Project Status Report

High End Computing Capability
Strategic Capabilities Assets Program

8 July 2011

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Simulation of Events in the Solar Interior Enabled by HECC Resources

- To provide insight into solar mechanisms that can affect NASA missions, researchers at NASA Ames and Stanford University are performing very large-scale simulations of solar interior events, using HECC supercomputing and storage resources. These simulations include:
  - Fully nonlinear, radiative magnetohydrodynamic (MHD) simulations to investigate important solar phenomena such as sunspots, mass ejections, jets, and magnetic flux emergence.
  - Simulations of turbulent MHD processes in the Sun's upper connection zone and lower atmosphere to study intense magnetic field concentration mechanisms that may explain sunspot formation.
  - Simulations of magnetoacoustic wave propagation to provide key validation and calibration for inferring conditions and events in the solar interior from helioseismology observations of solar oscillations.
- Related subjects of interest to NASA include Earth's evolving climate; risks to crewed and non-crewed spaceflight due to space weather phenomena; and the evolution of planetary systems throughout the universe.

Mission Impact: HECC resources provide the computational power, speed, and storage capacity needed to support NASA's intensive solar simulation projects.

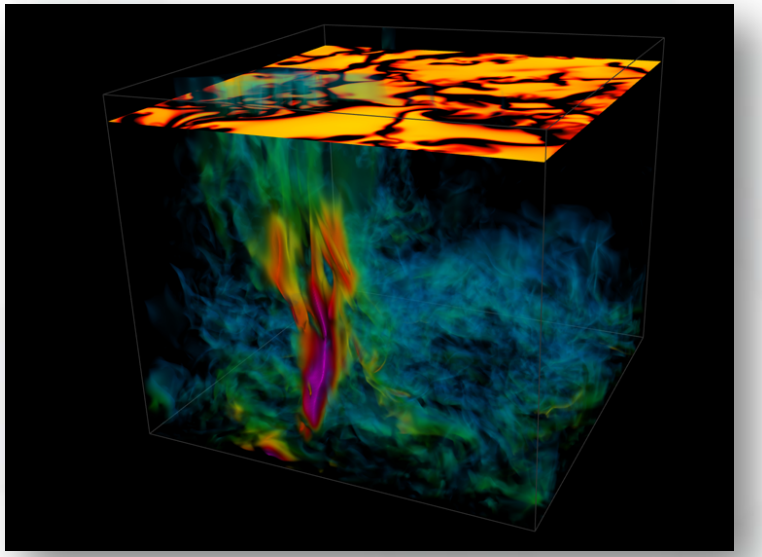


Figure: Realistic MHD simulation showing formation of a compact magnetic structure in the Sun's upper convective boundary layer. The image shows magnetic field strength, from 1,000 gauss (black) to 6,000 gauss (magenta), and solar surface temperatures above, from 4,000 kelvin (black) to 8,000 kelvin (yellow). (Irina Kitiashvili, Stanford University; Alan Wray, Tim Sandstrom, NASA/Ames)

POC: *Alan Wray, alan.a.wray@nasa.gov, (650) 604-6066, NASA Advanced Supercomputing Division*

CFD Simulations Run on Pleiades Support Multi-Purpose Crew Vehicle Design

- Researchers at NASA Ames are running computational fluid dynamics (CFD) simulations on Pleiades to assess key performance aspects of the Multi-Purpose Crew Vehicle (MPCV, formerly Orion), including:
  - Launch Abort Vehicle (LAV) stability and control, including complex interactions between the vehicle hardware, attitude control motor, and abort motor plumes;
  - Aerodynamic performance predictions of the LAV and MPCV crew module to extend wind tunnel data to flight operating conditions;
  - Predictions of the crew module's wake during entry and descent to support design and analysis of the parachute deployment system.
- These ongoing CFD simulations provide the CEV Aerosciences Project with key performance predictions for conditions that are difficult, or impossible, to obtain using ground-based or flight testing –HECC supercomputing resources enable efficient predictions of the aerodynamic performance of complex geometries and flow physics across a complete design space.

Mission Impact: HECC supercomputing resources enable efficient predictions of the aerodynamic performance of complex geometries and flow physics across a complete design space that are otherwise difficult or impossible to obtain.

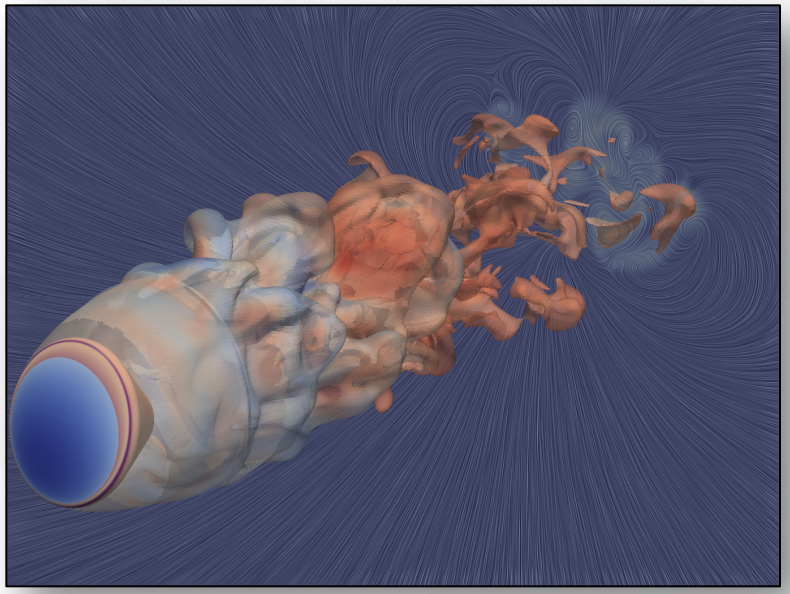


Figure: Iso-levels of entropy visualize the unsteady wake behind the MPCV. Line-integral-convolution highlights the flow topology in the downstream plane where the capsule parachutes will deploy. (Scott Murman/NASA Ames)

POC: *Scott Murman, scott.m.murman@nasa.gov, (650) 604-4470, NASA Advanced Supercomputing Division*

New Visualization Capability Supports Enzo AMR Astrophysics Data

- The HECC Visualization team has added a new capability to their software for visualizing data from the Enzo cosmological simulation code; the code generates Adaptive Mesh Resolution (AMR) files, where the mesh has multiple levels of refinement as required by the calculation.
- The capability was developed based on new research that allows variables to be interpolated without discontinuities in AMR data with arbitrary resolution changes between adjacent meshes; previous solutions only supported resolution changes that are factors of two.
- Visualizations can now be produced that show both the gas and particles (stars and dark matter) in astrophysics simulation. A new algorithm allows both types of data to be rendered using ray casting (a technique that produces images by calculating, for each pixel, how a ray of light would traverse the domain of the data set).
- User Renyue Cen, Princeton University is using visualizations of stars and neutral hydrogen to determine whether the simulation shows an expected "gas stripping" phenomena.

Mission Impact: The new visualization capability allows scientists to view high-quality images of Enzo output showing gas, stars, and dark matter all in the same frame.

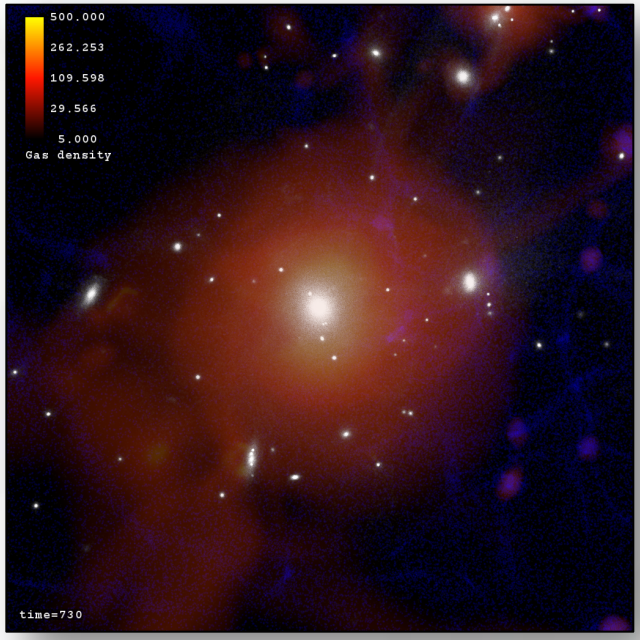


Figure: A frame from an animation that shows a galaxy cluster. The gas surrounding the cluster is shown using red, orange, and yellow; stars are shown in white; dark matter is shown in blue. (David Ellsworth, NASA/Ames)

***POC**: David Ellsworth, David.Ellsworth@nasa.gov, (650) 604-0721, NASA Advanced Supercomputing Division, Computer Sciences Corp.*

Installation of New Racks Brings Pleiades to 111,104 Cores

- In June, the HECC Systems team, with SGI engineers, installed 14 new Westmere racks on Pleiades bringing the total to 182 racks or 11,648 nodes.
- The new racks add another 10,752 Westmere cores (111,104 cores total), increasing the system's peak performance by an additional 126 teraflops – the system now delivers a 1.09 petaflops (PF) sustained performance rate (see slide 7), and has a 1.32 PF theoretical peak performance.
- The Systems team successfully added the racks using live integration techniques, which enabled the system to remain in use while the expansion was in progress, and saved over 7 million hours of computing time that would have been lost if the system had been brought down for the integration.

Mission Impact: The continuing expansion of Pleiades provides increased computational capability to keep up with the requirements of all NASA Mission Directorates.

Figure: Fourteen additional SGI Westmere racks were installed in June 2011, adding another 126 teraflops of computational capability to Pleiades.

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

Pleiades Ranks 7th Among the World's Fastest Supercomputers

- After the addition of 14 Westmere racks (see slide 6), Pleiades achieved a sustained performance of 1.09 petaflops (PF) on the LINPACK benchmark, which ranks the system as the seventh-fastest supercomputer on the June 2011 Top 500 list.
- The sustained performance delivers ~83% of the theoretical peak performance (1.32 PF), making it the third most efficient system of the top 10 systems on the list.
- Pleiades' efficiency increased by 3.3% since the last LINPACK run in 2010, despite the difficulty of attaining high efficiency with three generations of processors, varying amounts of memory per core across two generations of InfiniBand, and an expanded system configuration.

Mission Impact: Through the HECC Project, NASA science and engineering users get extremely efficient use of their computing time on Pleiades, one of the top computational resources in the world.

Figure: *Pleiades now delivers a sustained performance rate of 1.09 petaflops (PF), with a theoretical peak of 1.32 PF.*

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

Pleiades Dedicated Time Activities Improve System Reliability

- The HECC systems team made several changes to Pleiades during a dedicated time period, June 8-13. These changes include:
- Updates to the firmware on 1,280 Nehalem nodes to resolve an issue that prevented their InfiniBand interface from working correctly.
- Deployment of a patch to fix an issue that affected some Fortran applications on Pleiades Lustre filesystem.
- Updates to the Network File System (NFS) servers with new system software.
- Replacement of suspect system components that were discovered when diagnostic tests were run during the dedicated time.

Mission Impact: Improved system reliability gained through periodic updates and enhancements 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 the system.

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

Network Infrastructure Augmentation Provides Enhanced Connectivity

- The HECC Network team has successfully expanded the main computer room network infrastructure in Building N258.
- The new sub-floor network enclosure supports 64 connections required by the upcoming SGI graphics processing unit (GPU) systems and any additional compute racks in the area.
- The team's modular design of the network infrastructure allowed them to efficiently and easily relocate the sub-floor network enclosure to support the demands of HECC's ever-changing computational environment.
- Augmentation to the infrastructure now provides 84 copper Category 6A Ethernet ports to the expanded area – the cabling can now easily accommodate the latest standards and higher throughput rates.

Mission Impact: HECC augmentation to the network infrastructure provides enhanced connectivity, and allows for more efficient support of future compute-node expansion on the computer room floor, saving time and money.

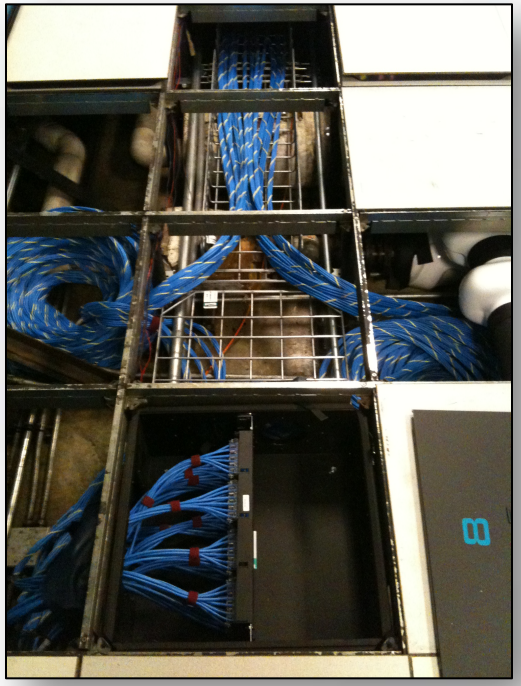


Figure: New sub-floor network enclosure located in Building N258 at NASA Ames.

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

HECC Network Team Shines During World IPv6 Day

- The HECC Networks team, working with the Engineering Servers and Services (ESS) and Security teams, successfully participated in World IPv6 Day on June 8th, during a global-scale trial of the new Internet Protocol, IPv6.
- For the 24-hour test, network engineers used the NASA Advanced Supercomputing (NAS) Division's website and local area network (NASLAN) – the only operational LAN across NASA that supports and uses native IPv6. The team has participated in IPv6 testing for over 10 years, and has operationally supported IPv6 on NASLAN for the last 5 years.
- Because the network environment already fully supports IPv6, the work to bring up the public web server using IPv6 went smoothly.
- The NAS website (www.nas.nasa.gov) received over 25,000 visits via IPv6 during the day-long event, giving NASA high-end computing information expanded visibility to the public.

Mission Impact: HECC's successful participation in a global-scale event demonstrated the readiness-level for NASA to implement IPv6 by the end of 2012, as mandated by the federal government.

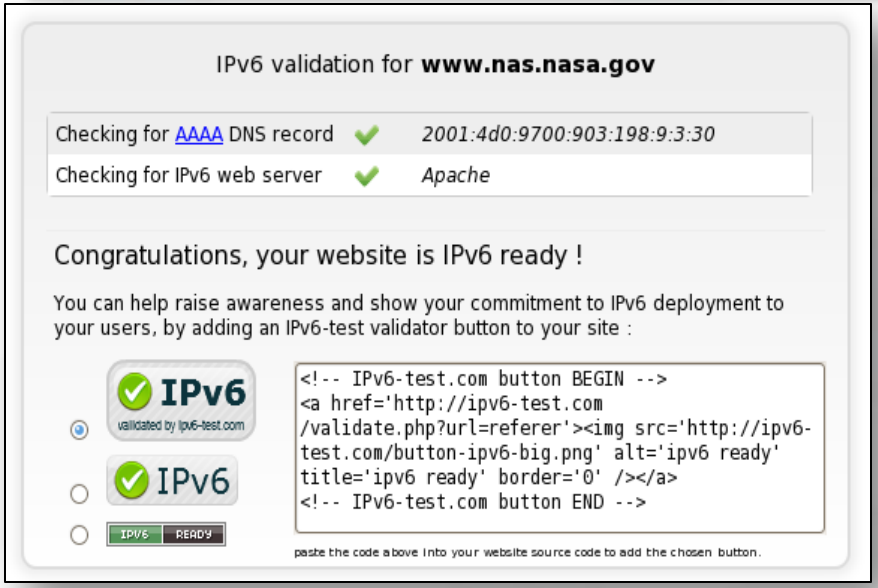


Figure: Test results shown in the above screenshot illustrate that the NASA Advanced Supercomputing Division's public web server is fully accessible from the Internet via IPv6 address.

POC: *Nichole Boscia, Nichole.K.Boscia@nasa.gov, (650) 604-0891, NASA Advanced Supercomputing Division, Computer Sciences Corp.*

HECC Successfully Migrates to NASA's Two Factor Token Infrastructure

- HECC uses RSA SecurID tokens to authenticate all users logging into computational resources, as well as those who perform privileged operation after log-in.
- As part of an Agency-wide program to consolidate management of all SecurID-based access, during the week of June 20, HECC migrated to the centrally managed Agency Two Factor Token Infrastructure (TFTI).
- Under TFTI, NASA users (with a few exceptions for missions) now need only one SecurID token for access to NASA systems, rather than the multiple tokens needed in the past.
- Access checks are strengthened under TFTI, since at each access, the NASA Enterprise Directory is checked to ensure that the user has an "enabled" Agency User Identify (AUID).
- To ensure availability, there are redundant TFTI RSA servers and NASA Enterprise Directory servers.

Mission Impact: The HECC RSA SecurID token migration supports NASA's goal to have a single system enforcing RSA SecurID authentication Agency wide, and ensures that all users have a valid NASA identity.

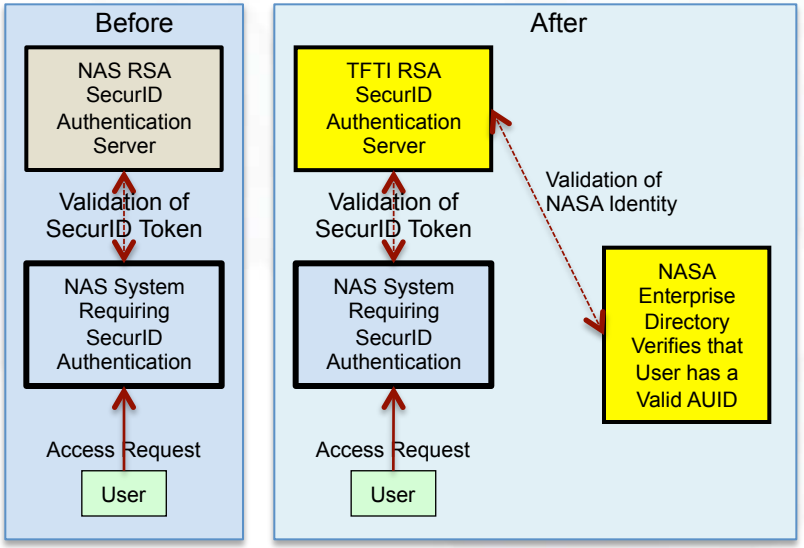


Figure: After migration, access to NAS systems now is vetted by a TFTI SecurID Server and the NASA Enterprise Directory.

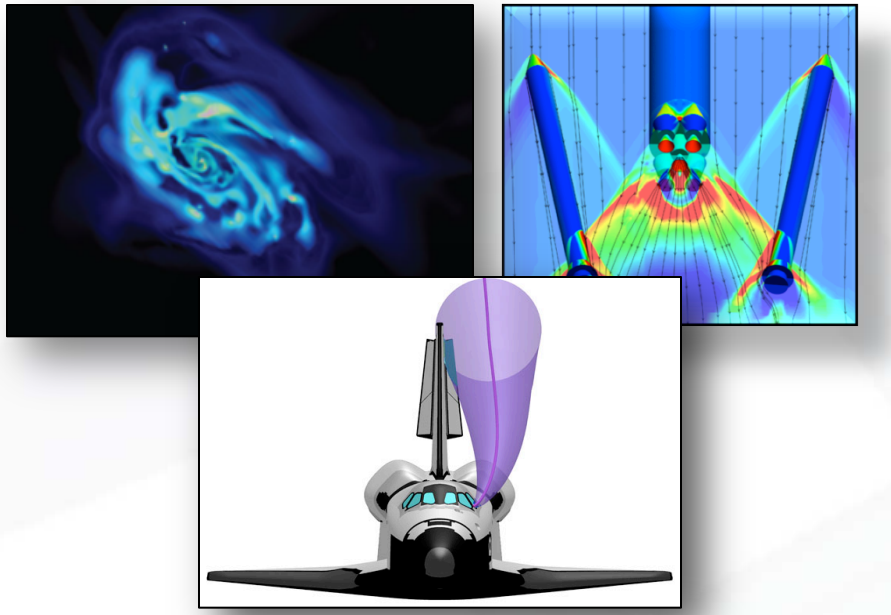
POC: *Thomas H. Hinke, thomas.h.hinke@nasa.gov, (650) 604-3662, NASA Advanced Supercomputing Division*

New Allocation Period for All Mission Directorates

Mission Impact: NASA programs and projects periodically review the distribution of supercomputer time to assure consistency with the achievement of their mission-specific goals and objectives.

- May 1 marked the beginning of a new allocation period (NOP) for the Exploration Systems Mission Directorate (ESMD), the NASA Engineering and Safety Center (NESC), the Science Mission Directorate (SMD), and the Space Operations Mission Directorate (SOMD).
- The 4 groups awarded new allocations on Pleiades and Columbia to over 300 computing projects that support their science and engineering activities.
- Combined awards exceeded 54 million Standard Billing Units* (SBUs) – a 60% increase over the 2010 awards.
- Continued expansion of Pleiades makes it possible for HECC to keep pace with these constantly growing demands for resources.
- The NOP provides an opportunity for each organization to rebalance allocations to meet computing needs for the upcoming year.

*1 SBU equals 1 hour of a Pleiades Westmere 12-core node.



Figures: Clockwise from left: Visualization of the cosmic web. (Anatoly Klypin, New Mexico State Univ.; Stephan Gottloeber, AIP-Germany); Solid rocket booster separation maneuver for Ares V. (Marshall Gusman, NASA/Ames); Simulation of the loss of a thermal protection system tile plug during shuttle reentry. (Reynaldo Gomez, NASA/JSC)

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

Presentations and Papers

- **29th AIAA Applied Aerodynamics Conference**, June 27-30, Honolulu

  "Adjoint-Based Low-Boom Design with Cart3D," M.J. Aftosmis, M. Nemec, S.E. Cliff*

  "Code-to-Code Comparison of CFD/CSD Simulation for a Helicopter Rotor in Forward Flight," J. Ahmad, R. Biedron*

  "High-Order Accurate CFD/CSD Simulation of the UH60 Rotor in Forward Flight," J. Ahmad, N. Chaderjian*

  "Analysis of Inviscid simulations for the Study of Supersonic Retropropulsion," N.M. Bakhtian, M.J. Aftosmis*

  "Evaluation of Refined Tetrahedral Meshes with Projected, Stretched, and Sheared Prism Layers for Sonic Boom Analysis," S.E. Cliff, S.D. Thomas*

  "Aerodynamic Database Generation for SRB Stage-Separation from a Heavy Lift Launch Vehicle," M.R. Gusman, M.F. Barad, C. Kiris*

  "Dual-Time Stepping Procedure Applied to Launch Environment Simulations," J. Housman, M. Barad, C.C. Kiris*

  "Analysis of Grid Fins for Launch Abort Vehicle Using a Cartesian Euler Solver," J. Kless, M.J. Aftosmis*

  "Computational Challenges in Simulating Jet Interaction For A Launch Abort Vehicle," S.E. Rogers, T.H. Pulliam*

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

Presentations and Papers (cont.)

- **20th AIAA Computational Fluid Dynamics,** June 27-30, Honolulu

  "Developments in Strategies and Software Tools for Overset Structured Grid Generation and Connectivity," W. Chan*

  "Automatic Hole-Cutting for Overset Grids Using Oriented X-rays," N. Kim, W. Chan*

  "Computation of Line Loads from Surface Triangulation and Flow Data," S. Pandya, W. Chan*

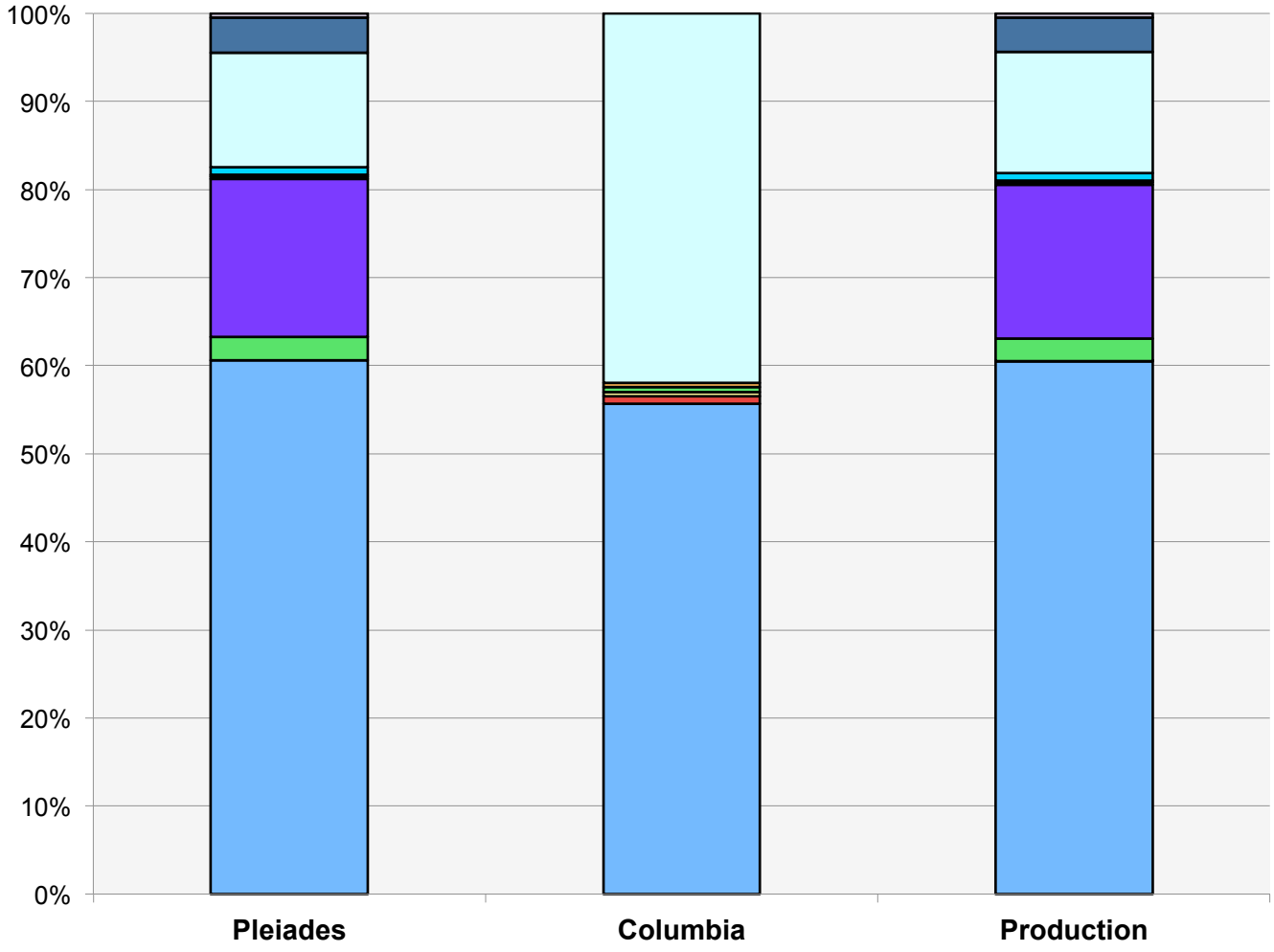
- "Recent Development of the NASA CAMVis for Tropical Cyclone Studies," Bo-Wen Shen, Wei-Kuo Tao, Bron Nelson, The Earth Science Technology Forum 2011 (ESTF2011), Pasadena, CA, June 21-23, 2011.*
  http://esto.nasa.gov.conferences/estf2011/Shen_ESTF2011.pdf

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

News and Events

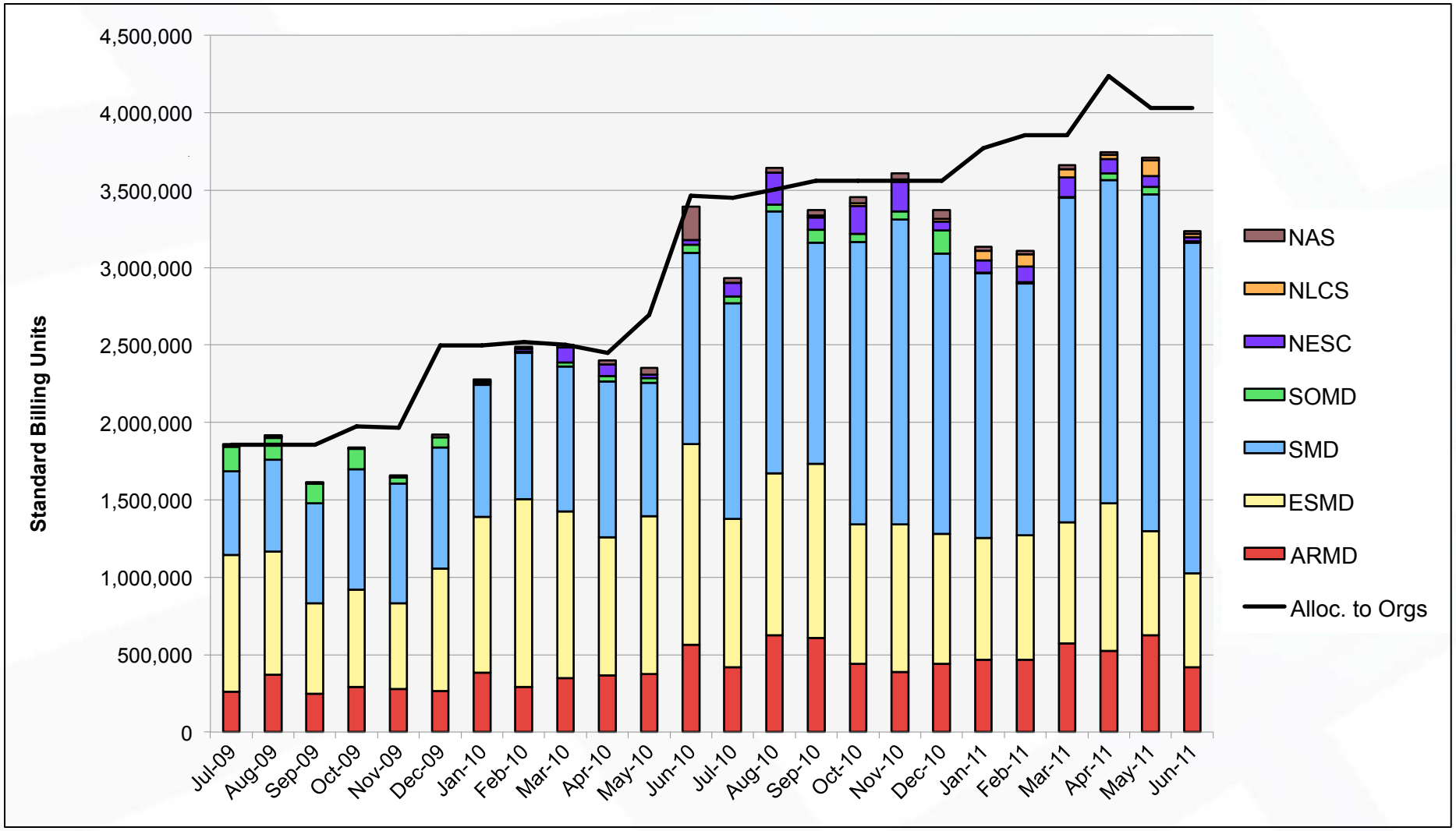
- **High-Fidelity Simulation of Landing Gear Noise**, *Scientific Computing,* June 2011 – Feature story by M.R. Khorrami and P.J. Moran detailing simulations of complex unsteady flow surrounding an aircraft nose landing gear to reduce sonic pollution. *http://www.scientificcomputing.com/articles-HPC-High-Fidelity-Simulation-of-Landing-Gear-Noise-062711.aspx*
- **NASA amps up sonic booms to learn how to quiet them**, *Network World,* June 2, 2011 – Includes account of researchers using large amounts of time on the Columbia supercomputer for sonic boom reduction. *http://www.networkworld.com/community/node/74552*
- **NASA and the NNSA to Evaluate Advanced InfiniBand Software from Obsidian Strategics**, *Obsidian Strategics press release*, June 20, 2011 – Announces an industry collaboration with the NAS Division at Ames Research Center and the Department of Energy's Lawrence Livermore National Laboratory, to assess new software engineered for networks with multiple subnets in complex topologies. Includes a quote from Bob Ciotti, HECC systems lead and chief system architect. *http://www.businesswire.com/news/home/20110620005711/en/NASA-NNSA-Evaluate-Advanced-InfiniBand-Software-Obsidian*
- **NASA's Pleiades Supercomputer Ranks Among World's Fastest**, *NASA press release*, June 20, 2011 – generated many stories from various media sources. *http://www.nasa.gov/home/hqnews/2011/jun/HQ-11-194_Supercomputer_Ranks.html*

NAS Utilization

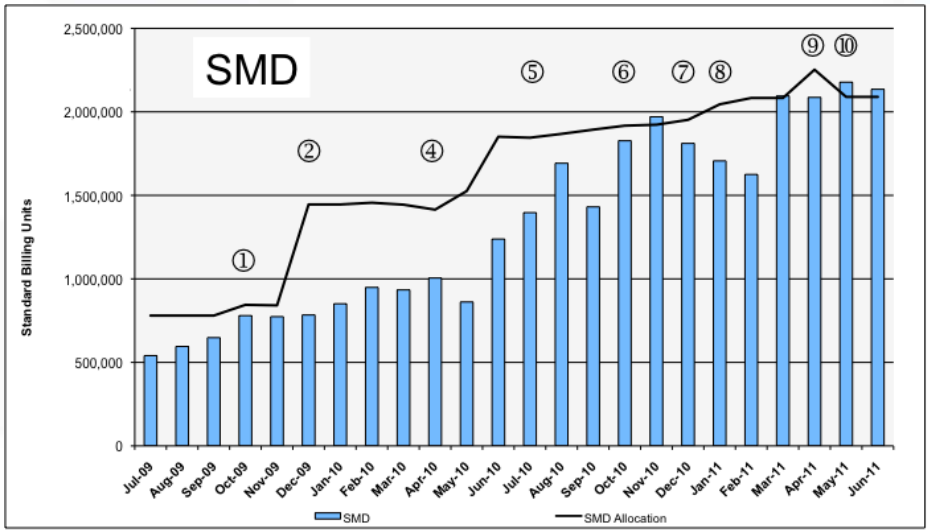


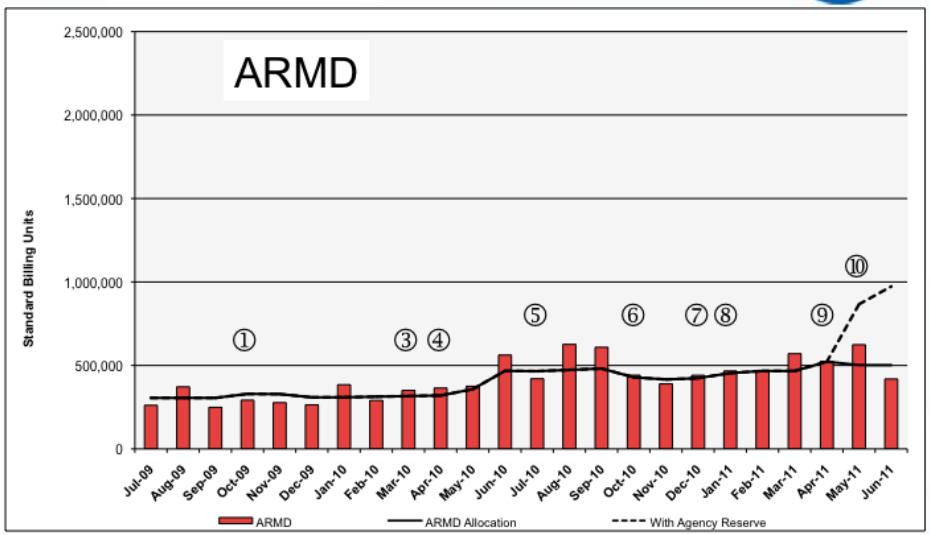
June 2011

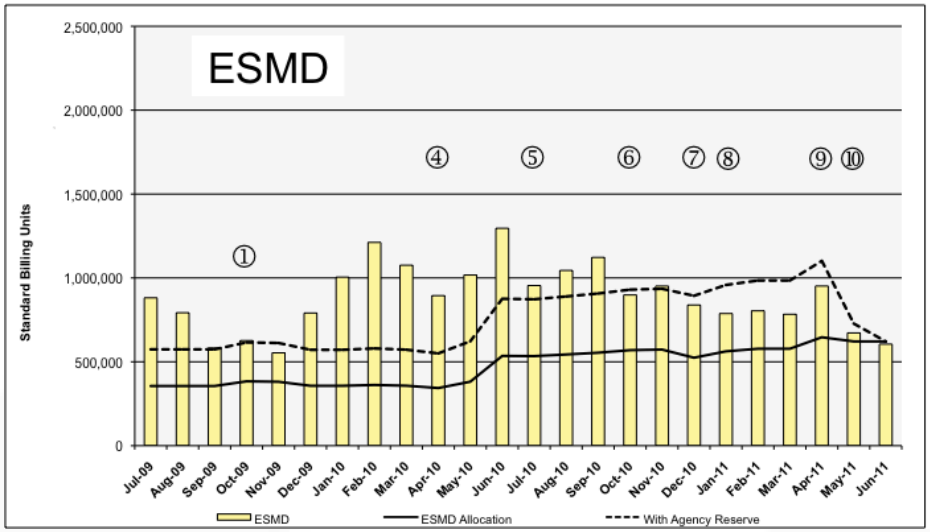
NAS Utilization Normalized to 30-Day Month

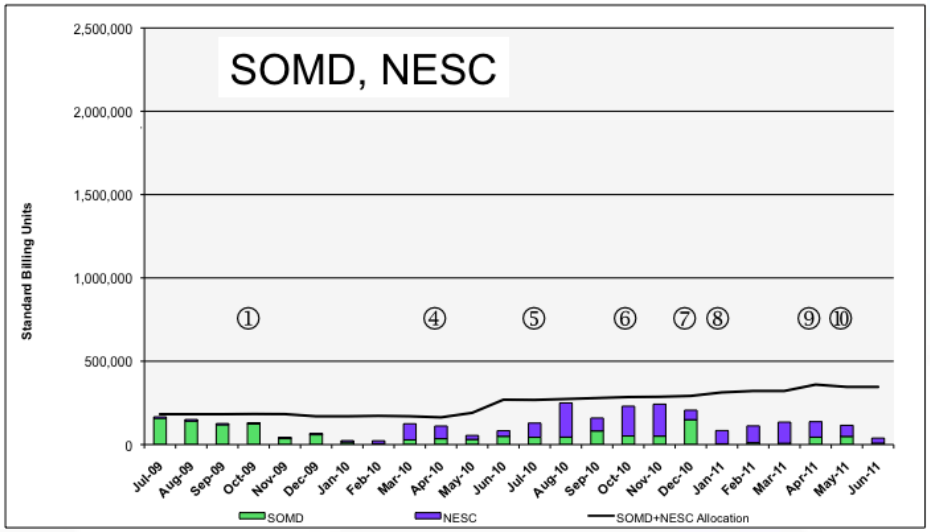


NAS Utilization Normalized to 30-Day Month



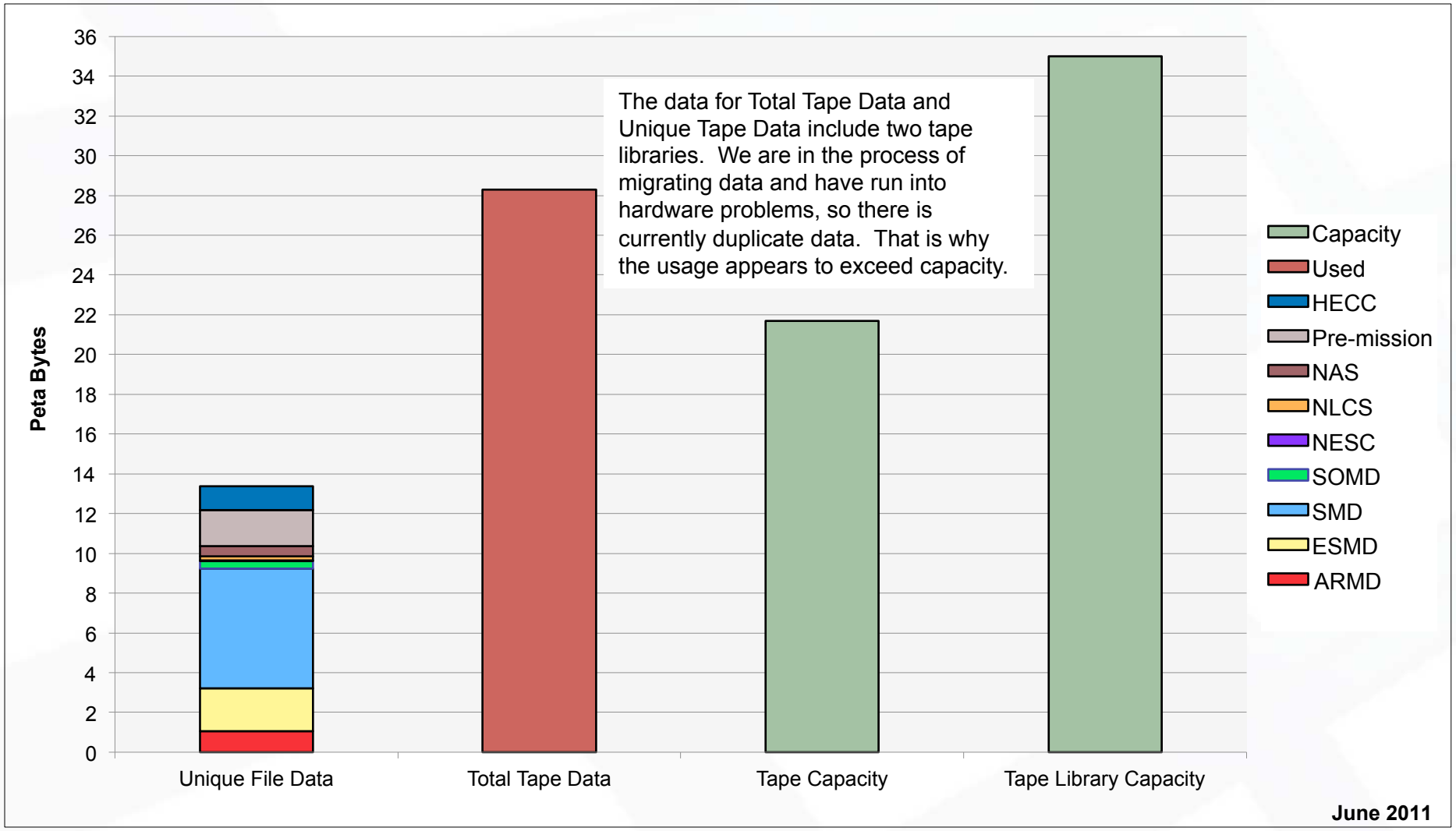




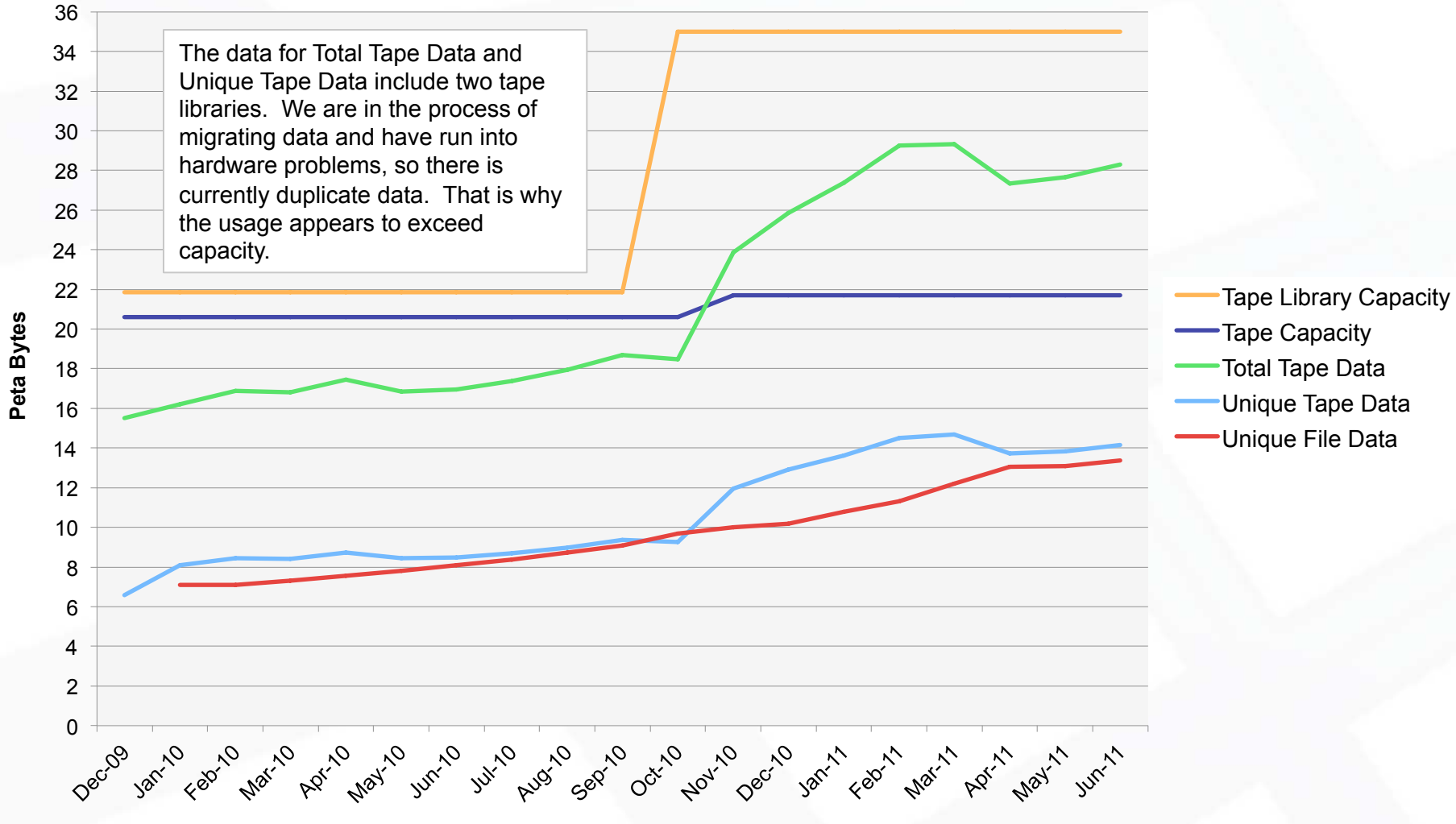


① Allocation to orgs. increased to 80% ② SMD augmentation ③ RTJones retired ④ 32 Westmere racks added
⑤ Schirra retired, 4 Westmere racks added ⑥ RTJones compensation removed ⑦ 8 Westmere racks added
⑧ Devel queue created ⑨ 12 Westmere racks added ⑩ Allocation to orgs. decreased to 75%, Agency reserve shifted to ARMD

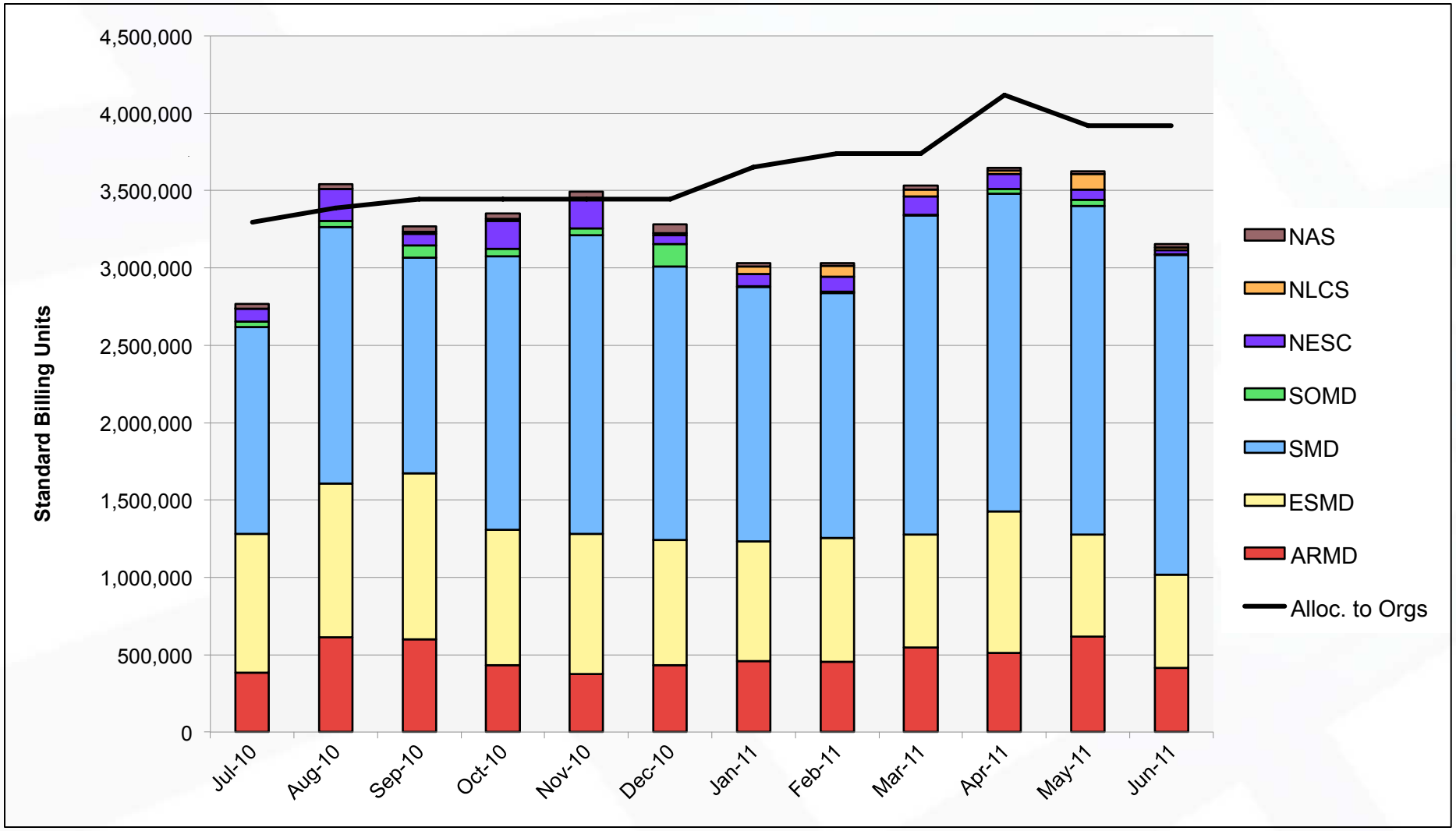
Tape Archive Status



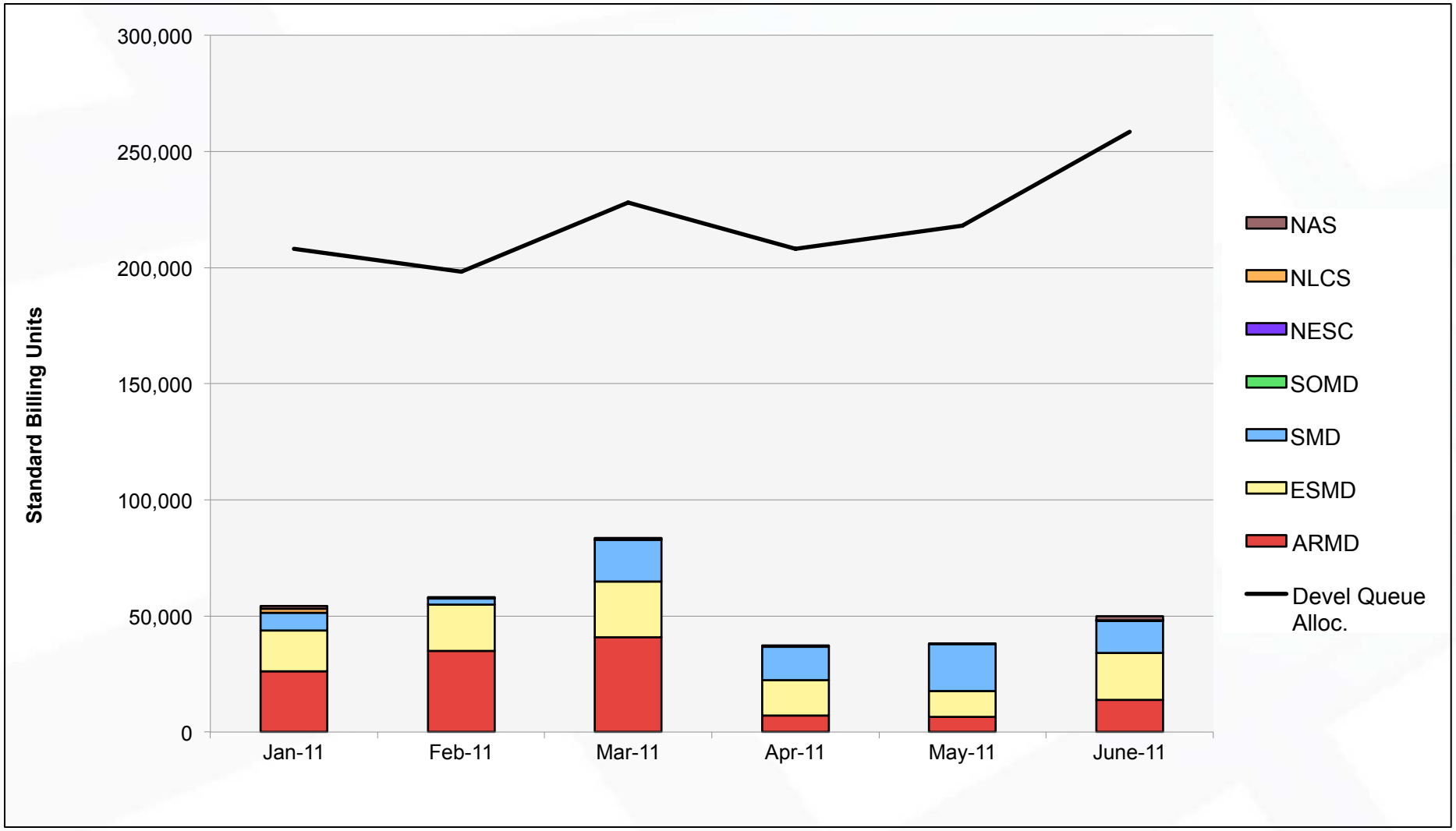
Tape Archive Status



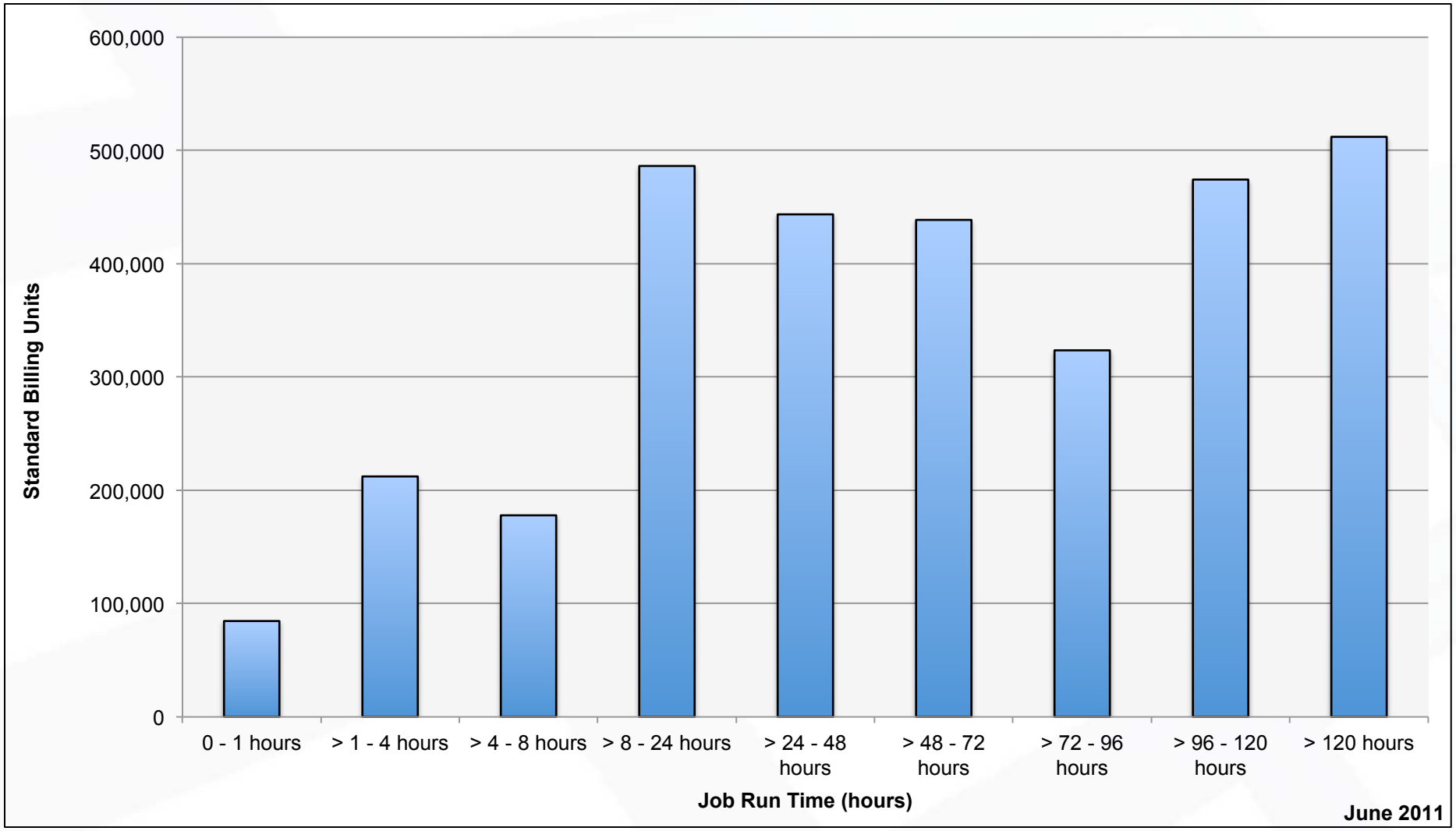
Pleiades:
SBUs Reported, Normalized to 30-Day Month



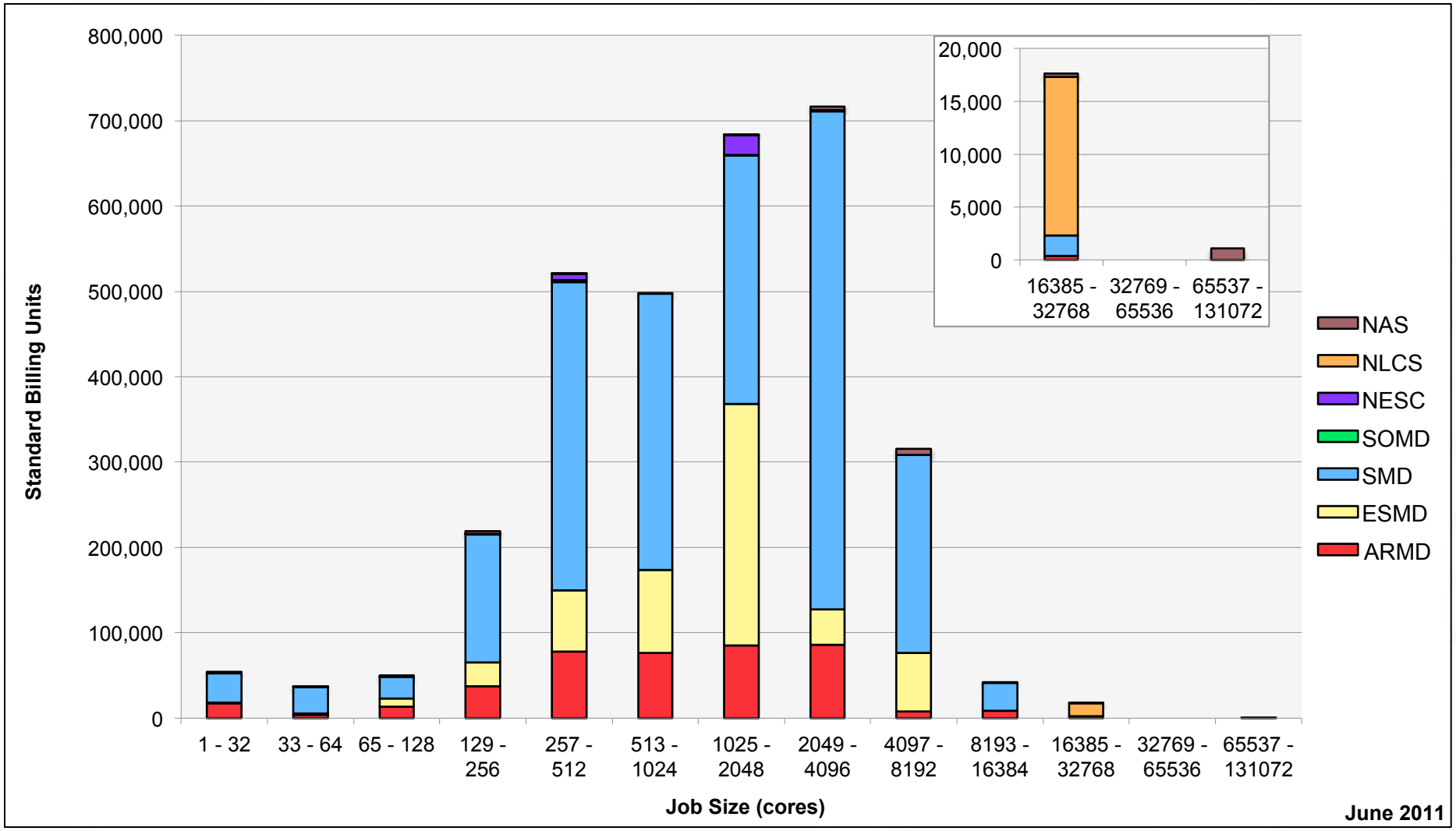
Pleiades:
Devel Queue Utilization



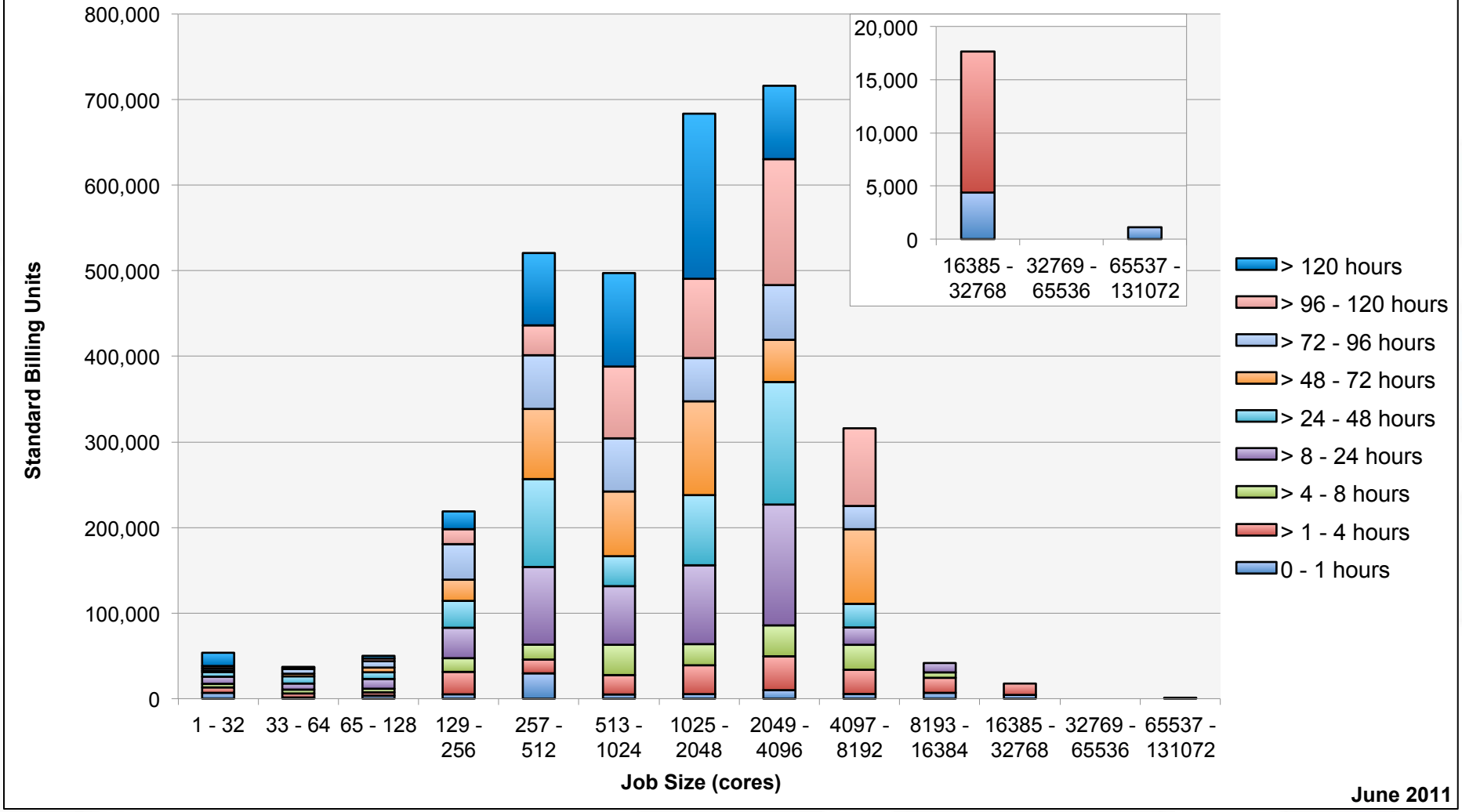
Pleiades:
Monthly SBUs by Run Time



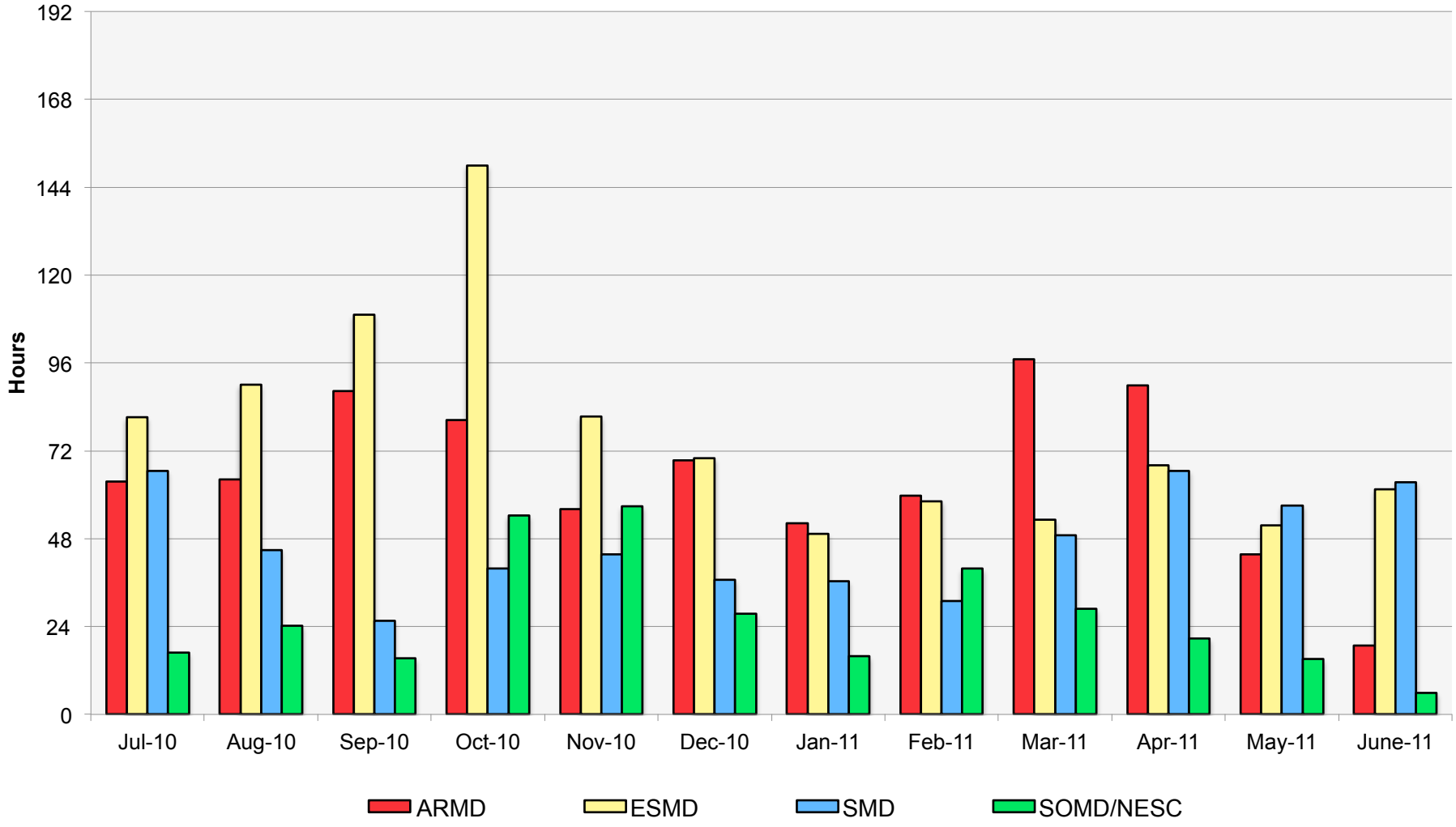
Pleiades:
Monthly Utilization by Size and Mission



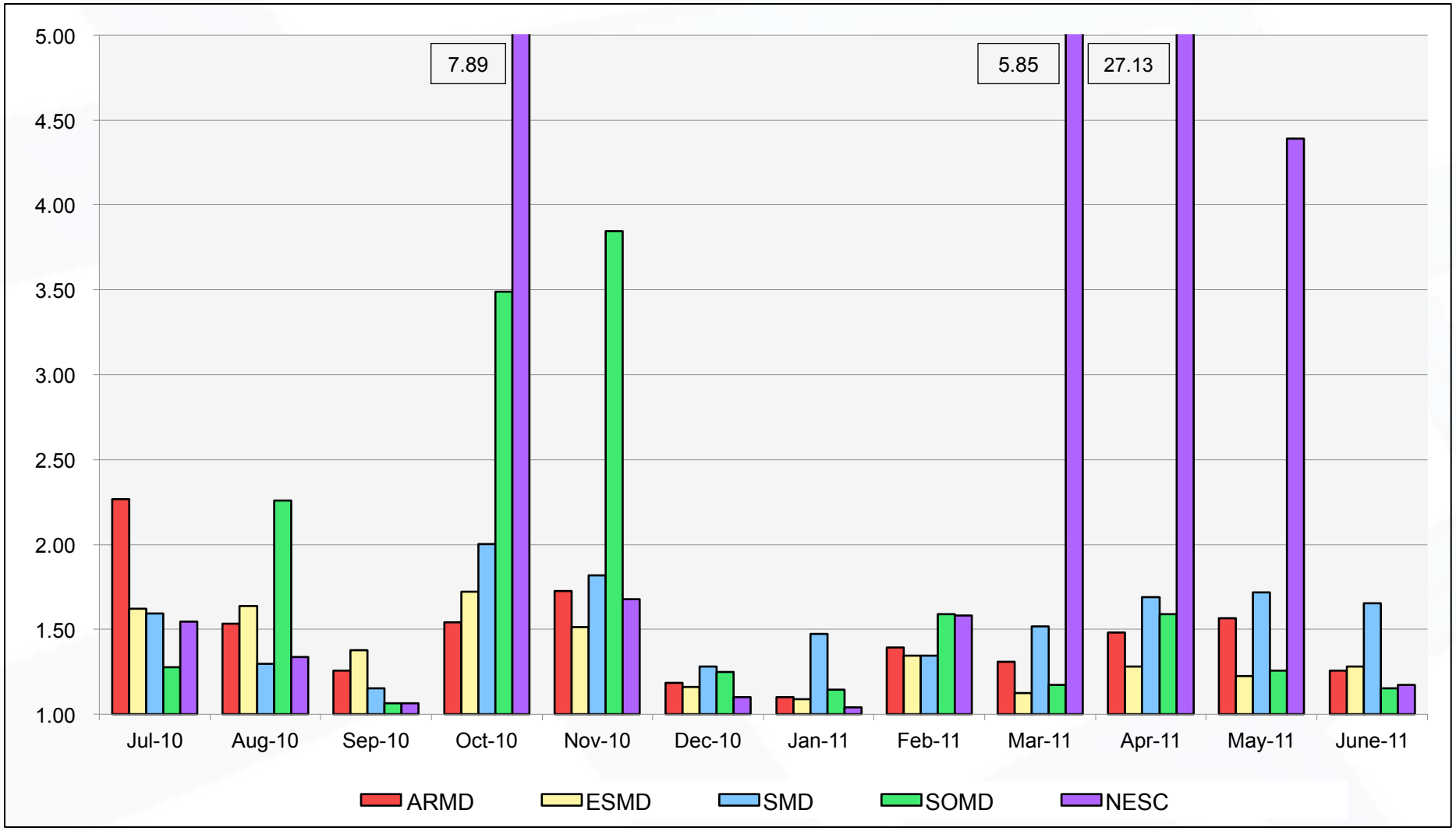
Pleiades:
Monthly Utilization by Size and Length



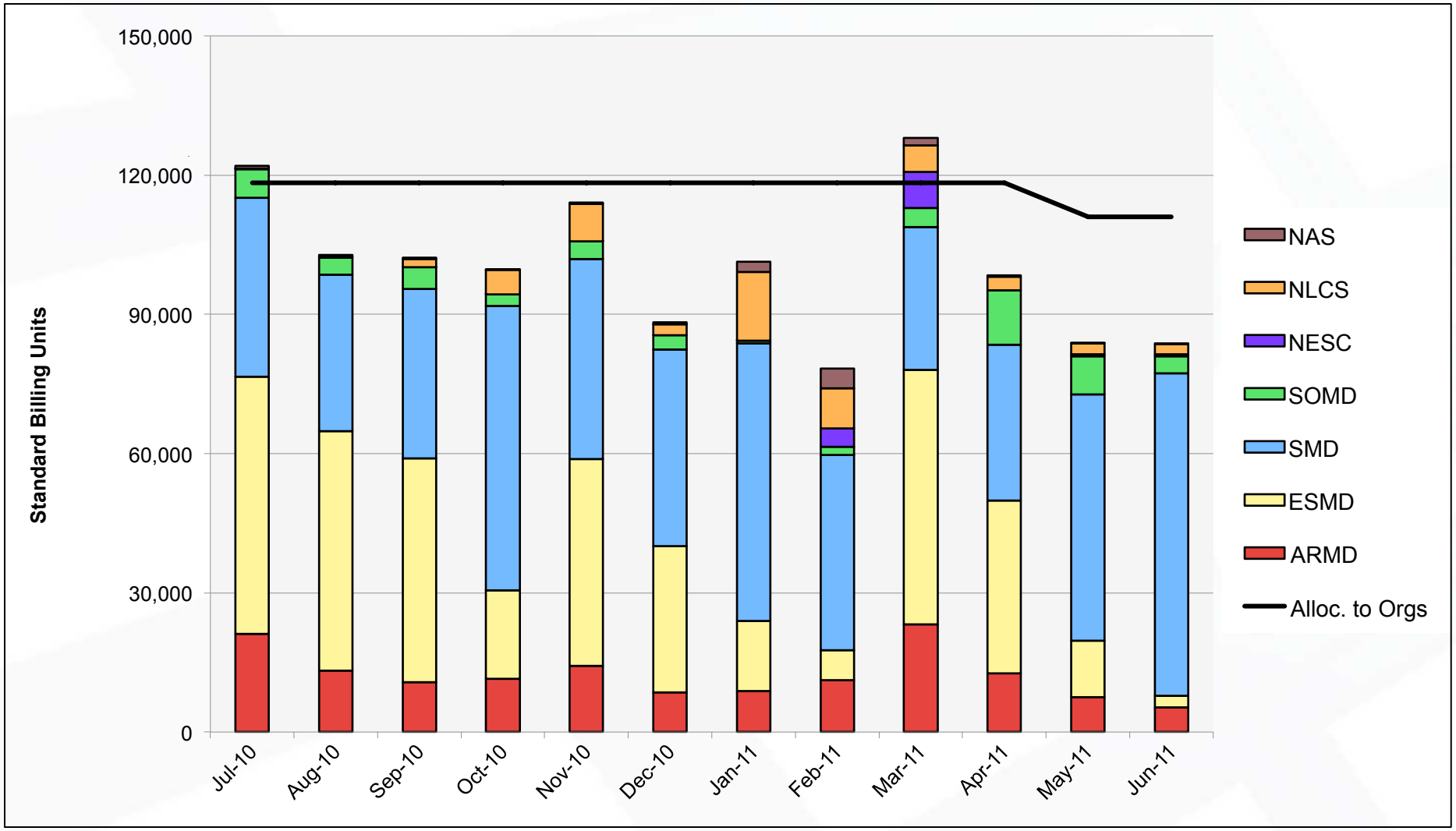
Pleiades:
Average Time to Clear All Jobs



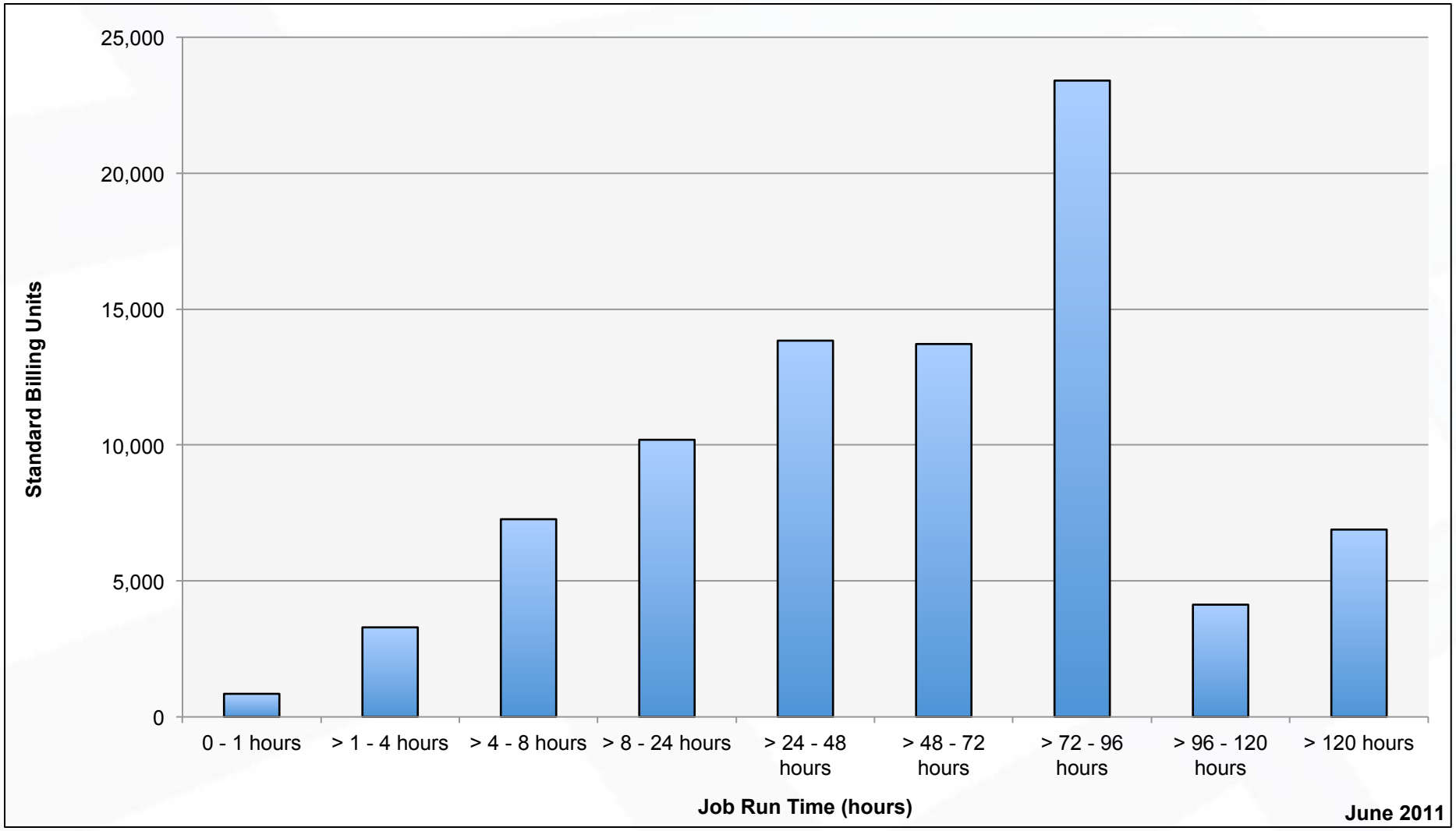
Pleiades:
Average Expansion Factor



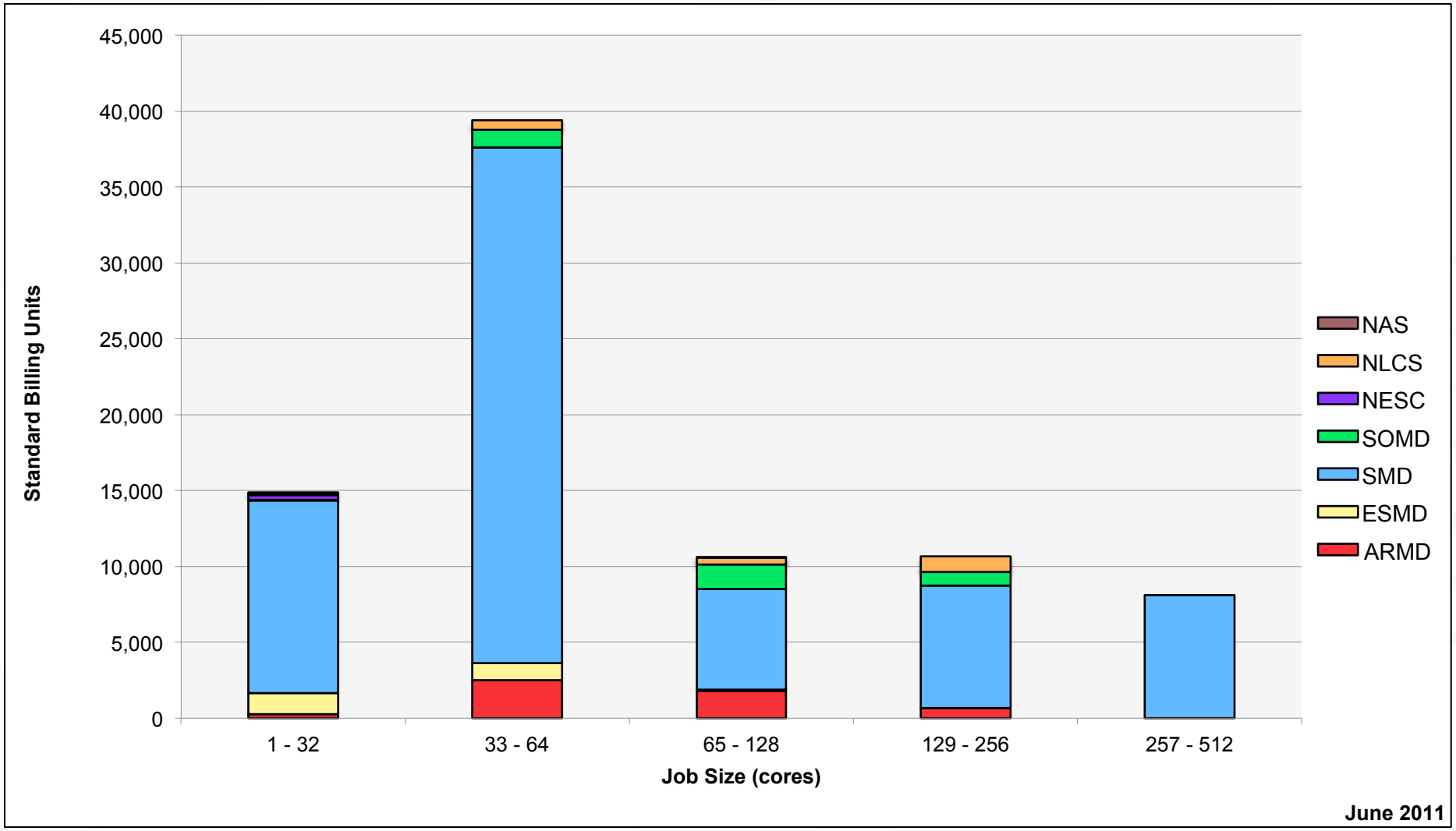
Columbia:
SBUs Reported, Normalized to 30-Day Month



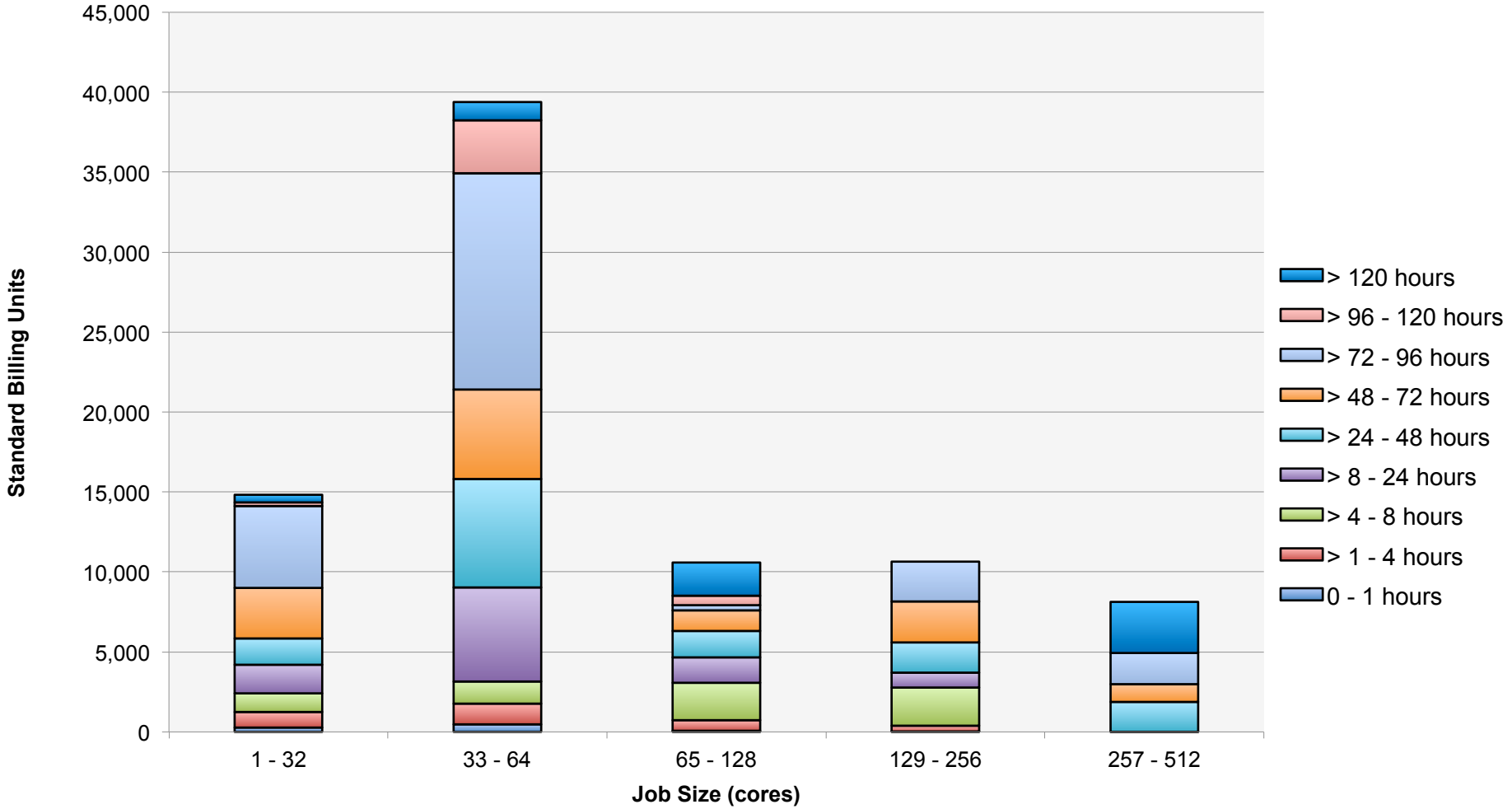
Columbia:
Monthly SBUs by Run Time



Columbia:
Monthly Utilization by Size and Mission



Columbia:
Monthly Utilization by Size and Length



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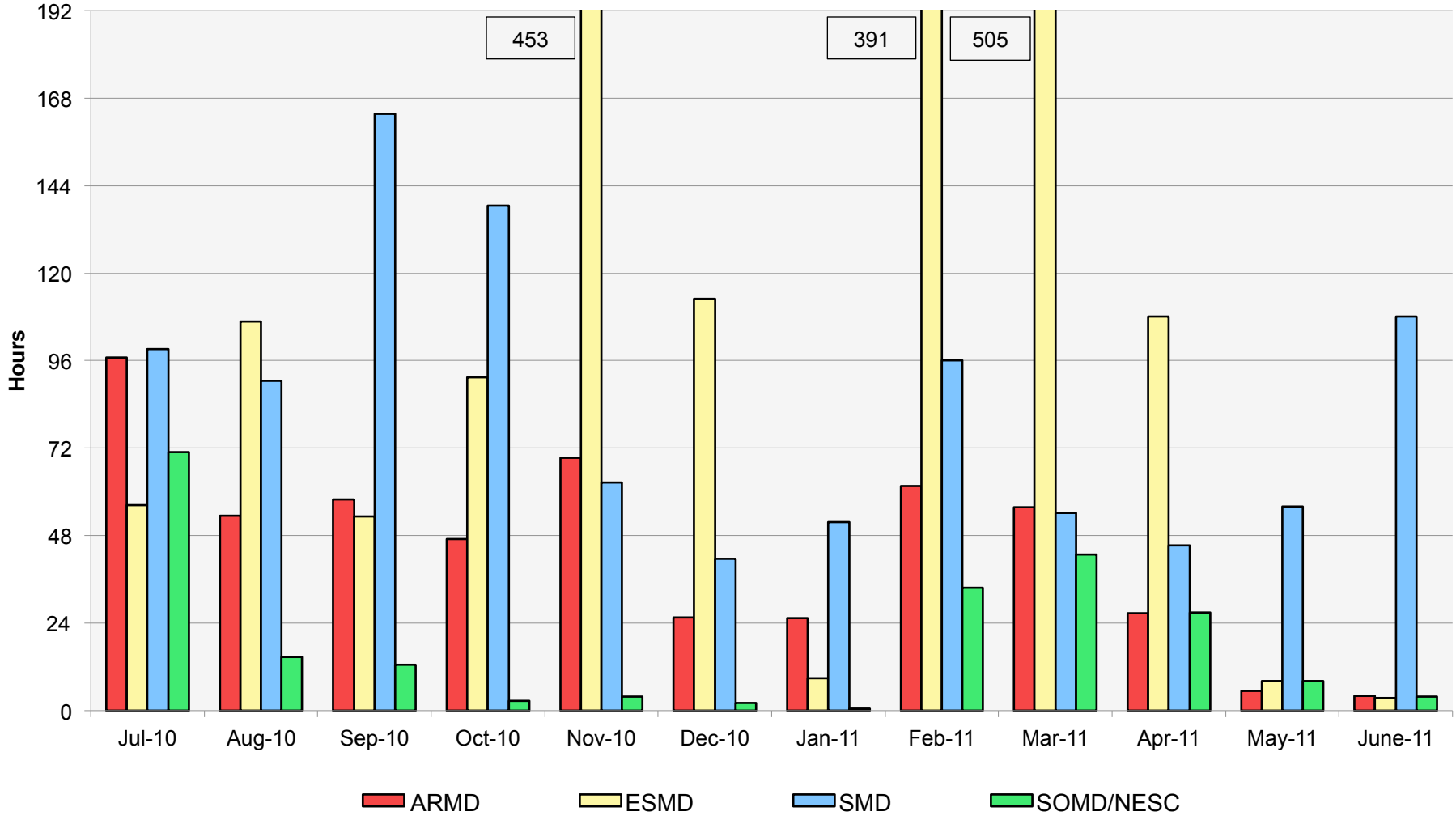

Columbia:
Average Expansion Factor