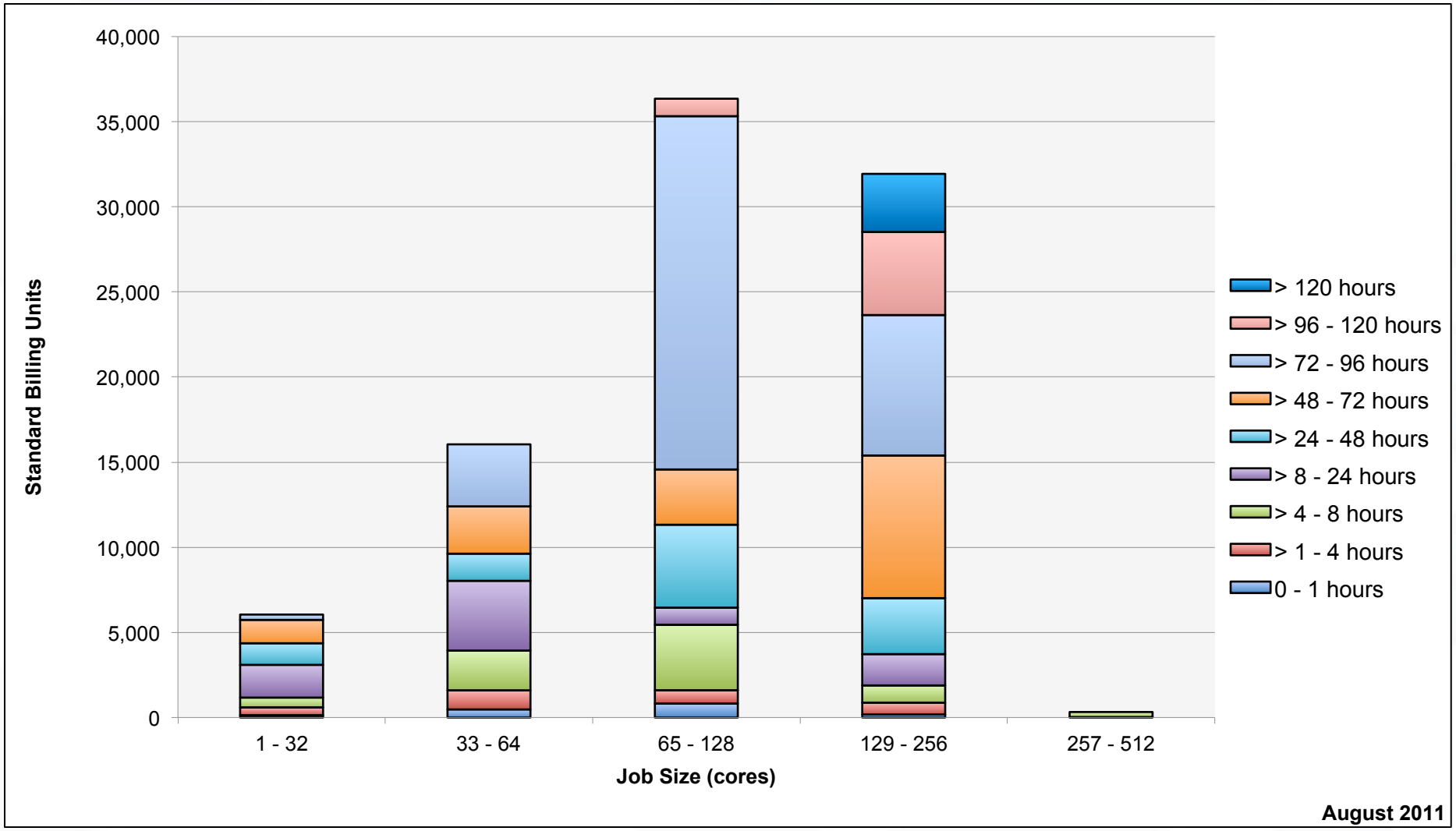
Columbia:
Monthly SBUs by Run Time



Columbia:
Monthly Utilization by Size and Mission



Columbia:
Monthly Utilization by Size and Length



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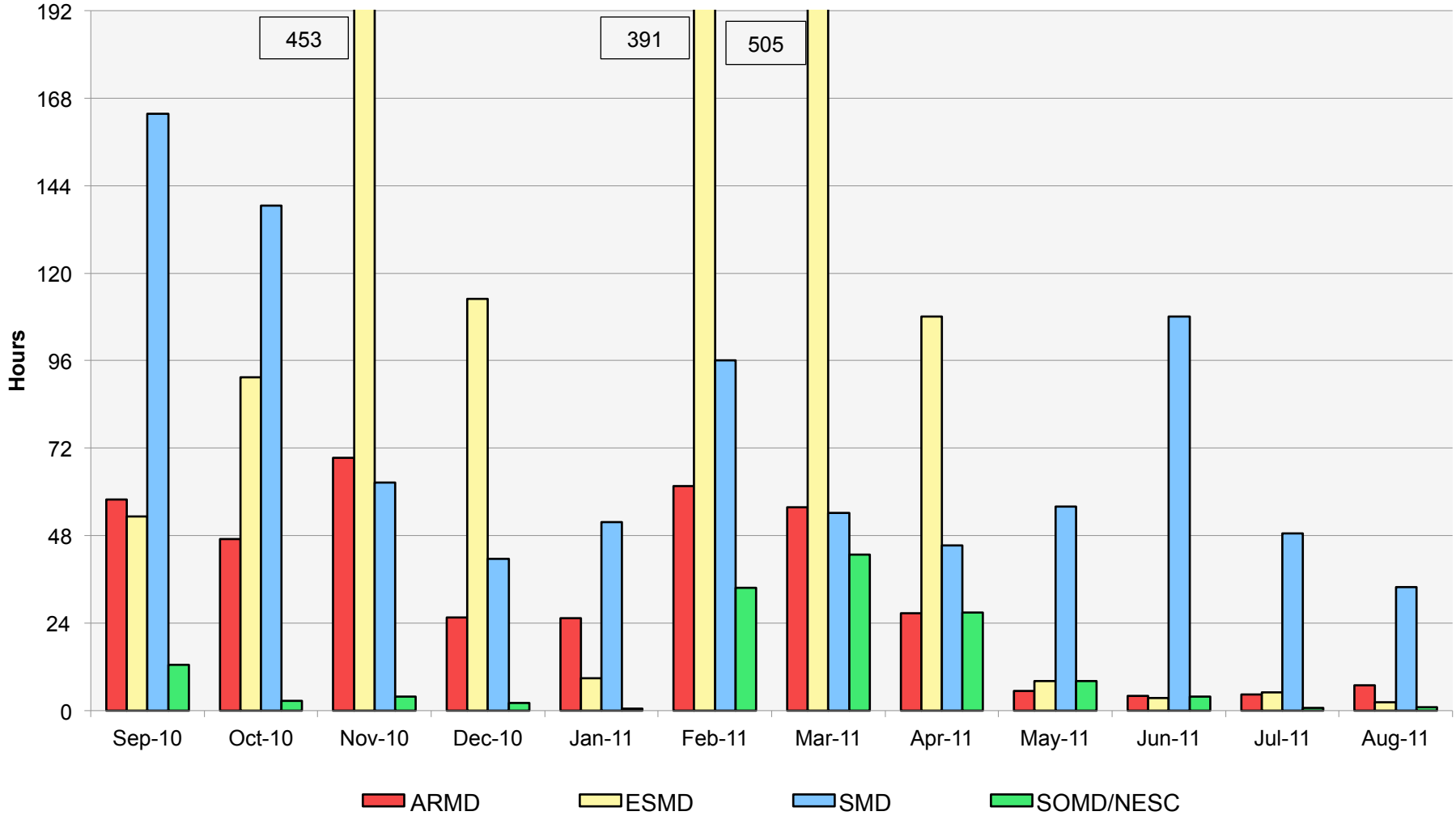

Columbia:
Average Expansion Factor