Project Status Report

High End Computing Capability
Strategic Capabilities Assets Program

13 April 2011

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Data Analysis Support for Kepler Mission Science Operations Center

- Extensive and timely HECC data analysis support has enabled the Kepler Mission's Science Operations Center (SOC) software team to analyze large datasets and meet specific mission milestone deadlines.
- Key support included a large-scale feasibility study and tests for conducting Kepler SOC data analysis on the Pleiades supercomputer, and creation of the infrastructure and approach to fully automate Kepler SOC production runs on Pleiades.
- Achieved the first fully-automated, end-to-end run of the DV (data validation) analysis module on Pleiades. This is the second Kepler SOC pipeline module (after TPS, the transiting planet search) to be deployed in "production mode" on the HECC systems at NAS.
- The HECC team presented status of the study to Kepler management, SOC personnel, and Ames Mission Software Review team, and gained approval for supercomputer processing options for both TPS and DV in the analysis pipeline to be deployed in the next version of Kepler software.

Mission Impact: HECC expertise has enabled the Kepler Science Operations Center to more accurately analyze large datasets and meet specific mission milestones.

Figure: NASA's Kepler space telescope's field of view superimposed on the night sky. Credit: Carter Roberts (from Kepler web site).

POC: *Chris Henze, christopher.e.henze@nasa.gov, (650) 604-3959, NASA Advanced Supercomputing Division*

Completion of New OVERFLOW CFD Simulations During Space Shuttle Launch Vehicle Ascent

- Preceding the recent Space Shuttle Discovery launch on February 24, scientists in the NASA Advanced Supercomputing Division at Ames completed OVERFLOW computational fluid dynamics (CFD) simulations of the ascending Space Shuttle Launch Vehicle using updated External Tank geometry.
- Previous mission elapsed time (MET) and cardinal Mach solutions did not include the new design for the +Z intertank aerovent.
- The new design uses significantly less foam around the vent and surrounding stringers, reducing the potential for crack formation.
- New CFD solutions provide better fidelity in the vicinity of the +Z aerovent.
- A total of 30 cases were run with OVERFLOW version 2.2, using the HLLC/SSOR algorithms on 256 cores of the Pleiades supercomputer, consuming a total of 1.7 million CPU hours.

Mission Impact: The new Shuttle launch simulations assure that debris transport, re-entry, and other analyses are based on the current geometry, so that launch and re-entry decisions can be made with the most accurate information.

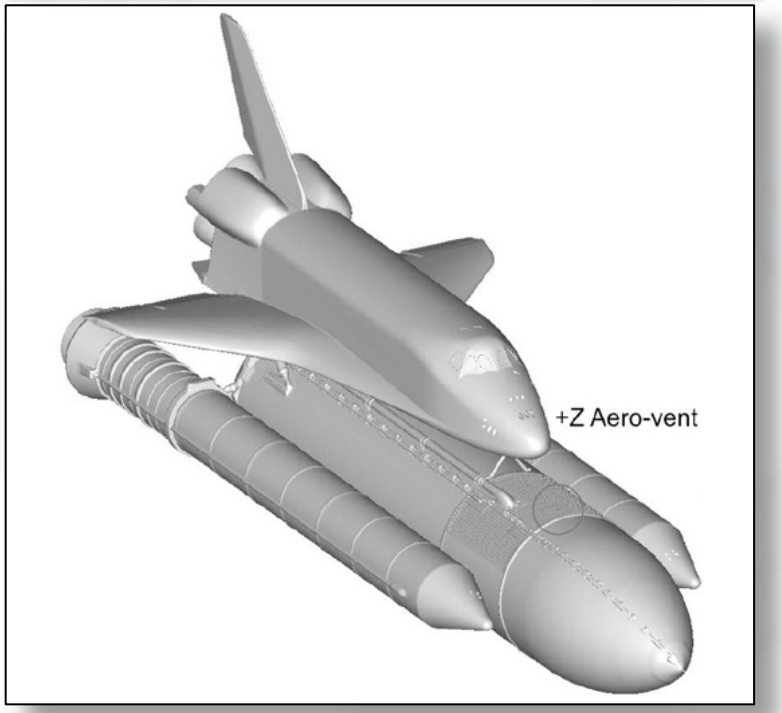


Figure: Space Shuttle ET-137 geometry with +Z aero-vent

POCs: *Ed Tejnil (STC/TNA) (650) 604-4527; Stuart Rogers (TNA) (650) 604-4481, NASA Advanced Supercomputing Division*

Visualization Support for High-Fidelity Simulation of Landing Gear Noise

- HECC visualization experts have produced a series of high-resolution images and videos for principal investigator Mehdi Khorrami, Computational Aerosciences Branch, NASA Langley; Khorrami's team uses numerical simulations to improve understanding of aircraft nose landing gear noise and provide guidance on effective noise-reduction technologies.
- The HECC team performed high-quality data analysis and visualization of the landing gear flow field, avoiding the need to save countless terabytes of information that would tax the storage capacity of even the largest supercomputers.
- Visualization staff generated numerous flow animations, which required saving a small portion (12,000 time steps) of the flow simulation record; each time step resulted in a 4-5 gigabyte file, with a total time record saved of more than 50-70 terabytes of data.
- HECC visualization of the flow interactions among gear components is crucial to understanding the air flow and noise propagation surrounding the landing gear.
- Mitigation of aircraft noise is a critical goal of NASA's Aeronautics Research Mission Directorate.

Mission Impact: HECC scientific visualization is an indispensable tool for improving understanding of the aircraft nose landing gear and communicating analysis results.

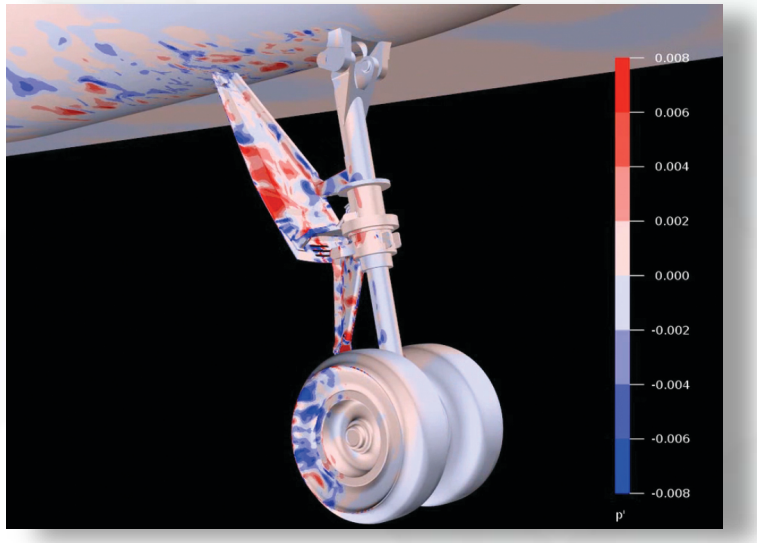


Figure: Pressure contours showing hydrodynamic pressure fluctuations in the nose landing gear wake and the radiated acoustic field. (Mehdi Khorrami, Airframe Noise Team, NASA/Langley; Patrick Moran, NASA/Ames)

POC: *Patrick Moran, patrick.j.moran@nasa.gov, (650) 604-1660, NASA Advanced Supercomputing Division; Mehdi Khorrami, mehdi.r.khorrami@nasa.gov, (757) 864-3630, NASA Langley*

Shape Optimization For Ultra-high Bypass Propulsion-Airframe Integration

- A new Cart3D-Adjoint design framework is being used by NASA Ames researcher Stephen Smith to perform aerodynamic shape optimization on the Columbia supercomputer.
- Special priority support by HECC enabled a flow-through configuration of the design to meet the Environmentally Responsible Aviation (ERA) Project's key milestone dates.
- Over 160 design variables simultaneously shape the wing and engine nacelle of a typical commercial transport configuration at two flight conditions.
- A Propulsion-Airframe Integration application was developed by the NASA Ames Experimental Aero-Physics Branch, under support from the ERA Project within Integrated Systems Research Program.
- Design efforts are continuing with a simulated powered nacelle.

Mission Impact: Special priority support on the Columbia supercomputer enabled meeting key ERA Project milestones. Continued support on Columbia is vital to the Cart3D-Adjoint design framework.

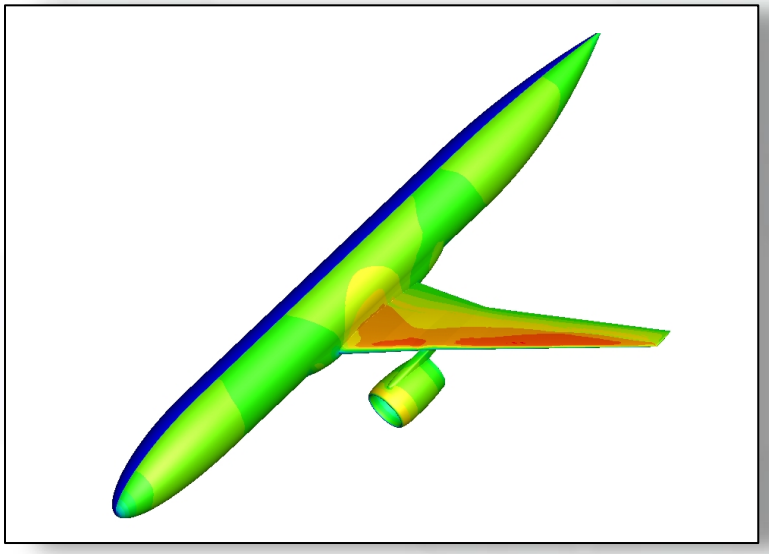


Figure: Ultra-high bypass engine nacelle integrated with typical single-aisle transport configuration. The Cart3D-Adjoint design framework was used, with over 160 shape variables at 2 flight conditions.

POC: *Stephen Smith, stephen.c.smith@nasa.gov, (650) 604-5856,*
NASA Ames Research Center, Experimental Aero-Physics Branch

HECC Supports Simulations for Heavy Lift Launch Vehicles

- Scientists in the NASA Advanced Supercomputing (NAS) Division at Ames Research Center are using HECC supercomputing resources to assist in the design of a heavy-lift Space Launch System (SLS), and improve understanding of heavy-lift launch vehicle (HLLV) aerodynamics during ascent.
- These resources, combined with HECC's powerful post-processing and visualization capabilities, enable NAS scientists to quickly compute entire aerodynamic databases and analyze many designs and conditions.
- Simulations include: aerodynamic analysis and comparison of aerodynamic performance and loads for candidate SLS architectures; validation studies using wind tunnel test data from the Ares V HLLV; and detailed analyses of protuberance effects, booster separation, and plume effects for HLLV ascent.
- These simulations are enabling rapid aerodynamic assessment and refinement of early SLS architectures, and will provide key data for selecting and developing the new vehicle design.

Mission Impact: Simulations of heavy-lift launch vehicle ascent, enabled by HECC resources, will directly inform the design of NASA's next-generation Space Launch System, which will be vital to achieving the Agency's space exploration and operations goals.

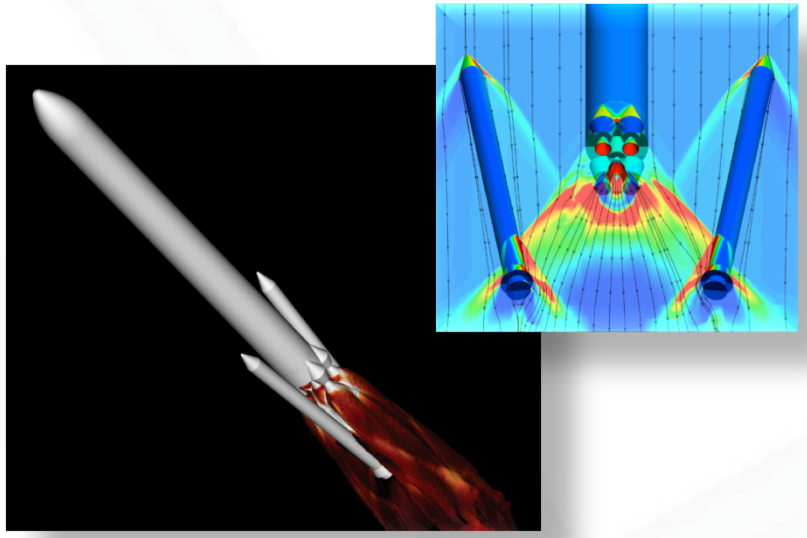


Figure: At right, solid rocket booster (SRB) separation maneuver for Ares V, showing plume isocontours colored by pressure. At left: SRB separation maneuver showing streamlines and pressure contours. (Marshall Gusman, NASA/Ames)

POC: *Cetin Kiris, cetin.c.kiris@nasa.gov, (650) 604-1660, NASA Ames Research Center; Marshall Gusman, marshall.r.guzman@nasa.gov, (650) 604-0594, Science and Technology Corp.*

3D Global Hybrid Simulations of Earth's Magnetosphere Require HECC Resources

- HECC users Homa Karimabadi and Burlen Loring, UC San Diego (UCSD), are running data-intensive global hybrid simulations of Earth's magnetosphere on the Pleiades supercomputer, as part of "space weather" studies for the Science Mission Directorate.
- These simulations are enabling a first glimpse of the global magnetosphere while capturing full ion kinetic effects; initial results have yielded key discoveries on the formation of flux ropes at the magnetopause.
- Large disk space and long queue time limits (the longest of any supercomputing site) on Pleiades have been two key elements to make these simulations possible.
- Particle simulations like these generate massive data sets—a single run can generate over 200 terabytes of data; to extract physics from these data, the UCSD team runs algorithms on large number of cores in a pre-visualization stage. The results are then made available for scientific visualization.
- These simulations have used over 25,000 cores on Pleiades, and the researchers are working with HECC to run jobs on the entire system.

Mission Impact: Researchers performed one of the largest 3D global hybrid simulation of the Earth's magnetosphere to date, enabled by NASA's Pleiades supercomputer.

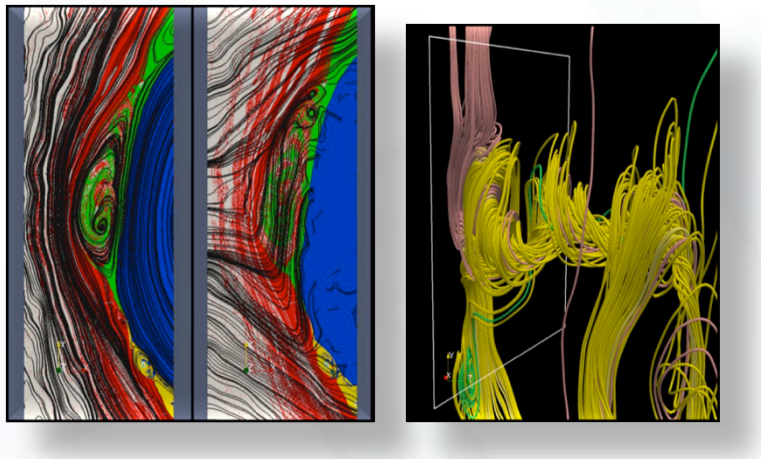


Figure: Left panel shows the magnetic field lines; middle panel shows the formation of a vortex in the flow generated by the passage of a flux rope; right panel shows the contours of density. (Burlen Loring, Homa Karimabadi, University of California, San Diego/SciberQuest)

POC: *Homa Karimabadi, hom@ece.ucsd.edu, (858) 793-7063, Burlen Loring, bloring@ucsd.edu, University of California, San Diego/SciberQuest*

HECC Security Increases Monitoring of RSA SecurID

- On March 18, RSA announced that a security breach of their network had occurred, resulting in stolen information pertaining to its SecurID two-factor authentication system.
- Not knowing the extent of the information stolen, HECC's Security team has increased monitoring to detect brute-force and denial-of-service (DoS) attacks against SecurID.
- The team detects brute-force attacks against SecurID by analyzing audit records and searching for patterns of multiple log-in attempts with a correct PIN or tokencode for a user while the corresponding PIN or tokencode is incorrect.
- Detecting DoS attacks against SecurID is performed by analyzing the audit records and searching for multiple passcode (PIN+tokencode) failures for the same user. Multiple failures for the same user may result in the account becoming disabled; thus a denial of service for the user.

Mission Impact: By increasing the monitoring of RSA SecurID, Security experts are able to detect targeted attacks against SecurID at the HECC facility.

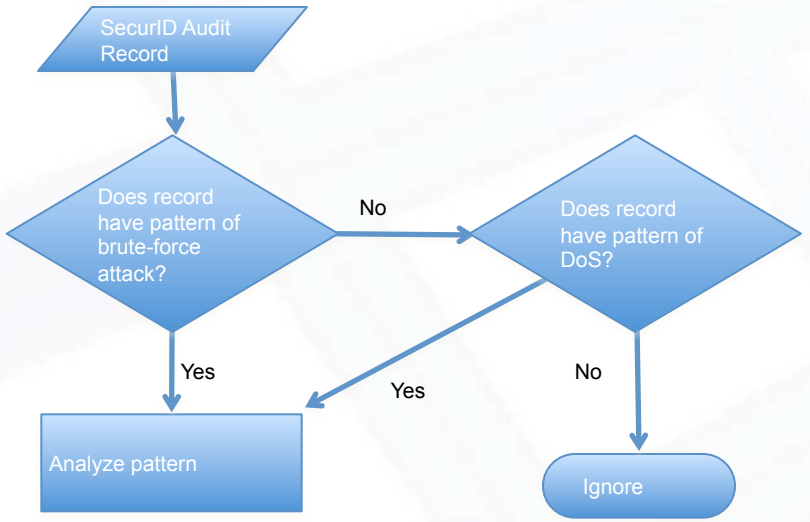


Figure: Basic diagram of log analysis of RSA SecurID audit messages.

POC: *Derek G. Shaw, derek.g.shaw@nasa.gov, (650) 604-4229,*
NASA Advanced Supercomputing Division, Computer Sciences Corp.

Installation of New Racks Brings Pleiades to 100,352 Cores

- In March, 12 new Westmere racks were installed on Pleiades, increasing the system's peak performance by an additional 108 teraflops (TF).
- The new racks add another 9,216 Westmere cores and expands Pleiades to 168 racks with 100,352 cores and 1.189 petaflops peak performance.
- HECC and SGI staff successfully added the new racks via a live integration technique, enabling the system to remain available to users—this process saved over 3 million hours of computing time that would have been unavailable if the system had to be brought down for the integration work.

Mission Impact: The continuing expansion of Pleiades provides increased computational capability to all NASA Missions Directorates.

Figure: Twelve additional SGI Westmere racks were installed in March 2011, adding another 108 teraflops of computational capability to Pleiades.

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

Network Infrastructure Upgrade Completed in Main Communications Room

- The HECC local area network team has successfully upgraded the network infrastructure in building N258's main communications room.
- The new infrastructure meets the latest industry standards and includes Category 6A copper Ethernet, which can support 10-gigabit data rates; in addition, new network racks were installed, providing room for expansion and better cable management.
- The new infrastructure also includes an above-rack cable tray to route fiber and copper cables between rows—this reduces the risk of damaging critical switch trunks.
- As part of the upgrade, the team also completed the removal of legacy network infrastructure, improving airflow and providing faster troubleshooting of fiber/cable problems.
- The team was able to transition production equipment (including two core routers) to the new network infrastructure with minimal user impact.

Mission Impact: The new network infrastructure provides enhanced connectivity and allows for the support of future network hardware expansion in the HECC main communications room.

Figure: New network racks located in the HECC facility's main communications room.

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

Network Team Develops Spanning Tree Protocol Dynamic Diagramming Tool

- The Network team has developed a tool that dynamically produces a real-time graphical display of the NASLAN layer 2 topology.
- This tool automatically queries all network devices; a dataset representing the Spanning Tree topology is automatically learned and stored in a MySQL database.
- In order to visualize the data, AJAX/Javascript, PHP, and CSS3 are used to dynamically draw lines representing paths between network devices, based on the information stored in the database.
- By viewing the logical paths taken by layer 2 traffic across the network, HECC engineers are able to easily identify faulty configurations and sub-optimal traffic paths across NASLAN.
- Since no commercial software exists that offers this capability at the switching layer, the Network team designed and developed this tool in-house.

Mission Impact: By utilizing this tool, network engineers are able to more efficiently identify and resolve spanning tree protocol problems, improving availability and ensuring optimal network performance.

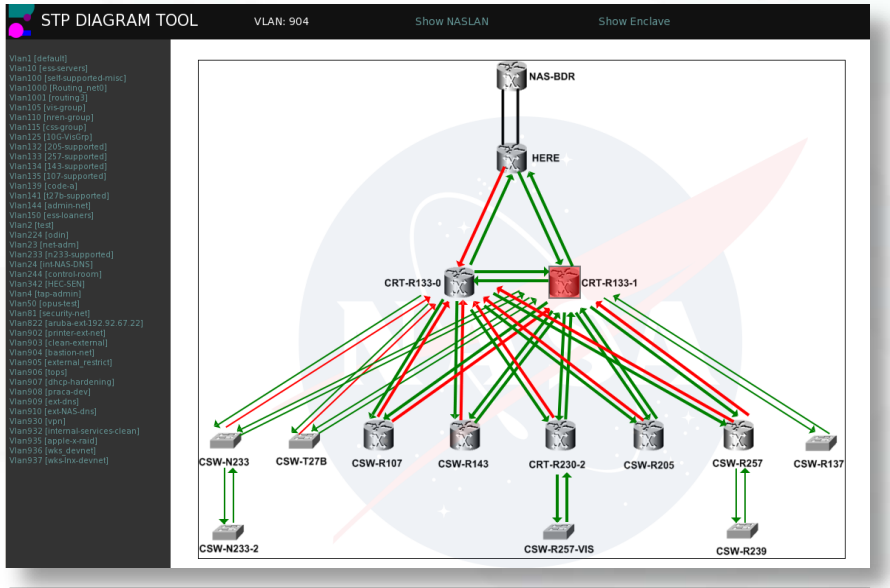


***Figure*:** Screenshot of the Spanning Tree Protocol diagramming tool. Shown here is the layer 2 layout of the NASLAN network, and the paths that are blocked (red) or forwarding (green) for a specific subnet.

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

Presentations and Papers

Papers

- Computation of Viscous Incompressible Flow, Dochan Kwak, Cetin C. Kiris, hardbound book, Springer, Scientific Computation Series, ISBN 978-94-007-0192-2.*
- The Evolution of Open Magnetic Flux Driven by Photospheric Dynamics, Jon A. Linker et al, The Astrophysical Journal 731 (2011) Number 2, March 31, 2011.*
- High Performance Computing using MPI and OpenMP on Multi-Core Parallel Systems, Haoqiang Jin, Dennis Jespersen, Piyush Mehrotra, Rupak Biswas et al, Parallel Computing (2011), February, Publisher: Elsevier B.V., available online 2 March 2011.
- Comparative Study of Different Numerical Approaches in Space–Time CESE Framework for High-Fidelity Flow Simulations, Gary C. Cheng et al, Computers and Fluids, Volume 45, Issue 1, available online 27 January 2011 *

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

News and Events

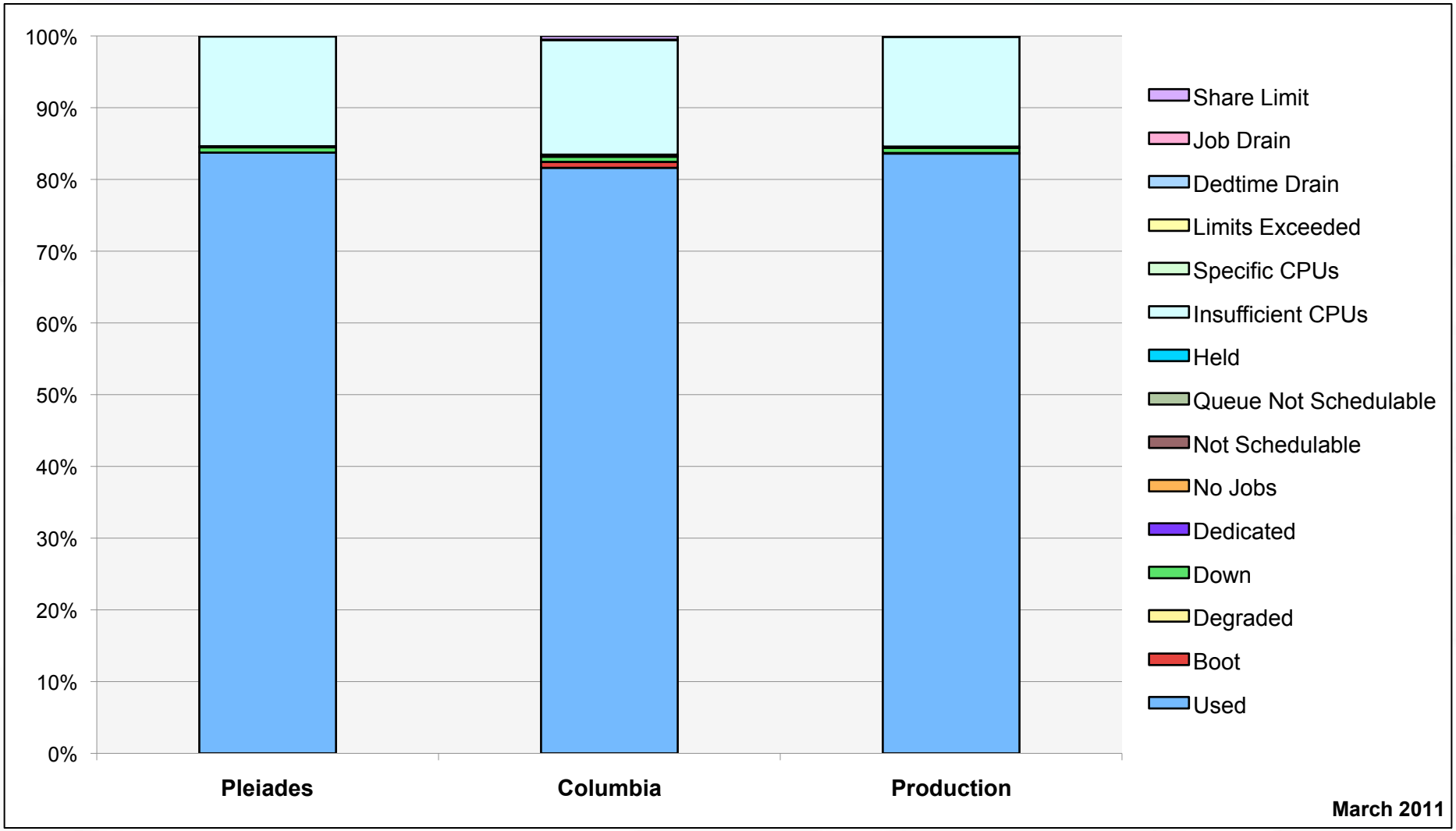
- **Amazon Rainforest Brown After Severe 2010 Drought**, *Environment News Service*, March 31, 2011 – Article summarizing results of an international study that used the combination of NASA's MODIS and TRMM data, NASA Earth Exchange, and support from HECC resources at NAS facility.*

- **NASA Extends Contract for Supercomputing Support Services**, NASA press release, March 30, 2011 – Announces that NASA will exercise the third one-year option (valued at ~$58.6 million) on a contract with Computer Sciences Corp. to provide supercomputing support services at NASA's Ames Research Center.

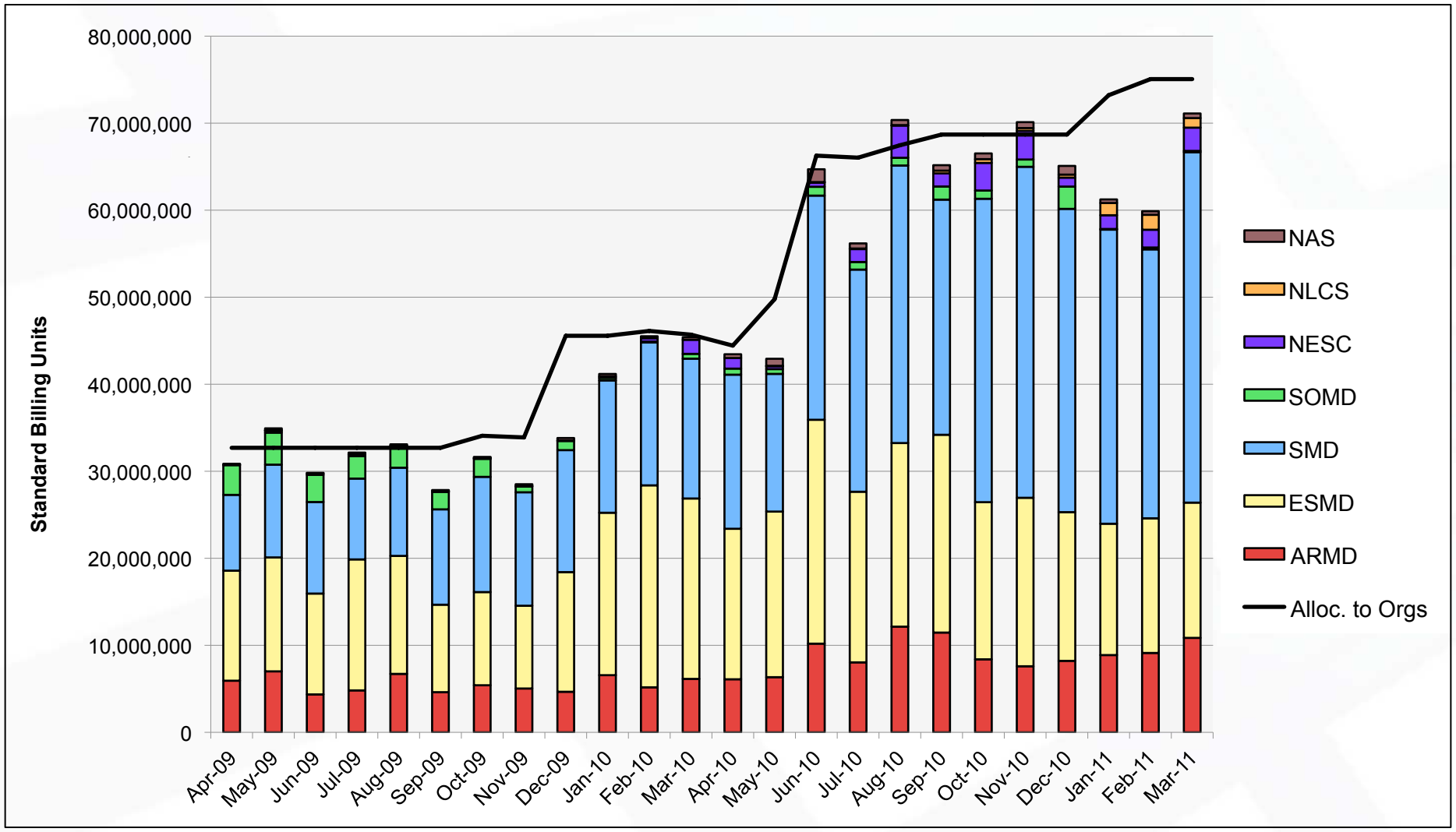
- **Modified X-51A Waverider ready for next hypersonic test**, *Defence Professionals*, March 17, 2011 – U.S. Air Force engineers said NASA has been critical to the development of the X-51A Waverider hypersonic vehicle through availability of HECC resources.* http://www.defpro.com/news/details/22896/?SID=d28d048c496717f9e873e6477edc5e5e
- **NASA Awards SBIR Funding To Kitware to Enhance Its Paraview Visualization Application**, Kitware press release, March 15, 2011 – Mentions that NASA uses the open-source visualization application, ParaView, to explore the results of trillion element particle simulations on Pleiades.

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

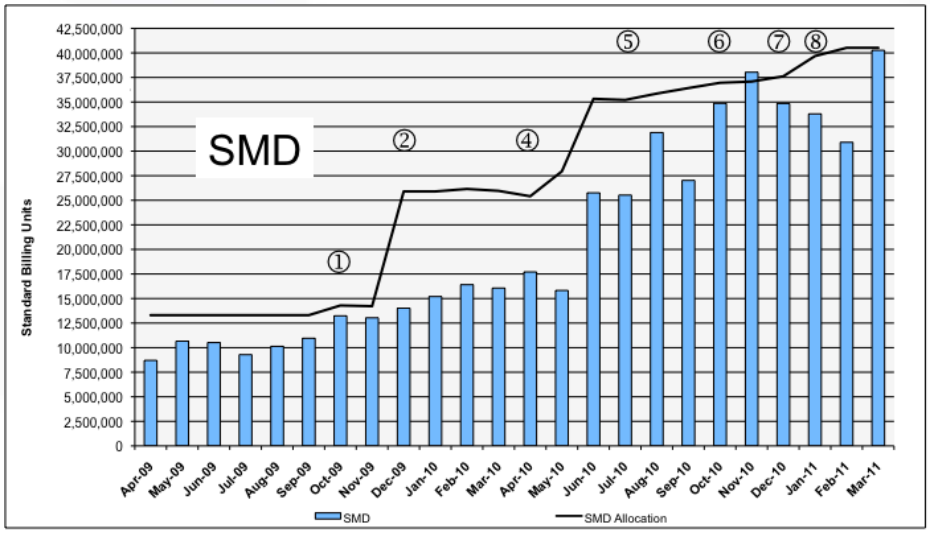
NAS Utilization

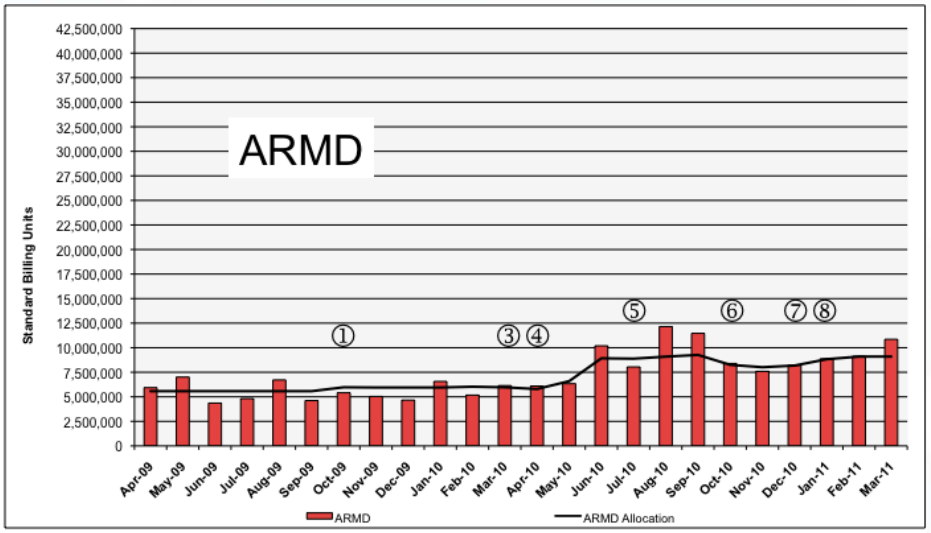


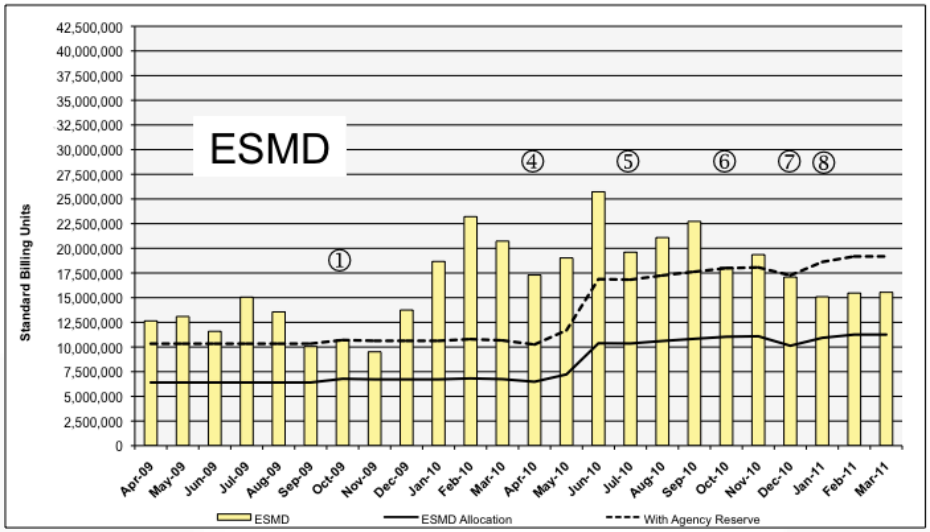
NAS Utilization Normalized to 30-Day Month

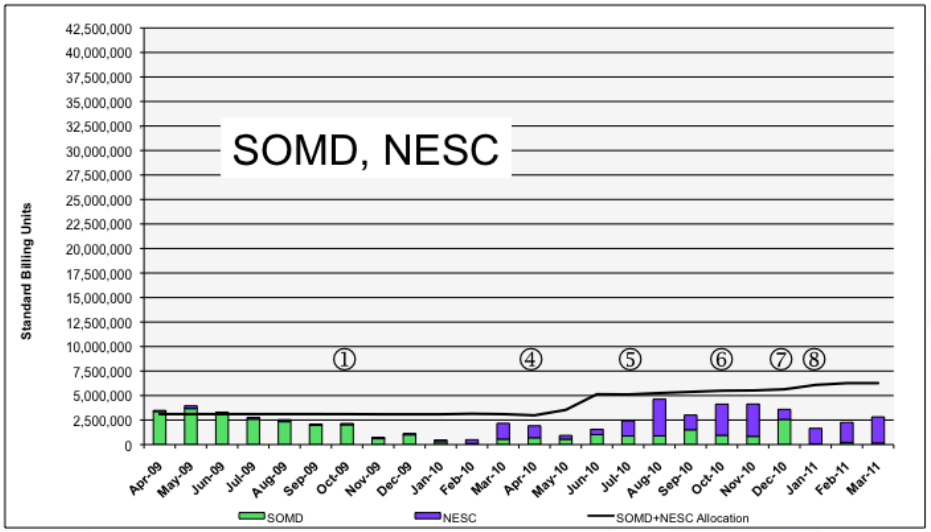


NAS Utilization Normalized to 30-Day Month





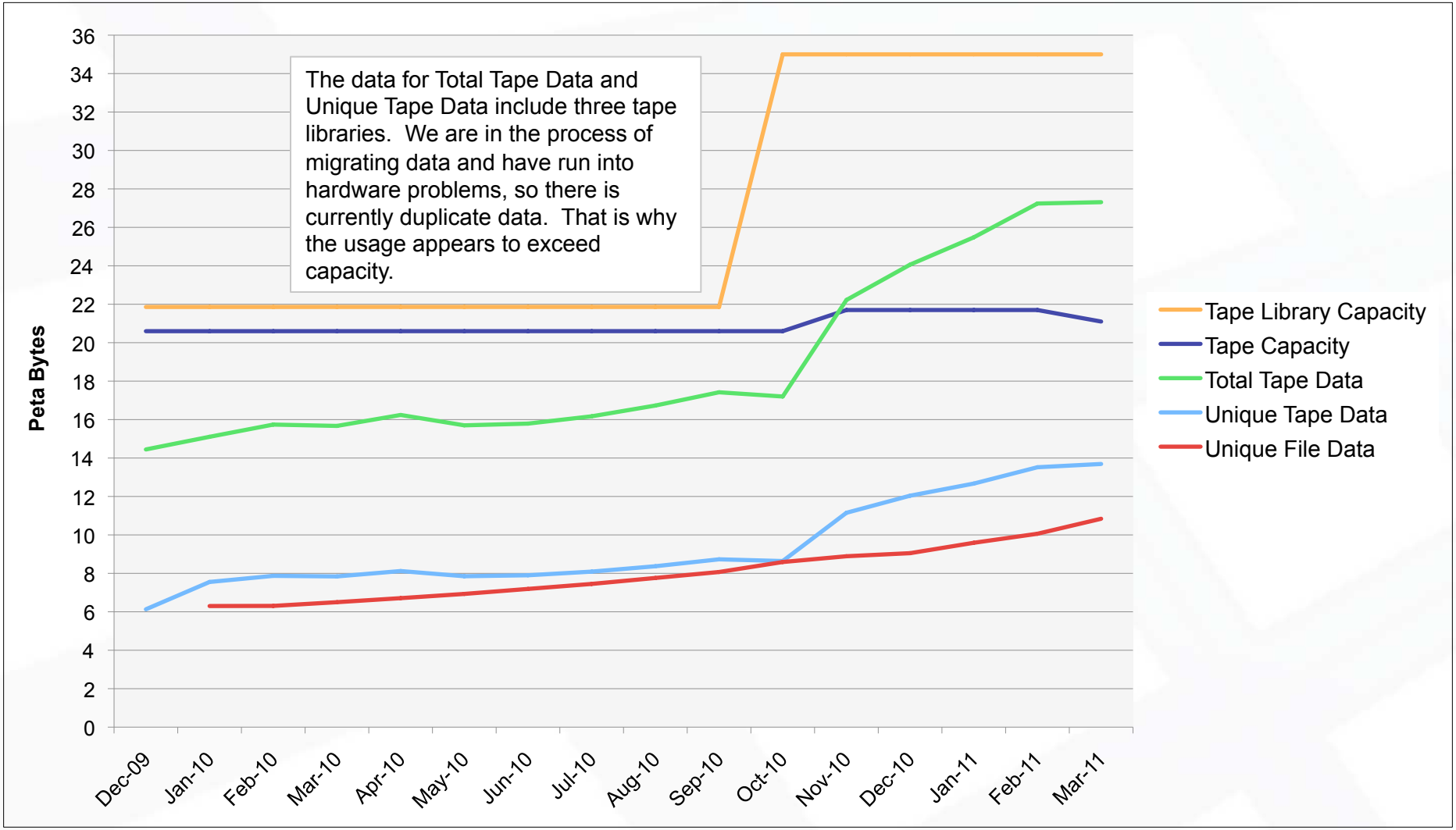




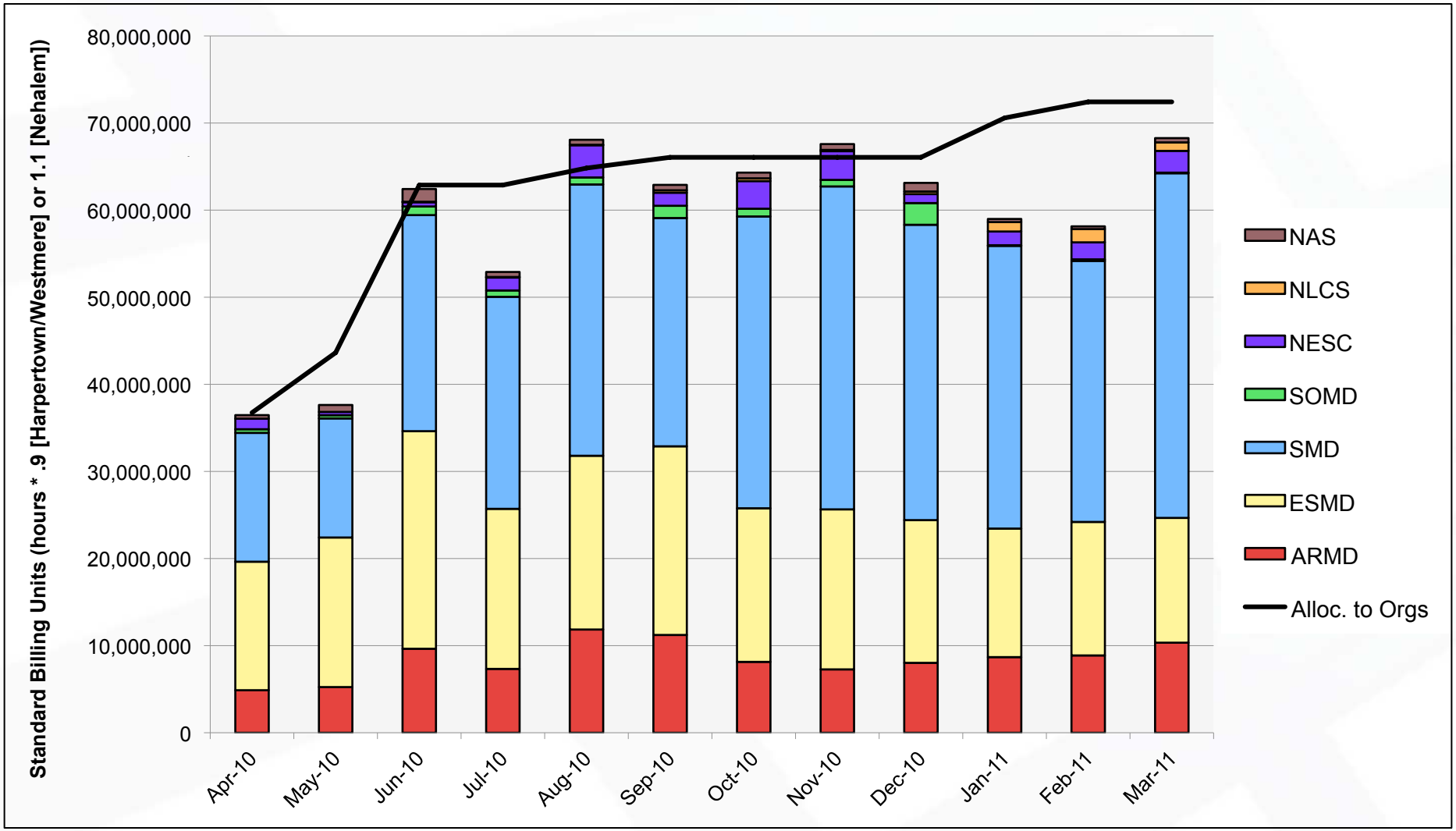
① Allocation to orgs. increased to 80% ② SMD augmentation ③ RTJones retired ④ 32 Westmere racks added
⑤ Schirra retired, 4 Westmere racks added ⑥ RTJones compensation removed ⑦ 8 Westmere racks added ⑧ Devel queue created

Tape Archive Status

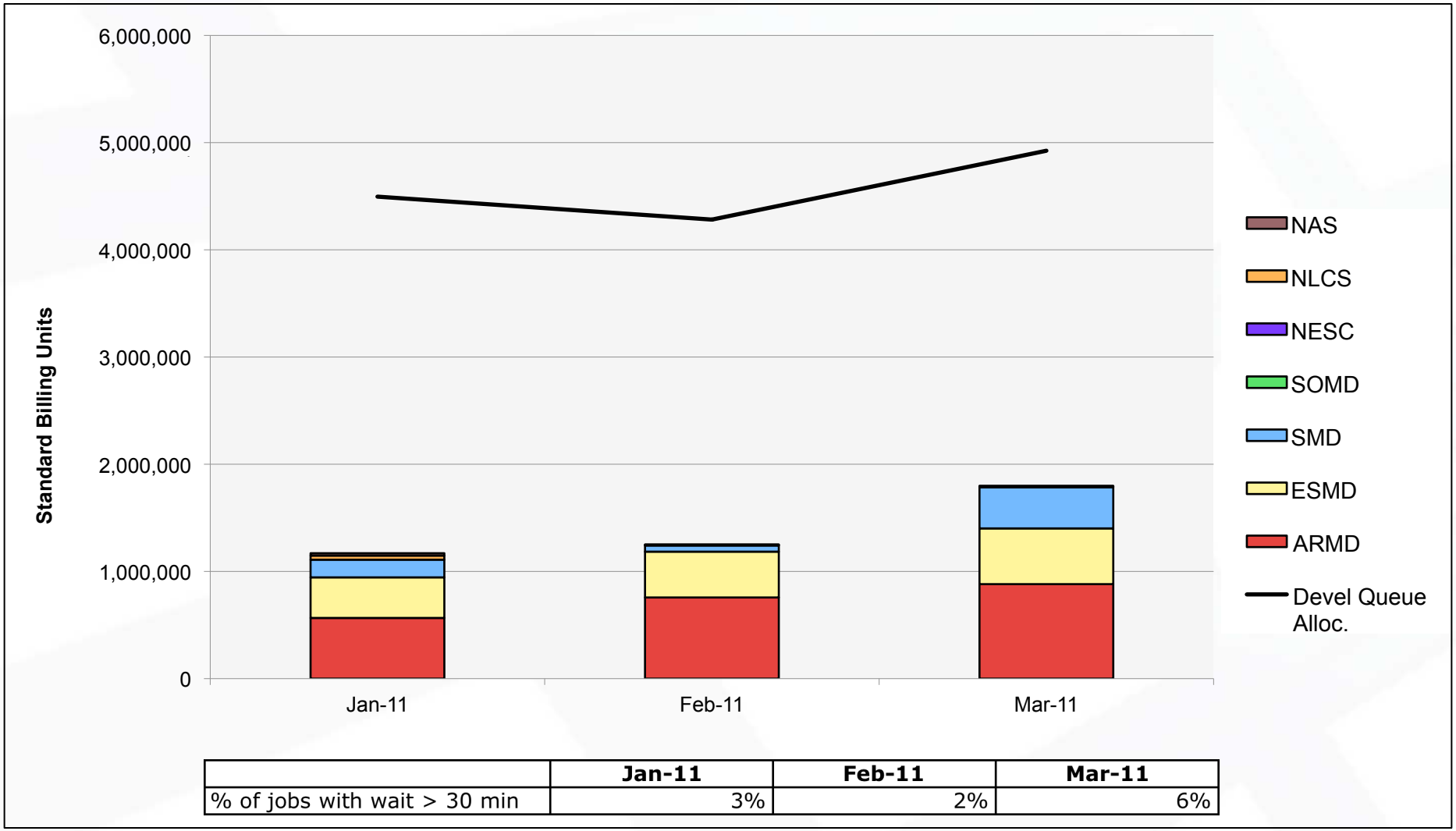
Tape Archive Status



Pleiades:
SBUs Reported, Normalized to 30-Day Month

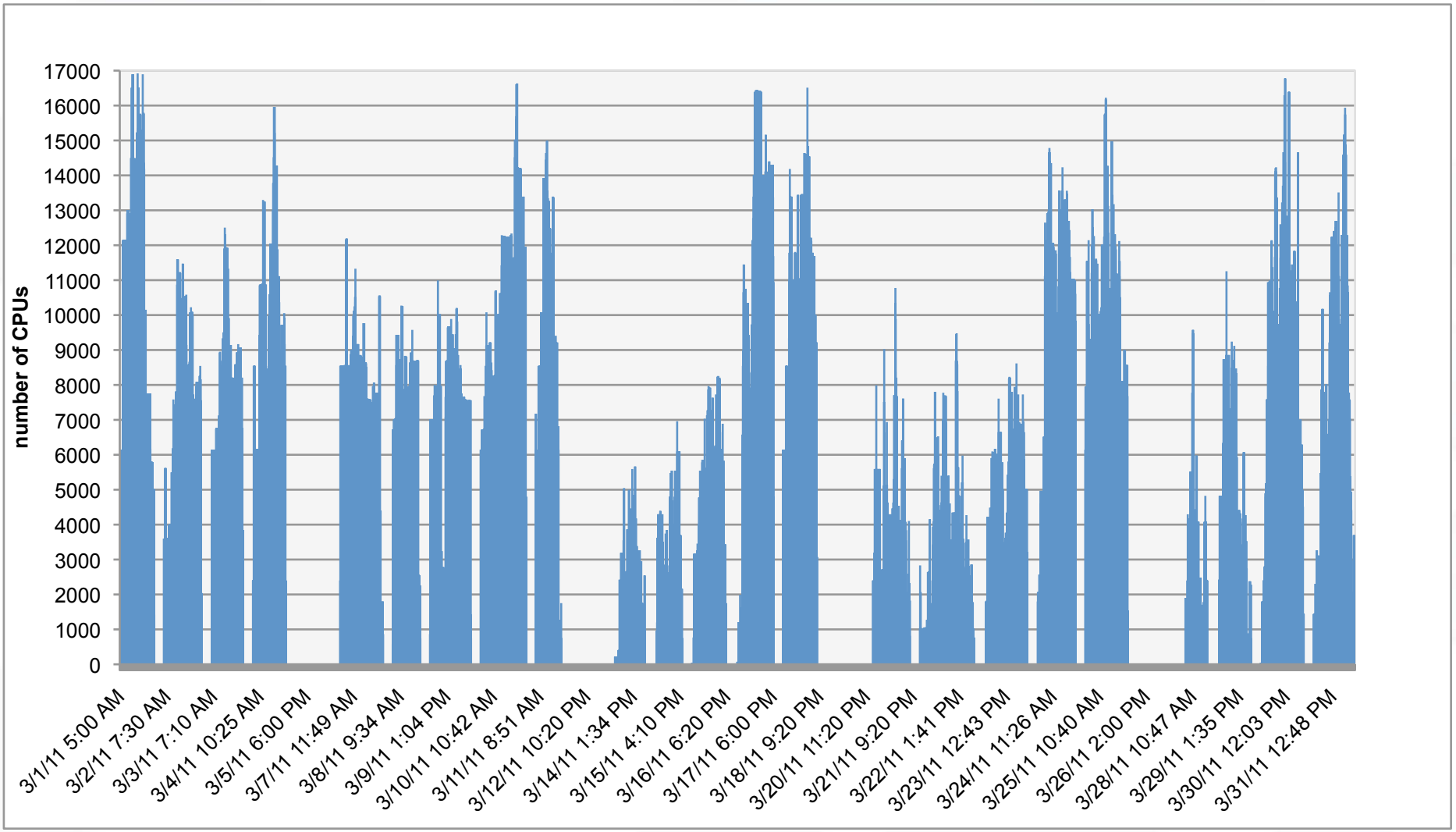


Pleiades:
"devel" Queue Utilization

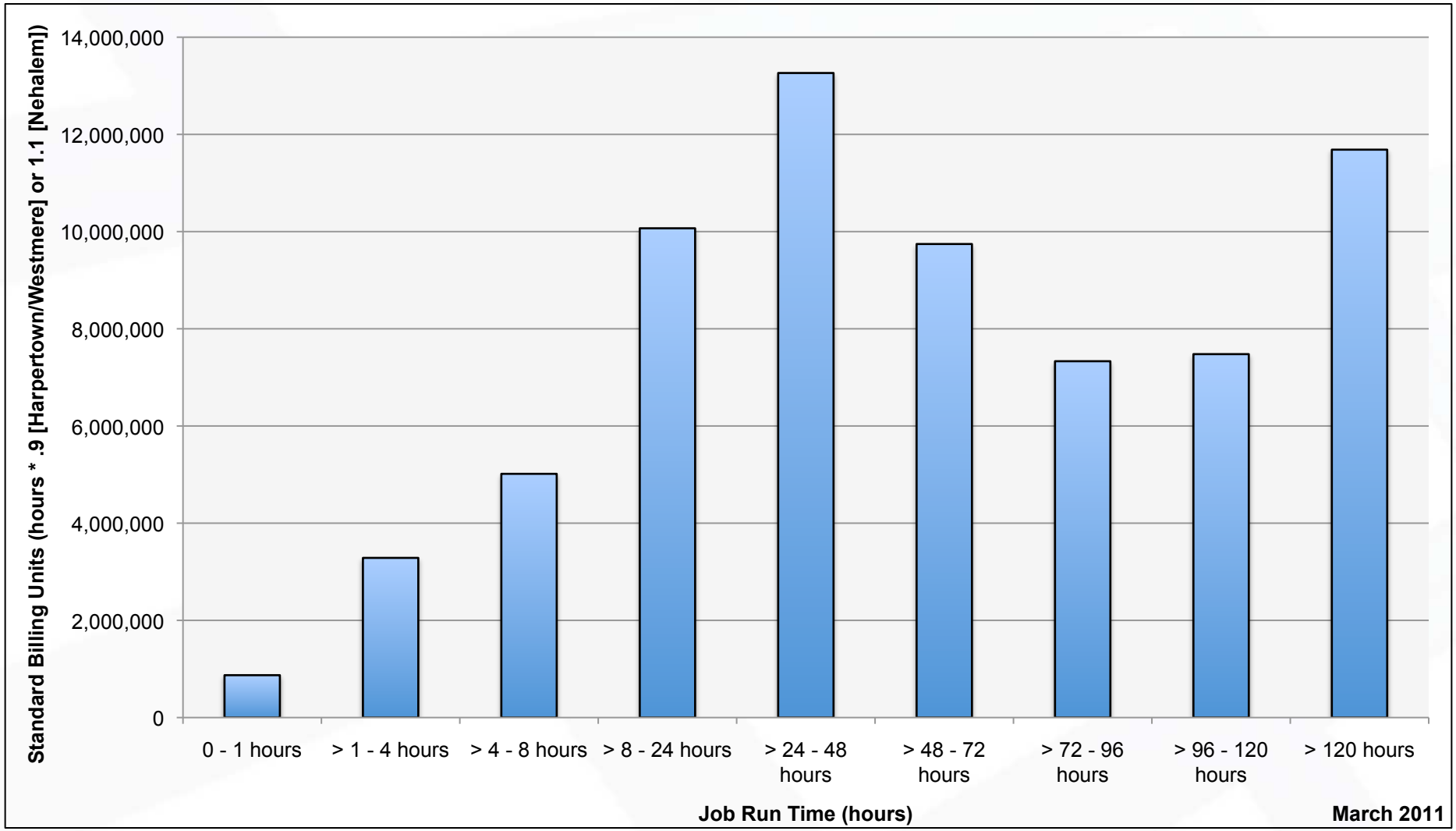


	Jan-11	Feb-11	Mar-11
% of jobs with wait > 30 min	3%	2%	6%

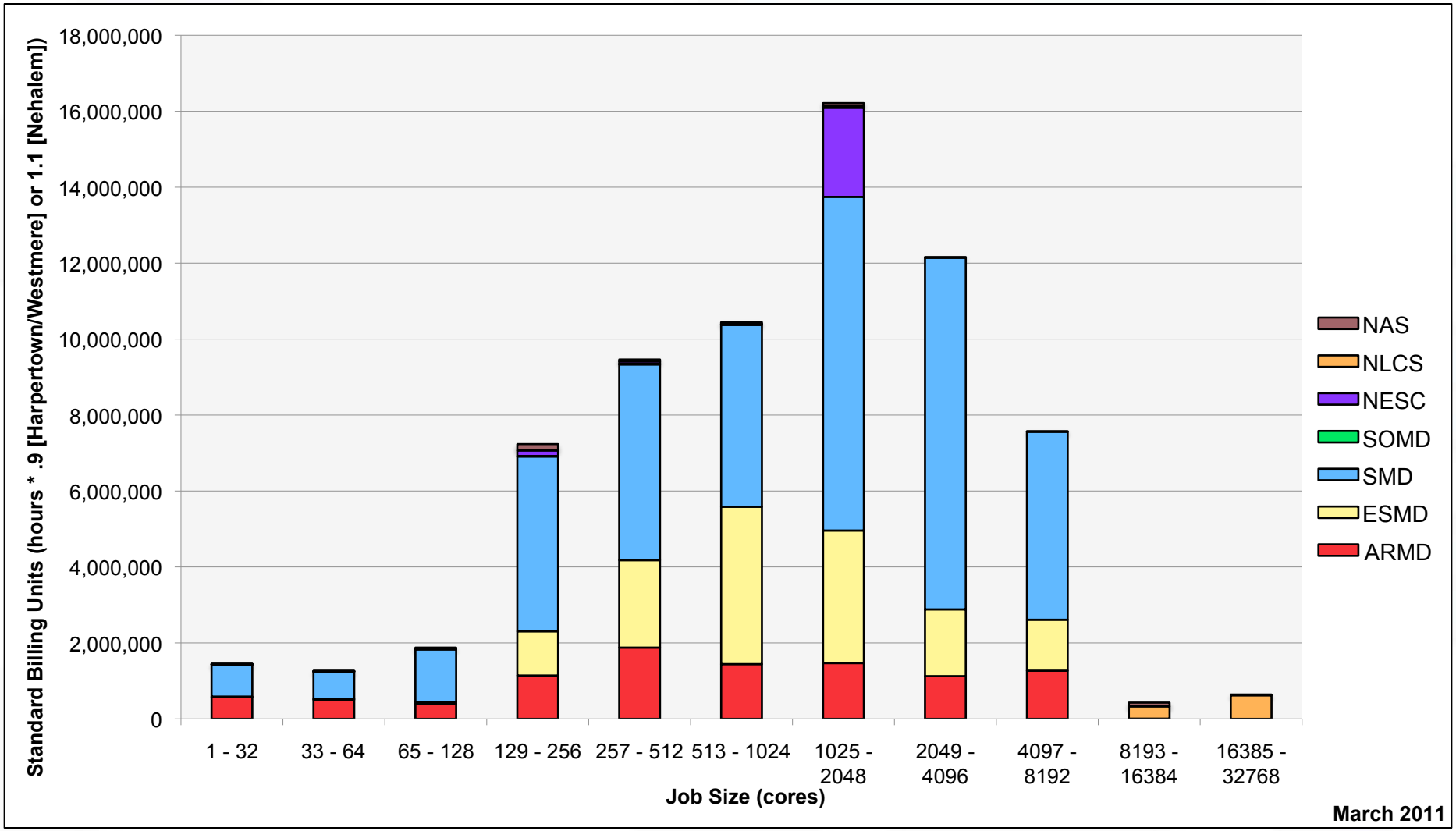
Pleiades:
Usage of “devel” Queue Resources



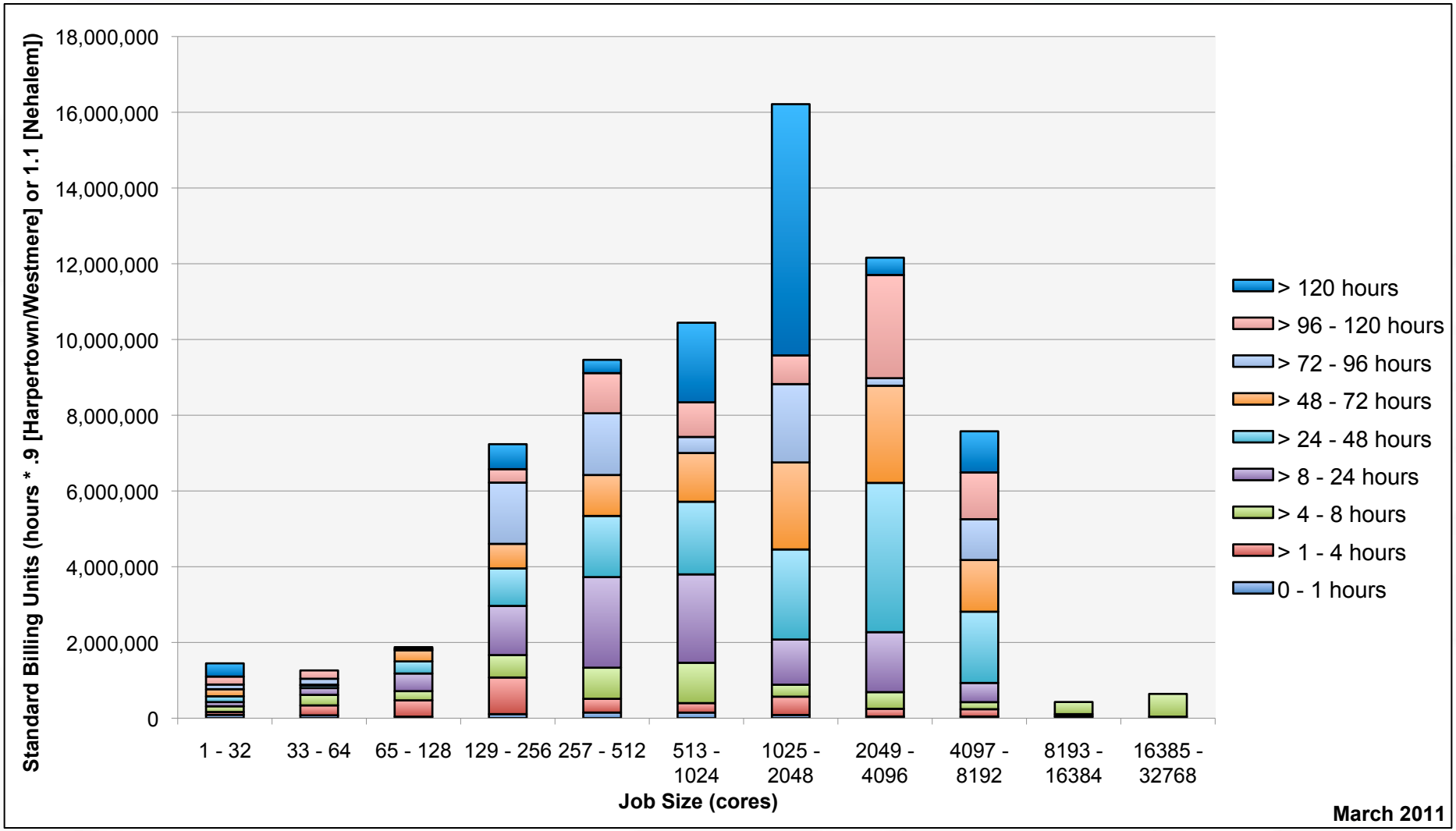
Pleiades:
Monthly SBUs by Run Time



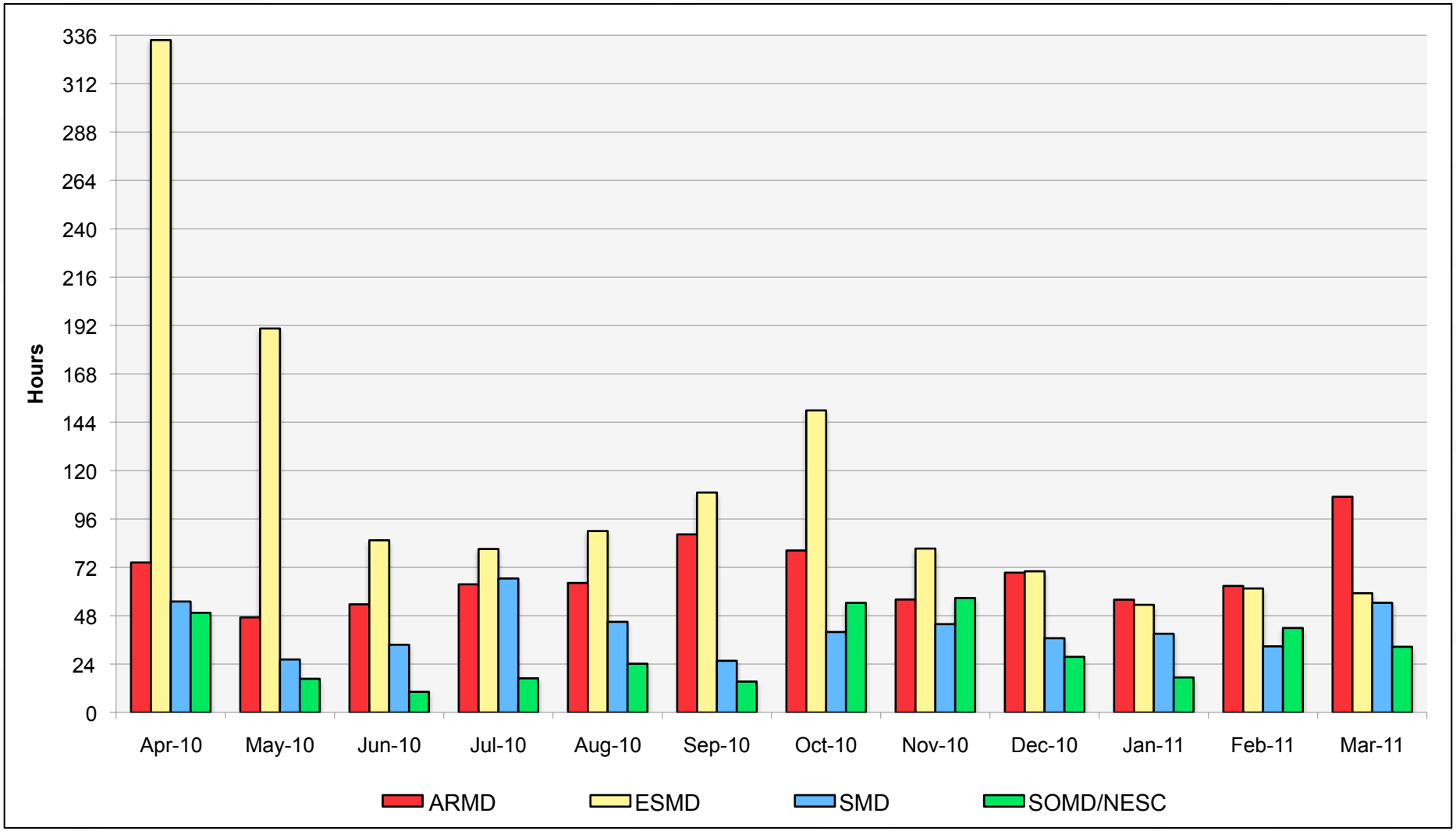
Pleiades:
Monthly Utilization by Size and Mission



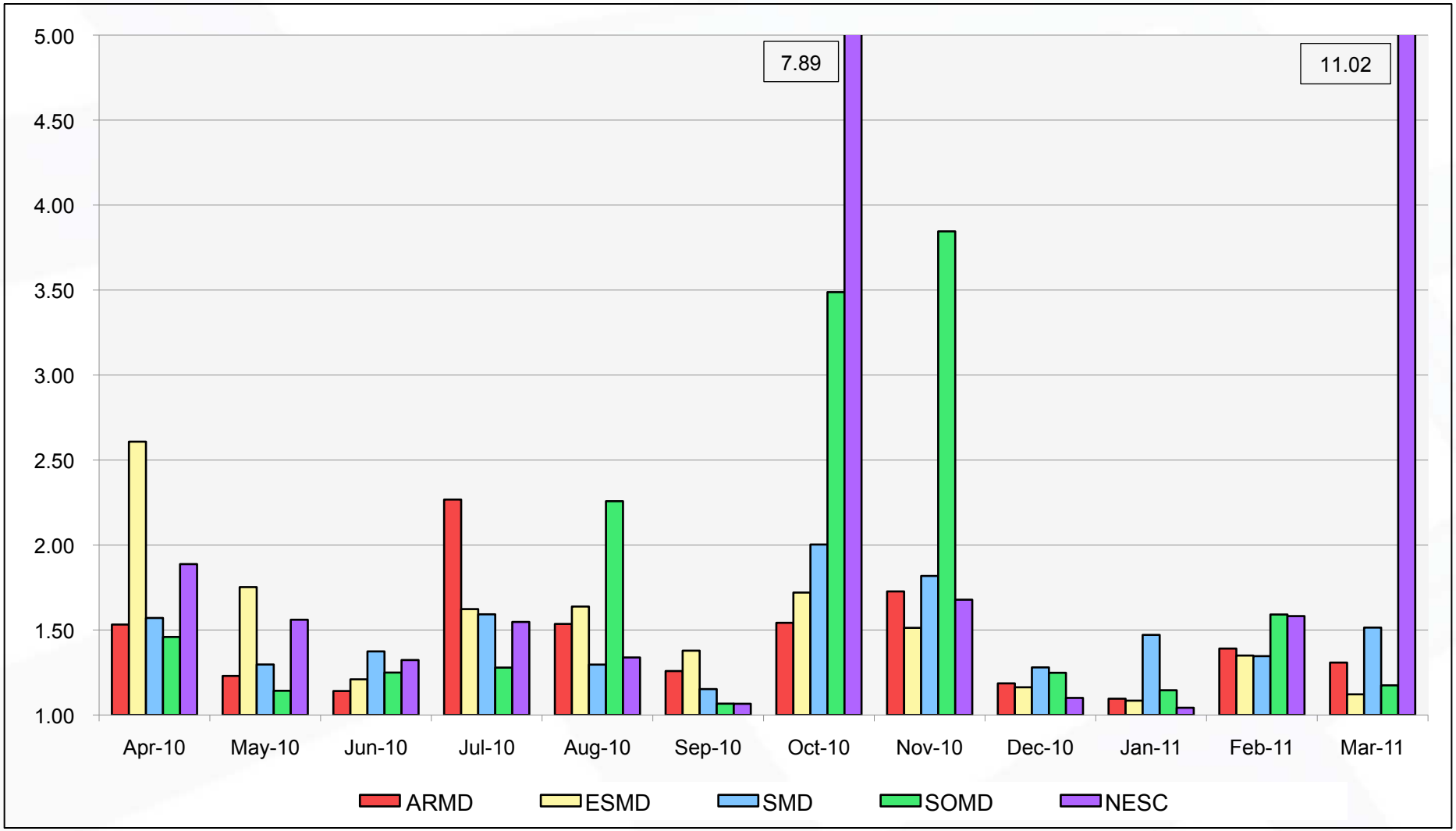
Pleiades:
Monthly Utilization by Size and Length



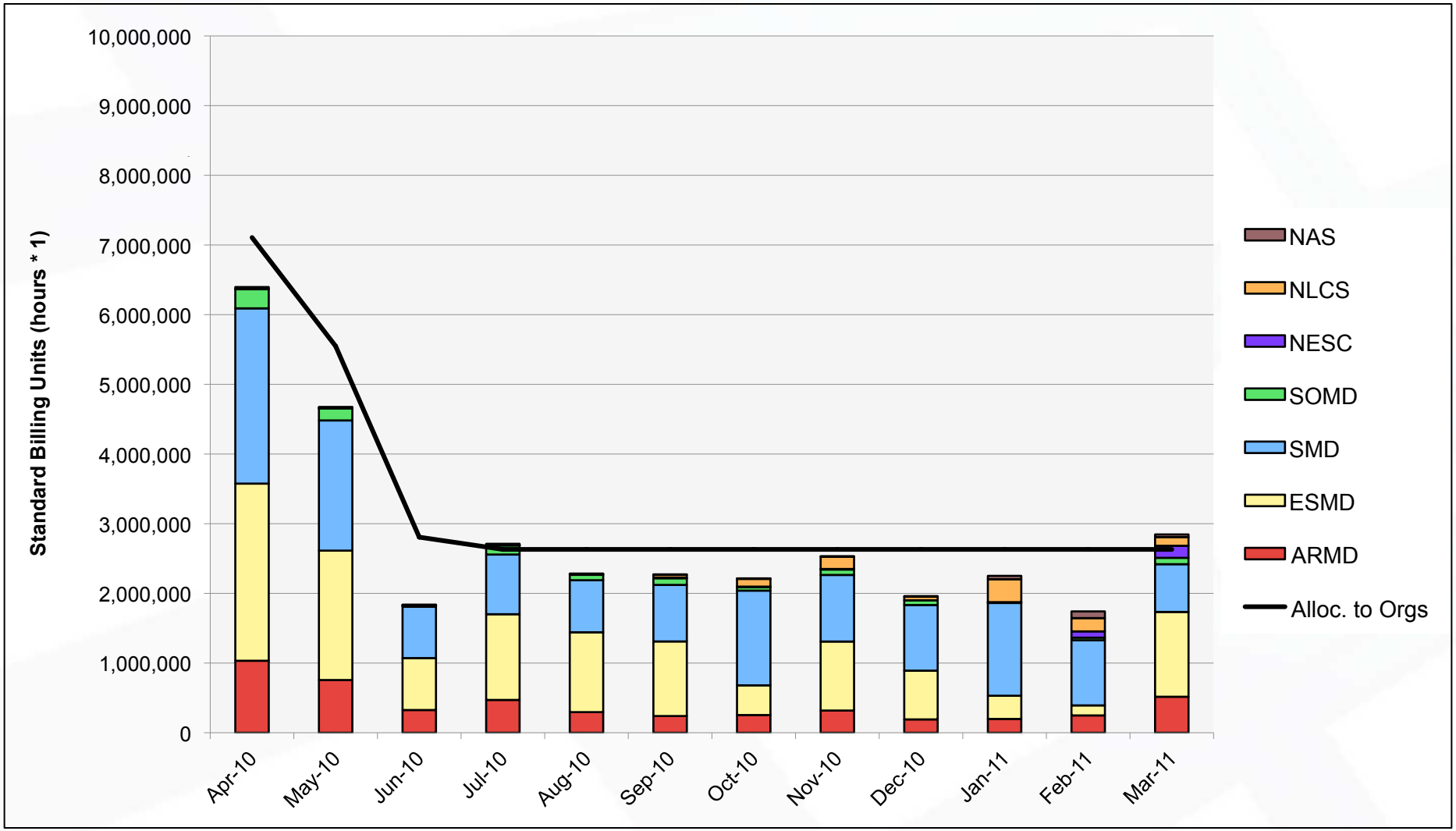
Pleiades:
Average Time to Clear All Jobs



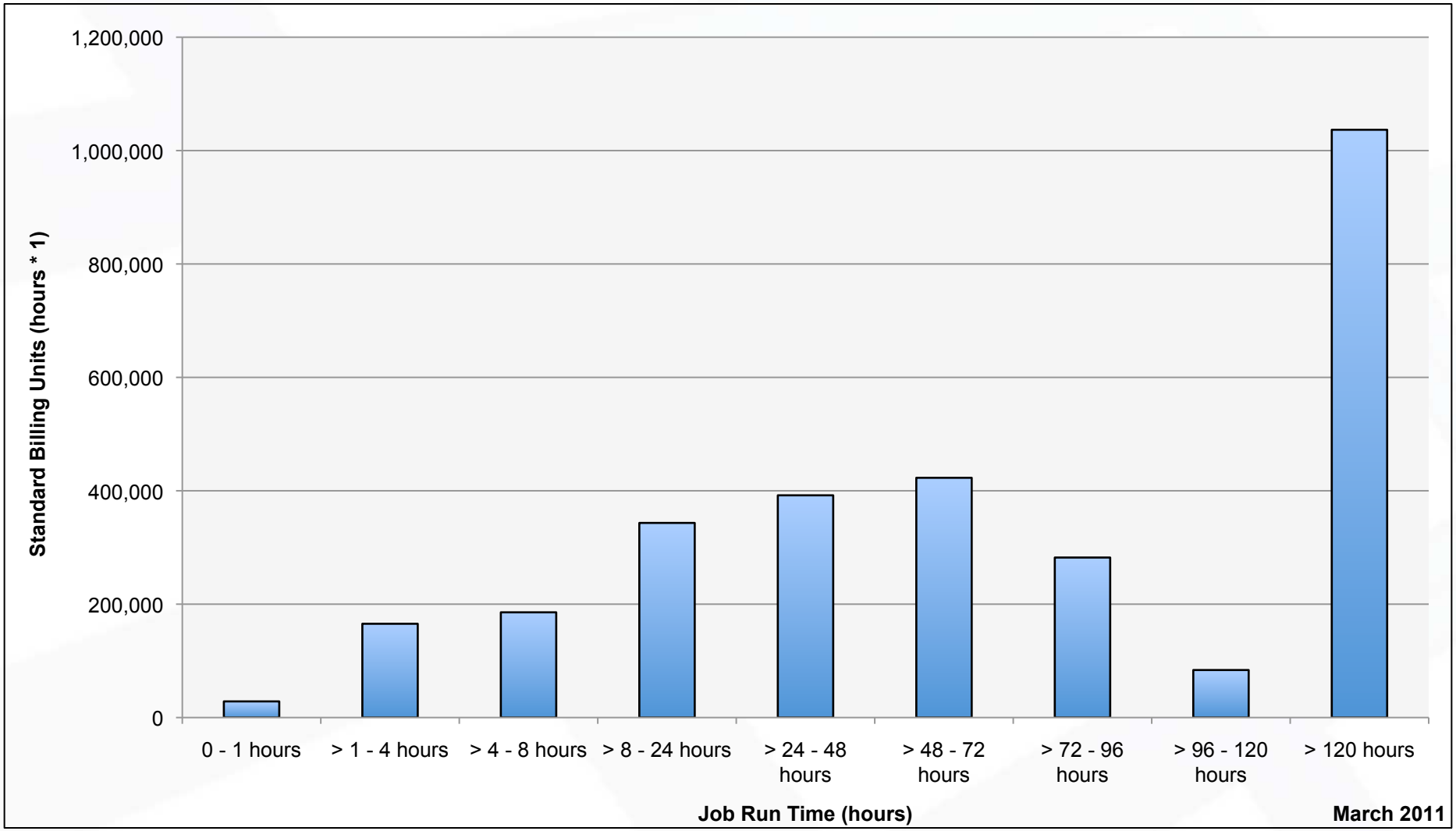
Pleiades:
Average Expansion Factor



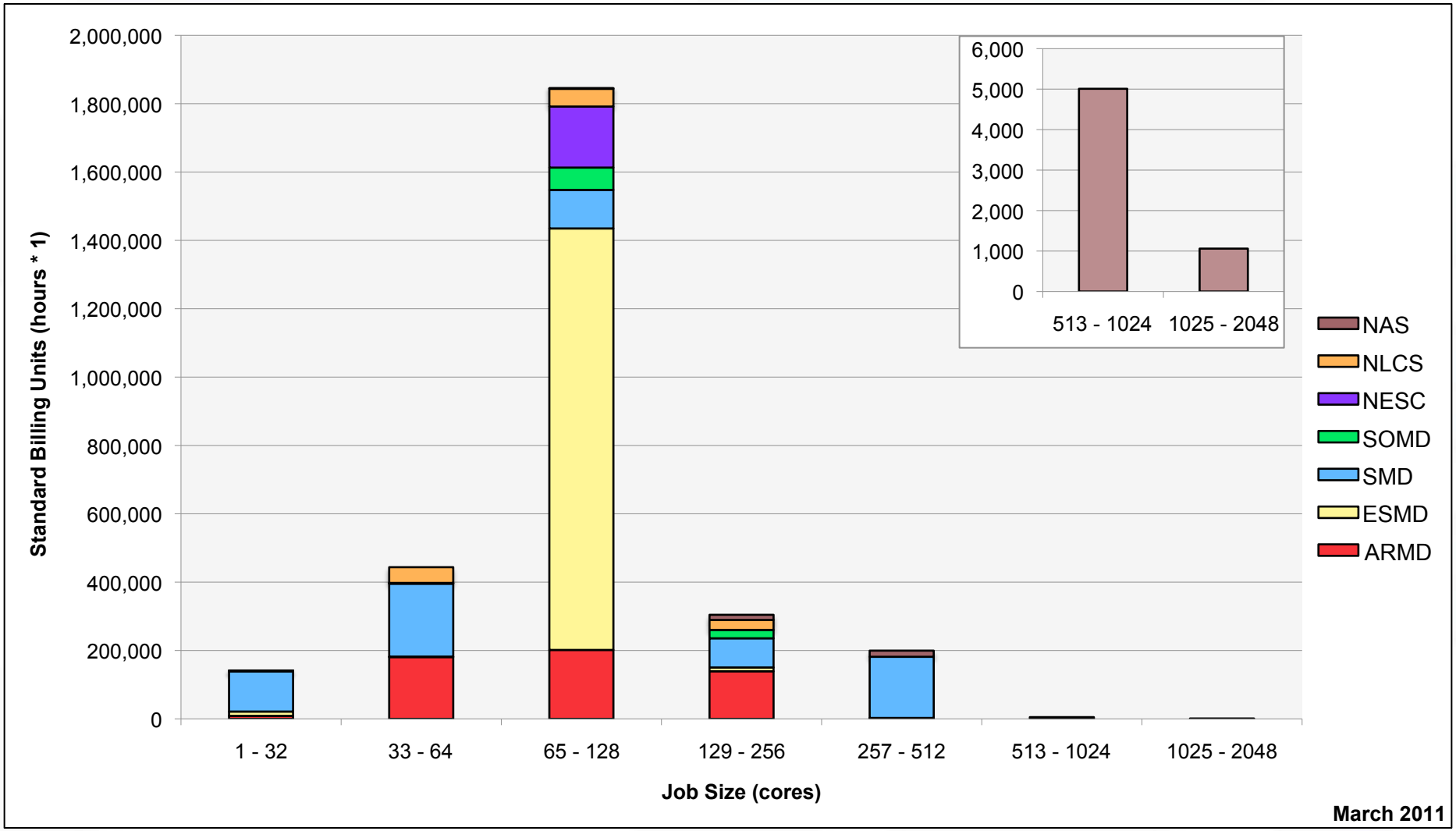
Columbia:
SBUs Reported, Normalized to 30-Day Month



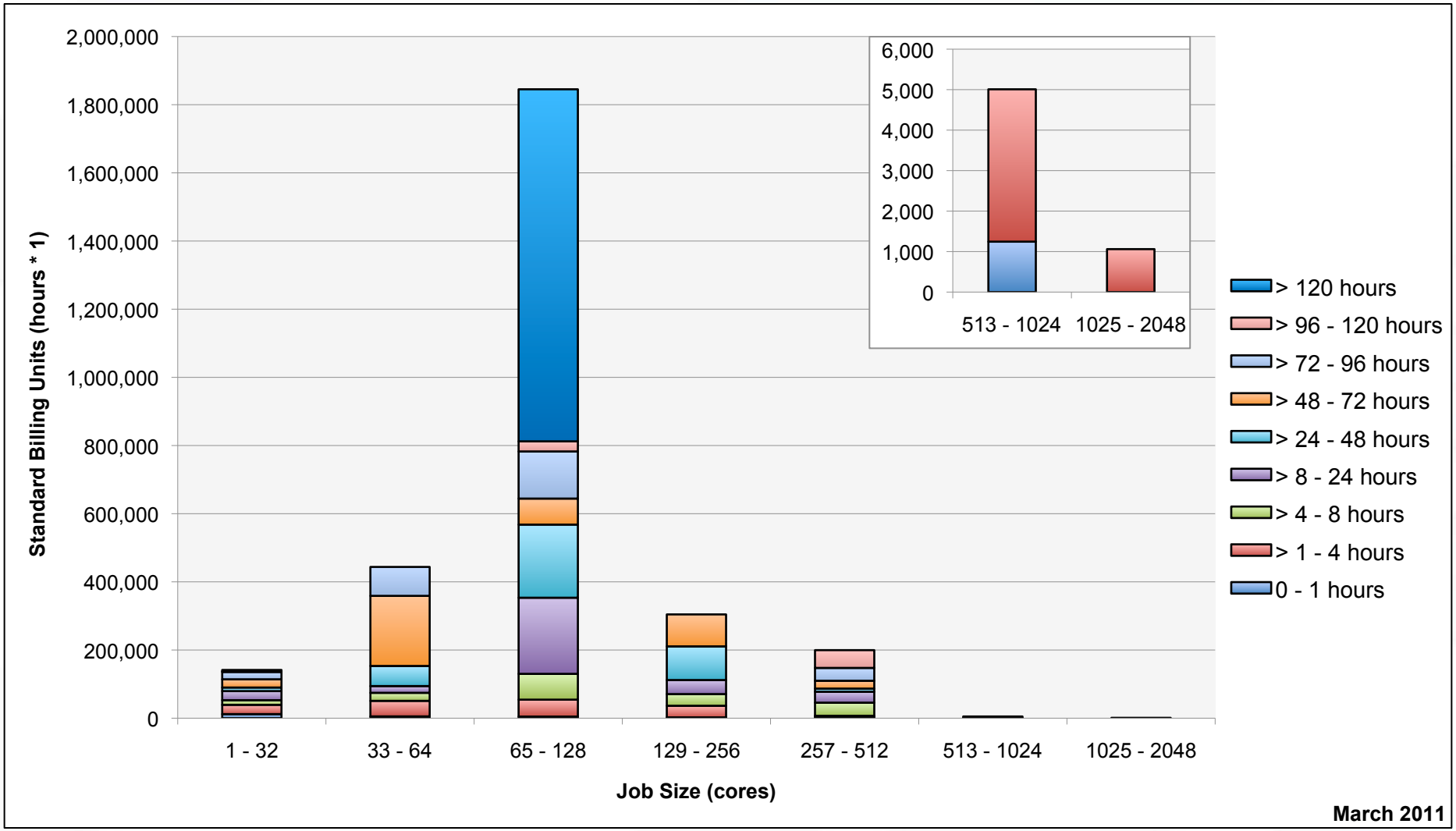
Columbia:
Monthly SBUs by Run Time



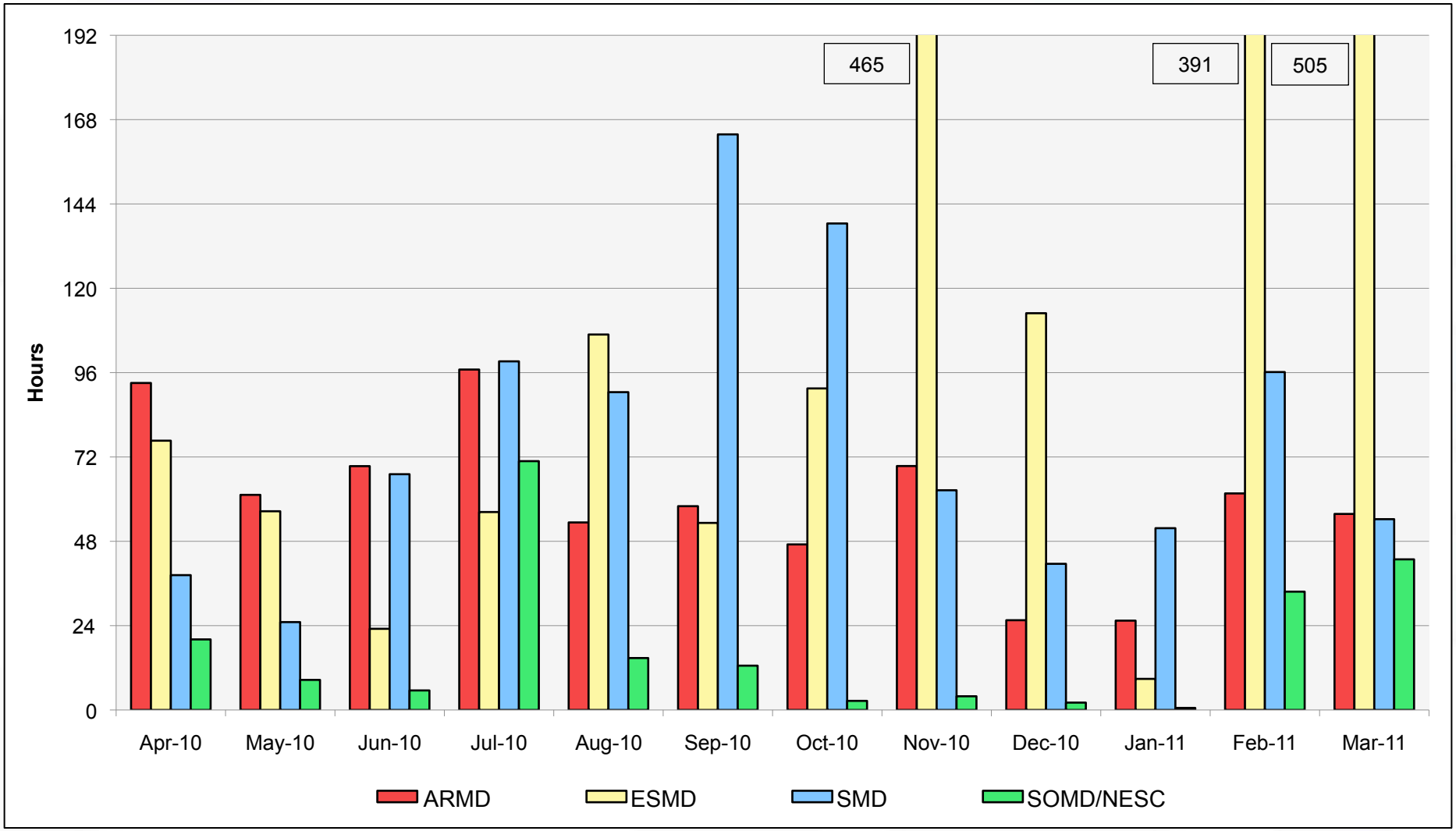
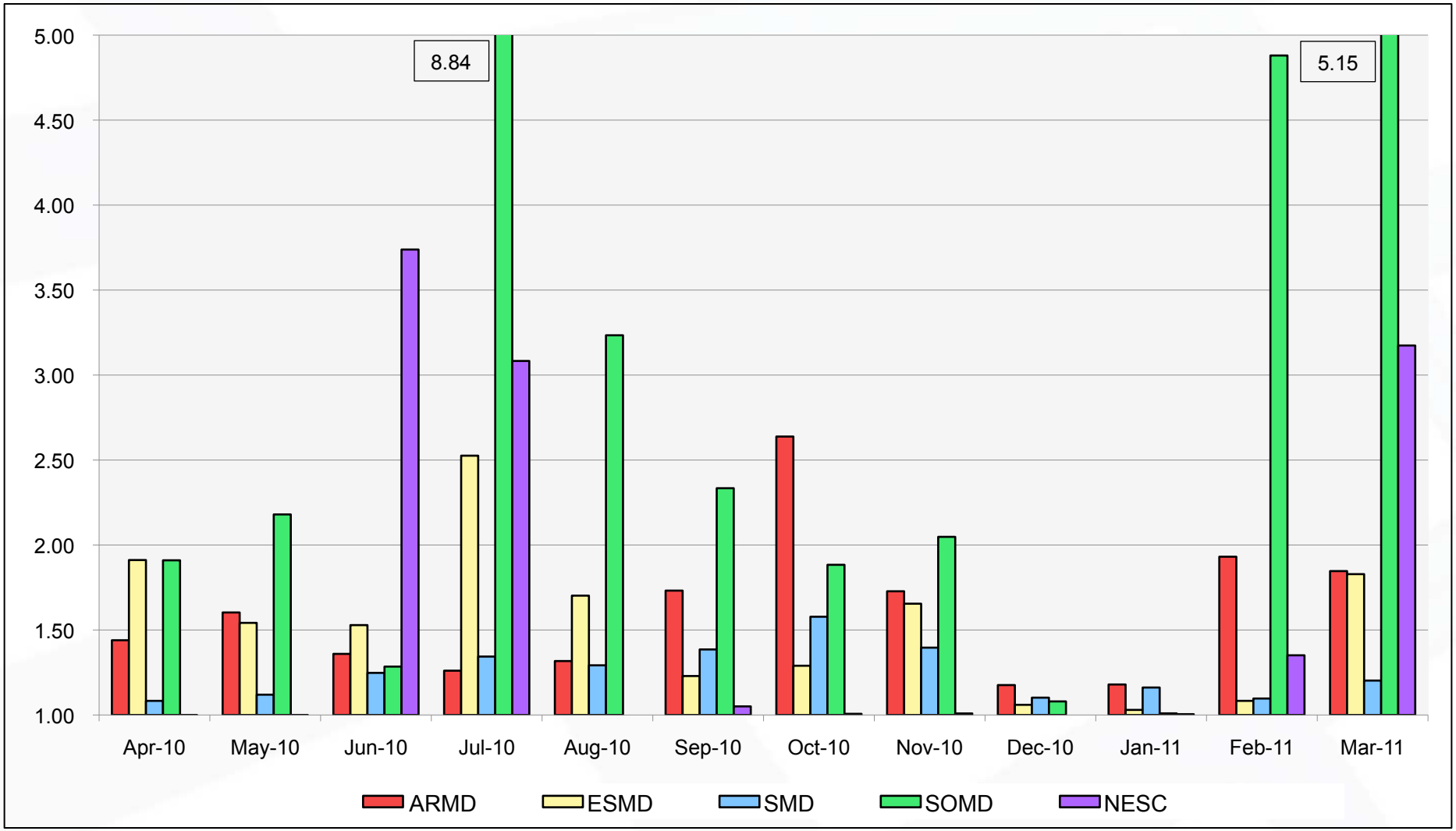
Columbia:
Monthly Utilization by Size and Mission



Columbia:
Monthly Utilization by Size and Length



Columbia:
Average Time to Clear All Jobs



Columbia:
Average Expansion Factor