DEPARTMENT OF DEFENSE

HIGH PERFORMANCE COMPUTING MODERNIZATION PROGRAM

FY 2001 REQUIREMENTS REPORT

DOD HIGH PERFORMANCE COMPUTING MODERNIZATION OFFICE

APRIL 2002

EXECUTIVE SUMMARY

The Department of Defense (DoD) High Performance Computing Modernization Office (HPCMO) has completed the seventh comprehensive tabulation of its user community's high performance computing (HPC) requirements. The results, as reflected in this report, guide acquisition and operational policies and execution decisions, as required by law. The program provides a complete set of HPC and communications capabilities, including hardware, software, training, and wide area networking, to facilitate computational science and engineering by the DoD science and technology (S&T) and test and evaluation (T&E) communities. These communities continue to expand their use of HPC capabilities to develop and test technologies that provide increased capability at a more affordable cost for current and future DoD weapons systems.

This report is based on the responses of HPC users to our fiscal year (FY) 2001 requirements survey and documents user requirements beginning in FY 2002. The HPCMO received responses through the World Wide Web on 646 computational projects involving over 4,300 HPC users at 55 government and numerous contractor sites. In addition, the program staff made site visits to 18 user sites to discuss their requirements in detail.

In the past several years, the HPC Modernization Program has seen overall requirements increase at a steady, consistent rate. However, the ratio of unclassified to classified requirements has changed drastically. Until FY 2001, unclassified requirements have been significantly higher than classified requirements. In FY 2001 classified requirements were slightly larger than unclassified requirements; however for FY 2002 and FY 2003, classified requirements are significantly higher (60% of total requirements) than the unclassified requirements. In FY 2005, classified requirements are only 51% of the total requirements and by FY 2006; classified requirements are lower (31% of total requirements) than the unclassified requirements.

A more detailed analysis of the requirements gathered during this process has been completed and made available to various HPCMP activities. This integrated analysis included a better understanding, at the computational project level, of the inter-relationships among requirements, allocations, and usage in past years.

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1. INTRODUCTION

1.1 BACKGROUND

The Department of Defense (DoD) High Performance Computing Modernization Office (HPCMO) conducts annual surveys to ensure that its activities are firmly based on users' high performance computing (HPC) requirements. The survey results are analyzed and the information is made available to program decision-makers for use in addressing program planning, acquisition, and operational issues. This is the seventh major report on the requirements of the High Performance Computing Modernization Program (HPCMP) user community. It covers the HPC requirements of the DoD science and technology (S&T) and test and evaluation (T&E) user communities

The first requirements analysis, performed in 1994, covered users only in the DoD S&T community. The document served as the basis for acquiring the complete HPC environment at each of the program's four major shared resource centers.

In 1996, the HPCMO published a report on the requirements of users in both the DoD S&T and developmental test and evaluation (DT&E) communities. The program used the report in carrying out a variety of program plans, operations, and activities, including the evaluation of HPC sites as distributed centers and the DoD Challenge Project process. Since 1996, four additional requirements reports were issued.

Acquisitions by the DoD HPCMP community have always focused on the high end of scientific computing—HPC systems not easily obtainable by an individual laboratory or test center or even by the Services and Agencies. The requirements-gathering process focuses strictly on HPC requirements as defined by an escalating set of thresholds described in Appendix D.

1.2 DEFINITIONS

The following terms are used in this report.

<u>Computational technology areas (CTAs)</u> – ten discipline specific areas into which the science and engineering community of DoD S&T and T&E laboratories and centers have been categorized. The CTAs are:

- *Computational Structural Mechanics (CSM)* – comprises high-resolution, multidimensional modeling of materials and structures subjected to a broad range of static, dynamic, and impulsive loading conditions;
- *Computational Fluid Dynamics (CFD)* – provides accurate numerical solutions of equations describing fluid and gas motion and fluid dynamics research;
- *Computational Chemistry and Materials Science (CCM)* – predicts basic properties of new chemical species and applies this molecular understanding to the development of advanced materials;
- *Computational Electromagnetics and Acoustics (CEA)* – provides high-resolution multidimensional solutions of Maxwell's equations and acoustic wave equations;

- *Climate/Weather/Ocean Modeling and Simulation (CWO)* – involves numerical simulation and forecast of the Earth's climate as well as oceanic and atmospheric variability;
- *Signal/Image Processing (SIP)* – extracts and analyzes key information from various sensor outputs in real time; sensors include sonar, radar, visible and infrared images, and signal intelligence and navigation assets;
- *Forces Modeling and Simulation/C4I (FMS)* – focuses on force level modeling and simulation for training, analysis, and acquisition and the integration of high-speed command, control, communications, computers, and intelligence (C4I) systems to manage a battle space;
- *Environmental Quality Modeling and Simulation (EQM)* – involves high-resolution, three-dimensional Navier-Stokes modeling of hydrodynamics and contaminant transport through the air and the ground and through aquatic ecosystems;
- *Computational Electronics and Nanoelectronics (CEN)* – analyzes, optimizes, and visualizes the performance of complex electronic and electromagnetic devices, circuits, and systems including study of the effects of signal propagation and designs, models, and simulates complex electronic devices, integrated circuits, and small components; and
- *Integrated Modeling and Test Environments (IMT)* – applies HPC software tools and techniques with live tests and hardware-in-the-loop simulations to test and evaluate DoD weapons, components, subsystems, and systems in virtual and in composite virtual-real environments.

Non-Real-Time Computing (NRTC) includes any type of batch or related interactive processing of computations involving modeling, simulation, and analysis where the computational resources are shared during the processing and are not totally dedicated to the computational task at hand. Tasks can be interrupted or stopped, analyzed, and then resumed, either at the termination point or at some previously saved point, in order to complete the calculation with the potential of changing analysis parameters.

One gigaflop-year (GF-yr) is the computational capacity represented by a 1-GF processor computing continuously for 1 year.

Real-Time Computing (RTC) encompasses the acquisition and/or production of test, experimental, or simulation data and the concurrent processing of that data to extract information or for interactive display and/or control purposes. Inherent to the definition is the presence of some external stimulus, whether it is data produced by an ongoing test, a human operator waiting to make a decision required by an ongoing process, or personnel and hardware participating in an interactive simulation. Hardware-driven input/output (I/O) processes, rather than computational processes, often dominate real-time computing. One of its major challenges is to apply the extensive computational power offered by HPC systems to perform increasingly sophisticated real-time analysis and display in order to impact an ongoing test, simulation, or experiment.

User is a person who spends a significant amount of time (25% or more) performing HPC computations. A user may actually participate in multiple projects, but for this analysis, the HPCMO attempted to eliminate duplication and count each individual only once, irregardless of the number of computational projects with which a specific user may be associated. However, there is a possibility that some users were double counted so the sum of users across all projects may be slightly inflated.

1.3 HPCMO Requirements-Gathering Process

The HPCMO requirements-gathering process is project based. The HPCMO uses a variety of methods to gather information including:

- Posting a detailed requirements questionnaire (survey) on the HPCMP Web site,
- Conducting site visits to interview project leaders,
- Visiting other functional organizations and forums that might have a need for HPCMP assets, and
- Soliciting input from the Service/Agency Approval Authorities (S/AAAs).

The requirements questionnaire collected information on the following characteristics of each project: file sizes, total memory, response times, and number of processors. The HPCMO asked project leaders to base their estimates on average job characteristics. The project leaders were also asked to estimate their maximum fiscal year (FY) 2002 HPC requirements based on the same characteristics. In addition, the questionnaire gathered requirements on data storage, software, networking, and training. The S/AAAs were responsible for verifying the responses.

The program office staff conducted 18 site visits during 2001 to interview project leaders about their requirements. These detailed discussions were instrumental in gaining a better understanding of that organization's requirements. The HPCMO's goal is to visit each user organization once every three years to discuss requirements. The staff also attended conferences/symposia as an outreach function to establish dialogues with potential users and to encourage them to make their requirements known.

Overall, HPC performance requirements for non-real-time computing are calculated in GF-yrs. In order to compare HPC requirements over multiple HPC systems, we converted the requirements—expressed as the number of hours on specific HPC systems—to GF-yrs by using the vendor-provided theoretical peak computational performance for each system. Theoretical peak performance has been shown to be a poor indicator of actual performance of HPC systems and the percentage of peak performance achieved by any specific HPC system varies considerably among applications. Thus, peak performance is not a very useful parameter for making acquisition decisions; appropriate benchmarks should clearly be used for that. Aggregated HPC performance requirements, however, have been used to establish requirements trends and compare requirements among large organizations or categories of usage (such as classified/unclassified) that each have a representative sampling of available HPC architectures. This kind of aggregation is at least partially validated by consistency in trends between usage and requirements.

There is no similar way to total real-time requirements since real-time HPC systems must be capable of accepting and processing data at the rate required by an external stimulus. This capability is required whether the data comes from an ongoing test, from a human operator interacting with the system, or from the hardware and personnel participating in an interactive simulation. Processing data at a rate even slightly less than the required data rate quickly results in either the loss of valuable data or the total shutdown of the system. Consequently, the most significant requirement for a real-time HPC system is maximum speed. Like electrical power production, computational cycles cannot be stored and used later. The instant these commodities are required, they must be available. Therefore, real-time HPC systems must be sized for the maximum speed necessary for the requirement they are designed to address.

2. USER DEMOGRAPHICS

2.1 OVERALL USER PROFILE

During the 2001 survey, the HPCMO identified 4,320 HPC users at 55 government sites and numerous contractor locations. (Note that the HPCMO gathers information on both current and potential future users with valid HPC requirements. Thus the number of users counted in the survey does not equal the number of users with active accounts on HPC systems.) This is a decrease from the number of users identified in 2000 (5,243).

Figure 1 shows the total user base divided among government users and on-site and off-site contractors. On-site contractors are those who perform the majority of their work at government facilities. Seventy-two percent of all users work at government sites with the remaining 28% working in academia or the private sector. The number of contractors (both on- and off-site) continues to be larger than the number of government users, although the percentage dropped significantly this past year (64% in 1999, 65% in 2000, and 57% in 2001). One possible rationale for this drop is the HPCMO's efforts to reduce the possibility of double-counting users. In particular, one organization with a significant number of on-site contractors was double-counting users in several of its projects. The off-site contractor community works at 43 universities and almost 40 contractor locations. Most of the off-site contractors' work is supported by grants and contracts with the basic research-granting agencies (Air Force Office of Scientific Research [AFOSR], Army Research Office [ARO], Office of Naval Research [ONR]), and the Defense Threat Reduction Agency [DTRA]).

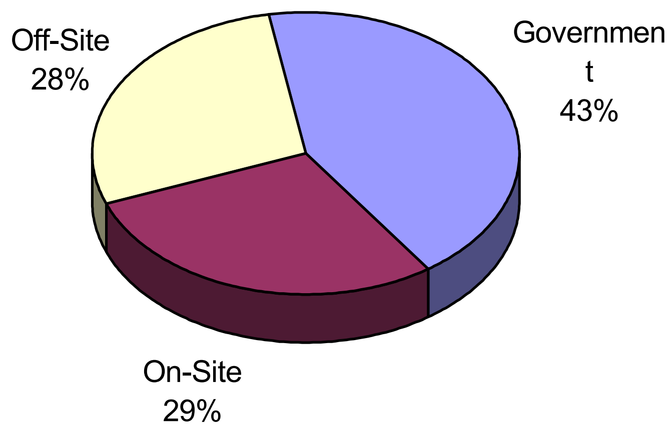

Figure 1. Overall Breakdown of DoD HPC Users

Figure 2 shows the percentage of HPC users associated with each Service or participating Agency. Although percentages for the Army and Air Force remained almost unchanged (28% and 32% respectively), the percentage of users for the Navy increased from 27% to 33% while the percentage from the Agencies decreased from 13% to 6%. The major contributing factor to this decrease was the drop in number of users associated with the

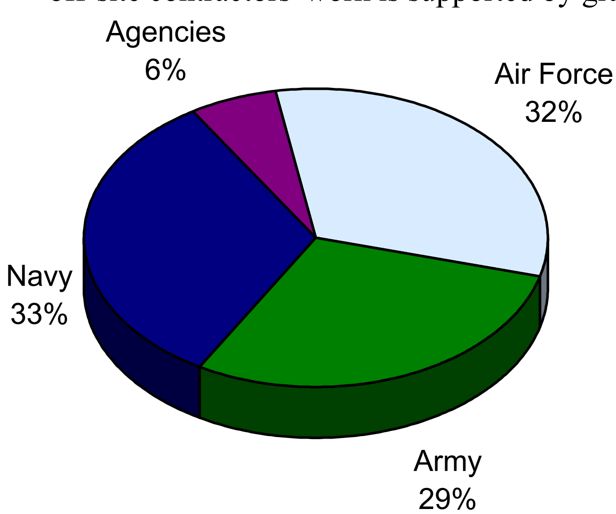

Figure 2. Breakdown of DoD HPC Users by Service/Agencies

BMD Simulation Support Center at the Joint National Test Facility (JNTF)[1]. The number of users decreased from 302 to 10. The decrease may be attributed to a reevaluation of the number of users and a reclassification of what constitutes a user.

Figures 3 and 4 show the distribution of government and contractor HPC users. There are marked distribution differences between the Services and Agencies. Most users associated with the Agencies are contractors. The Air Force has a high percentage of users who are contractors, whereas both the Army and Navy have approximately equal ratios of government and contractor HPC users (see Table 1). These results are similar to the past surveys.

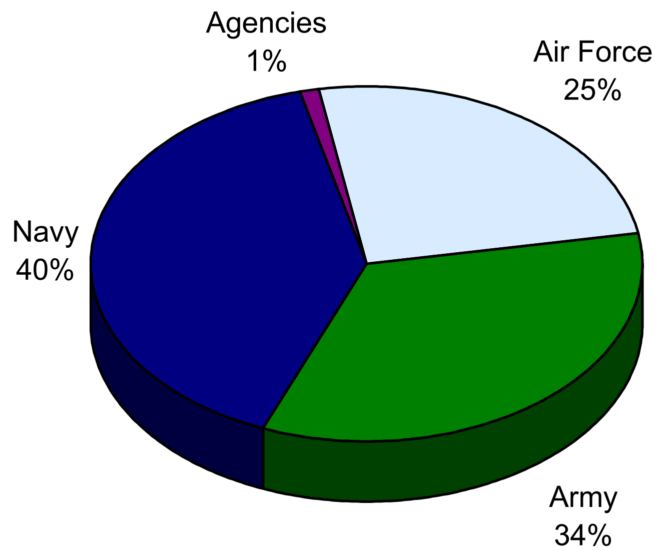

Figure 3. Distribution of Government HPC Users

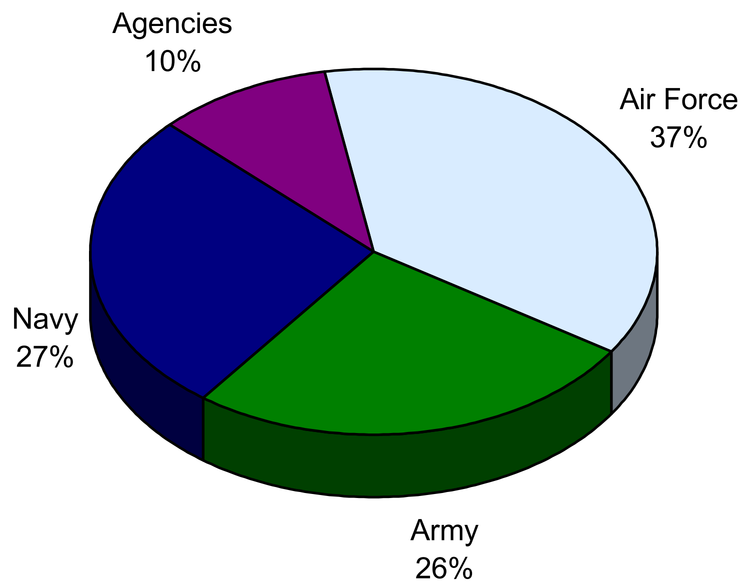

Figure 4. Distribution of Contractor HPC Users

[1] On 1 November 2001, JNTF was renamed the Joint National Integration Center (JNIC).

2.2 PROJECTS AND USERS IN SERVICES AND AGENCIES

Table 1 displays the total distribution of HPC users based on their Service/Agency affiliation and primary computing environment (real-time, non-real-time, or both). Overall, most users (2,722 out of 4,320) have only non-real-time requirements, while approximately nine percent (408) have only real-time requirements, and about 25 percent (1,059) have both non-real-time and real-time requirements. A majority of the users with real-time requirements are within the test and evaluation community. A small percentage of the users (3%) listed "Other" as their primary computing environment.

Table 1. Functional Distribution of Users Based on Service or Agency Affiliation

Total for Service or Agencies	Total Projects	Govt. Personnel	Contractors	Total Users	Real-Time Users Only	Non-Real-Time Users Only	Both
Air Force	208	463	924	1,387	18	796	557
Army	112	618	635	1,253	95	873	280
Navy	311	742	668	1,410	4	25	131
Agencies	15	10	260	270	291	1,028	91
TOTAL	**646**	**1,833**	**2,487**	**4,320**	**408**	**2,722**	**1,059**

The tables in Appendix A detail the distribution of HPC users based on their Service/Agency affiliation and their primary computing environment (real-time, non-real-time, or both). There is a substantial difference in the number of users associated with each computational project among the Services. The Navy has an average of 4.53 users per project, similar to the past two years. The Air Force averages 6.67 users per project, while the Army's average is 11.19. This represents a slight decrease for both Services (down 2.69 and 1.77 respectively).

2.3 PROJECTS AND USERS IN COMPUTATIONAL TECHNOLOGY AREAS

The HPCMO asked the project leaders to specify the computational technology area associated with each project. When more than one area was appropriate, the project leader identified a primary CTA and one or more secondary CTAs. The project leader assigned a percentage to each CTA. Users are identified with the project's primary CTA as shown in Figure 5. For the past two years, IMT has surpassed CFD; however, this year CFD is slightly larger (1,112 users) than IMT (997 users). In addition, CFD continues to encompass the most projects and the largest computational requirements.

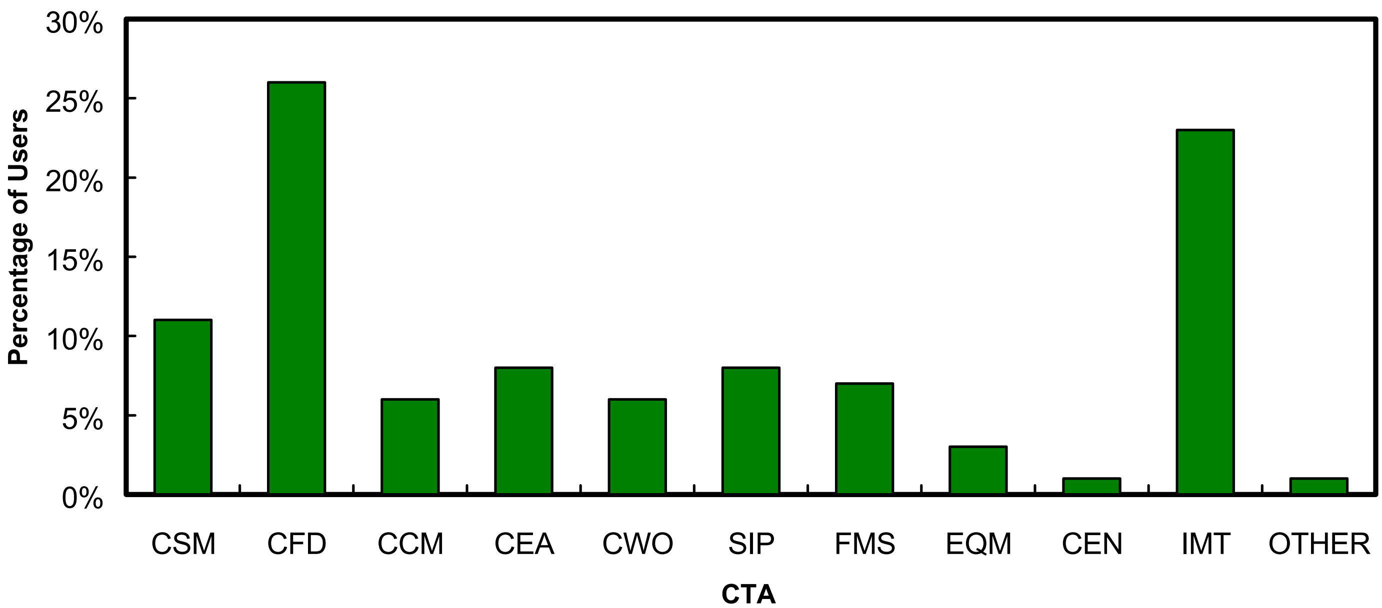

Figure 5. Percentage of HPC Users in Primary CTAs

Table 2 shows the total distribution of projects and users by CTA for each Service/Agency. Each project is included in the total for an organization if it reported that CTA as either primary or secondary; therefore, there may be double counting of projects and users. As shown in Table 2, the Services perform work in all of the computational areas. The tables in Appendix B show the distribution of projects and users by computational technology area for each user organization.

Table 2. Services and DoD Agencies: Distribution of Projects and Users by Computational Technology Area

	CTA *(Projects:Users)*										
	CSM	**CFD**	**CCM**	**CEA**	**CWO**	**SIP**	**FMS**	**EQM**	**CEN**	**IMT**	**Other**
Air Force	36:507	96:743	33:436	41:546	14:347	30:498	20:468	3:310	7:327	27:508	10:34
Army	33:456	34:384	13:222	18:188	10:88	20:364	16:219	4:209	2:70	34:479	8:110
Navy	39:182	123:503	39:174	50:173	45:233	42:184	10:72	4:16	10:51	37:334	4:27
Agencies	5:81	8:117		6:76	3:60		3:141			5:141	
TOTAL	**113:1,226**	**261:1,747**	**85:832**	**115:983**	**72:728**	**92:1,046**	**49:900**	**11:535**	**19:448**	**103:1,462**	**22:171**

Table 3 shows the correlation between the ten CTAs (by primary CTA only) and non-real-time and real-time computing functional environments based on project and number of users. As in the past, a significant share of non-real-time computing is conducted in CFD. The majority of real-time computing continues to occur in IMT. In addition, a large number of users in IMT, SIP, and FMS do both non-real-time and real-time computing.

Table 3. Correlation Between Primary CTAs and Functional Environments (Project:Users)

CTA	Non-Real-Time Computing	Real-Time Computing	Both	Other
CSM	67:395		6:74	
CFD	208:989	1:7	5:27	5:89
CCM	58:272		1:2	
CEA	58:266		4:62	1:31
CWO	50:230	1:1	2:20	
SIP	37:150	6:42	12:140	1:6
FMS	11:55	4:22	8:243	
EQM	2:116		1:4	
CEN	9:33			
IMT	22:178	32:332	21:487	
Other	11:38	1:4		1:5

3. RESOURCE REQUIREMENTS

This section describes the resource requirements, including system speed, total computational resources, memory sizes, file sizes, and archival storage. Resource requirements for non-real-time computing (section 3.1) and real-time computing (section 3.2) are discussed separately because the meaningful categories for the two functional areas are not identical. Total computational requirements of the non-real-time user community are almost five times that of the real-time user community, although it is difficult to compare the two on a consistent basis.

3.1 RESOURCE REQUIREMENTS FOR NON-REAL-TIME COMPUTING

Non-real-time computing includes all HPC modeling, simulation, or analysis not driven by external stimuli interacting with the HPC system in real-time. Non-real-time computing also supports real-time tests and simulations during test planning (pre-test), test execution and control, and post-test analysis. Some test support activities have stringent turnaround time requirements. Others are time sensitive due to deadlines imposed by weapon system program milestones and cost constraints.

3.1.1 Overall Performance Requirements

The overall performance requirements represent aggregate totals of HPC requirements. As described in Section 1.3, we combined the overall performance requirements over disparate systems by using the vendor-provided theoretical peak computational performance of each system. Although system performance varies considerably when using actual application codes, using the peak theoretical performance is the most consistent method of standardizing requirements data over all systems. During the survey, each project leader had the option of stating requirements as the number of processor-hours on specific HPC systems or as the number of hours on a system with a generic capability stated in gigaflops. The requirements data was analyzed in terms of GF-yrs; the specific system data is not included in this report.

Data on overall performance requirements are precise to hundredths of a GF-yr. Although it is difficult to accurately determine an individual project's requirements, we are confident in the accuracy of the trends articulated in this report. We have extensive experience in performing requirements analyses over the last several years, and have found that analyzing aggregate requirements across projects reduces the uncertainty of the total requirements.

Table 4 presents the total projected performance requirements of Services and Agency sites for FY 2002 through FY 2007 for unclassified non-real-time computing. The Army and Navy have large out-year growth rates in unclassified non-real-time requirements with significant increases in FY 2007. The sharp increase in Army requirements may be attributed to three projects – two located at the Army Research Laboratory in Aberdeen Proving Ground, MD and one at the Engineer Research Development Center in Vicksburg, MS. This increase in requirements is primarily due to extensive three-dimensional simulations and the availability of more robust coupled software. The increase in Navy requirements may be attributed to an ocean modeling and prediction project at the Naval Research Laboratory at Stennis Space Center, MS. The Air Force and DTRA have a slight growth in requirements while the requirements for the other

Agencies either remain constant or decline in the out-years. The decline is based primarily on the inability to predict funding in the out years.

Table 4. Services and DoD Agencies: Summary of Projected Overall Performance Requirements for Unclassified NRTC (GF-yrs)

Organization	Location	FY 2002	FY 2003	FY 2005	FY 2007
	Air Force				
AEDC	Arnold AFB, TN	198.85	290.47	434.77	498.79
AFAAC	Eglin AFB, FL	28.64	28.94	29.97	30.54
AFIT	Wright-Patterson AFB, OH	5.79	6.84	7.39	8.07
AFOSR	Arlington, VA	694.88	926.03	645.41	1,005.34
AFRL/DE	Kirtland AFB, NM	218.44	259.95	297.65	322.68
AFRL/IF	Rome, NY	41.56	34.87	47.68	49.50
AFRL/ML	Wright-Patterson AFB, OH	106.20	100.44	244.77	303.55
AFRL/MN	Eglin AFB, FL	136.64	189.38	268.04	404.34
AFRL/PR	Edwards AFB, CA	149.44	186.01	214.54	225.32
	Wright-Patterson AFB, OH	322.94	432.90	486.59	396.28
AFRL/SN	Hanscom AFB, MA	0.13	0.13	0.04	0.04
	Wright-Patterson AFB, OH	51.83	18.69	20.98	17.50
AFRL/VA	Wright-Patterson AFB, OH	234.91	287.57	207.63	256.72
AFRL/VS	Hanscom AFB, MA	80.03	97.16	32.13	24.76
AFWAC	Offutt AFB, NE	63.15	28.90	12.28	12.28
ASC	Wright-Patterson AFB, OH	11.50	12.78	14.62	17.06
Other Air Force	Various Locations	3.40	6.81	10.08	14.24
SMC	Los Angeles AFB, CA	94.48	104.43	113.51	121.92
USAFA	Colorado Springs, CO	0.56	0.76	1.37	3.08
TOTAL AIR FORCE		**2,443.37**	**3,013.06**	**3,089.45**	**3,712.01**

Organization	Location	FY 2002	FY 2003	FY 2005	FY 2007
		Army			
AMCOM	Moffett Field, CA	91.49	107.18	98.80	13.76
	Langley AFB, VA	1.60	1.60	0.00	0.00
	Redstone Arsenal, AL	826.18	819.90	1,003.44	1,232.68
AMSAA	Aberdeen Proving Ground, MD	0.05	0.05	0.05	0.05
ARL	Aberdeen Proving Ground, MD	6,480.16	9,416.24	19,010.48	39,242.94
	Adelphi, MD	299.44	527.73	639.81	1,096.50
ARO	Research Triangle Park, NC	234.50	301.75	284.68	574.29
ATC	Aberdeen Proving Ground, MD	1.50	1.93	2.37	2.80
	Fort Rucker, AL	0.01	0.01	0.01	0.01
CECOM	Ft. Belvoir, VA	2.05	3.01	3.29	3.29
ERDC	Hanover, NH	147.81	243.07	285.06	327.06
	Vicksburg, MS	945.64	1,358.71	5,832.62	26,607.16
MRMC	Frederick, MD	0.27	0.27	0.27	0.27
NRDEC	Natick, MA	98.20	98.32	137.99	189.26
RTTC	Redstone Arsenal, AL	0.53	1.00	2.38	4.68
SBCCOM	Aberdeen Proving Ground, MD	14.72	16.89	19.06	21.23
SMDC	Huntsville, AL	189.97	193.47	96.97	101.40
TACOM	Dover, NJ (ARDEC)	2.65	2.66	2.66	1.48
	Warren, MI (TARDEC)	1.42	1.75	2.17	2.64
USMA	West Point, NY	1.74	1.74	1.74	1.74
WSMR	White Sands Missile Range, NM	2.56	3.62	2.08	2.26
TOTAL ARMY		**9,342.49**	**13,100.90**	**27,425.93**	**69,425.50**

Organization	Location	FY 2002	FY 2003	FY 2005	FY 2007
		Navy			
NAWC	China Lake, CA	27.12	27.17	27.17	27.17
	Patuxent River, MD	1,328.40	1,491.80	1,846.58	1,982.92
NPS	Monterey, CA	688.07	927.29	1,068.23	1,134.05
	Monterey, CA	105.73	174.23	242.52	311.08
NRL	Stennis Space Center, MS	2,748.97	5,439.64	21,589.27	85,686.04
	Washington, DC	326.90	410.68	536.35	690.24
NSWC	Carderock, MD	52.10	63.68	80.84	96.14
	Dahlgren, VA	58.48	39.27	31.96	36.53
	Indian Head, MD	21.80	28.60	71.92	53.60
	Panama City, FL	7.42	11.13	0.00	0.00
NUWC	Newport, RI	58.78	69.99	93.40	95.67
Other Navy	Various Locations	84.16	87.23	95.49	97.21
ONR	Arlington, VA	1,732.35	2,140.58	2,717.11	3,635.62
SSCSD	San Diego, CA	53.30	62.03	77.01	92.00
USNA	Annapolis, MD	6.51	6.51	6.51	6.51
TOTAL NAVY		**7,300.09**	**10,979.83**	**28,484.36**	**93,944.78**

Organization	Location	FY 2002	FY 2003	FY 2005	FY 2007
		Agencies			
DARPA	Arlington, VA	71.81	68.10	0.00	0.00
DOTE	Arlington, VA	2.05	2.05	2.05	2.05
DTRA	Alexandria, VA	232.30	265.37	347.85	411.40
JNTF	Schriever AFB, CO	34.70	34.70	34.70	34.70
TOTAL AGENCIES		**340.86**	**370.22**	**384.60**	**448.15**
GRAND TOTAL		**19,426.81**	**27,464.04**	**59,384.32**	**167,530.44**

Table 5 describes classified requirements for non-real-time computing. For the second time in a row, total classified requirements are higher than the unclassified requirements, except for FY 2007 where classified requirements are approximately 32% of the total FY 2007 non-real-time computing requirements. Most of the classified requirements as well as their growth can be attributed to the Army and, specifically an ARL project located at Aberdeen Proving Ground, MD. This project is conducting research and development in munitions lethality, armor protection, and munitions survivability.

Table 5. Services and DoD Agencies: Summary of Overall Performance Requirements for Classified NRTC (GF-yrs)

Organization	Location	FY 2002	FY 2003	FY 2005	FY 2007
	Air Force				
AEDC	Arnold AFB, TN	205.23	254.77	343.11	397.88
AFRL/DE	Kirtland AFB, NM	17.12	20.55	23.97	27.40
AFRL/IF	Rome, NY	2.47	2.47	2.47	2.47
AFRL/PR	Wright-Patterson AFB, OH	0.00	5.71	5.71	5.71
AFRL/SN	Wright-Patterson AFB, OH	12.33	14.16	15.07	9.13
Other Air Force	Various Locations	40.44	42.14	57.73	56.89
TOTAL		**277.59**	**339.80**	**448.06**	**499.48**
	Army				
AMSAA	Aberdeen Proving Ground, MD	0.24	0.24	0.24	0.24
ARL	Aberdeen Proving Ground, MD	27,246.76	35,933.56	54,971.96	67,767.67
	Adelphi, MD	3,000.21	4,000.25	6,000.33	8,000.41
ATC	Aberdeen Proving Ground, MD	0.09	0.14	0.18	0.23
ERDC	Vicksburg, MS	17.12	25.68	171.23	856.16
TACOM	Natick, NJ (NRDEC)	0.61	0.61	0.00	0.00
RTTC	Redstone Arsenal, AL	1.63	1.69	1.92	2.15
SMCCA	Aberdeen Proving Ground, MD	1.37	1.37	1.37	1.37
SMDC	Huntsville, AL	9.63	17.85	9.63	9.63
WSMR	White Sands Missile Range, NM	0.18	0.23	0.27	0.34
TOTAL		**30,277.84**	**39,981.62**	**61,157.13**	**76,638.20**
	Navy				
NAWC	China Lake, CA	11.76	11.94	11.91	11.96
	Patuxent River, MD	43.38	38.93	40.18	41.44
NSWCC	Carderock, MD	34.54	43.96	59.37	74.78
NSWC	Dahlgren, VA	23.06	27.40	31.96	36.53
	Panama City, FL	1.83	36.53	0.00	0.00
NUWC	Newport, RI	1.46	0.00	0.00	0.00
Other Navy	Arlington, VA	24.29	34.23	33.94	33.94
SSCSD	San Diego, CA	26.39	28.91	31.50	34.06
TOTAL		**166.71**	**221.90**	**208.86**	**232.71**
	Agencies				
DTRA	Alexandria, VA	85.75	95.89	124.43	160.96
JNTF	Schriever AFB, CO	8.41	10.06	13.52	17.60
TOTAL		**94.16**	**105.95**	**137.95**	**178.56**
GRAND TOTAL		**30,816.30**	**40,649.27**	**61,952.00**	**77,548.95**

The growth rate of aggregated non-real-time requirements has remained fairly constant over the years. Figure 6 shows total aggregated non-real-time requirements for each requirements survey taken since the inception of the program. The slope of this semi-log plot for the entire set of data equates to a constant factor of (1.80±0.26). In the earlier survey years (1994-1997), even though the slopes were consistent, the trend line shifted to the right with each successive survey. It appears that project leaders essentially re-baselined their near-year requirements for each survey based on the small percentage of resources they were actually able to obtain in the previous year, since in those years program resources were much smaller than total requirements. In recent years, as program resources have become a substantial fraction (30-50%) of total requirements, this re-baselining is not a large factor, so all of the survey trend lines tend to coalesce. This year's (2001) survey data matches previous year's data very well for the near-year points (2002 and 2003), but its slope is obviously less (corresponding to a growth factor of 1.42) than the average slope over all survey years. Last year's (2000) survey data also had a lower slope than the average, with a value corresponding to a growth factor of 1.70. We attribute this apparently lower slope to the heavy predominance of classified requirements in recent surveys. Classified requirements are more short-term oriented, since they are generally based on defined weapons systems or programs. Classified requirements thus have a lower growth rate, which affects the slope much more in the last two years than they did in earlier years. In general, however, there is excellent consistency among requirements survey results over the last several years, at least for aggregate non-real-time requirements.

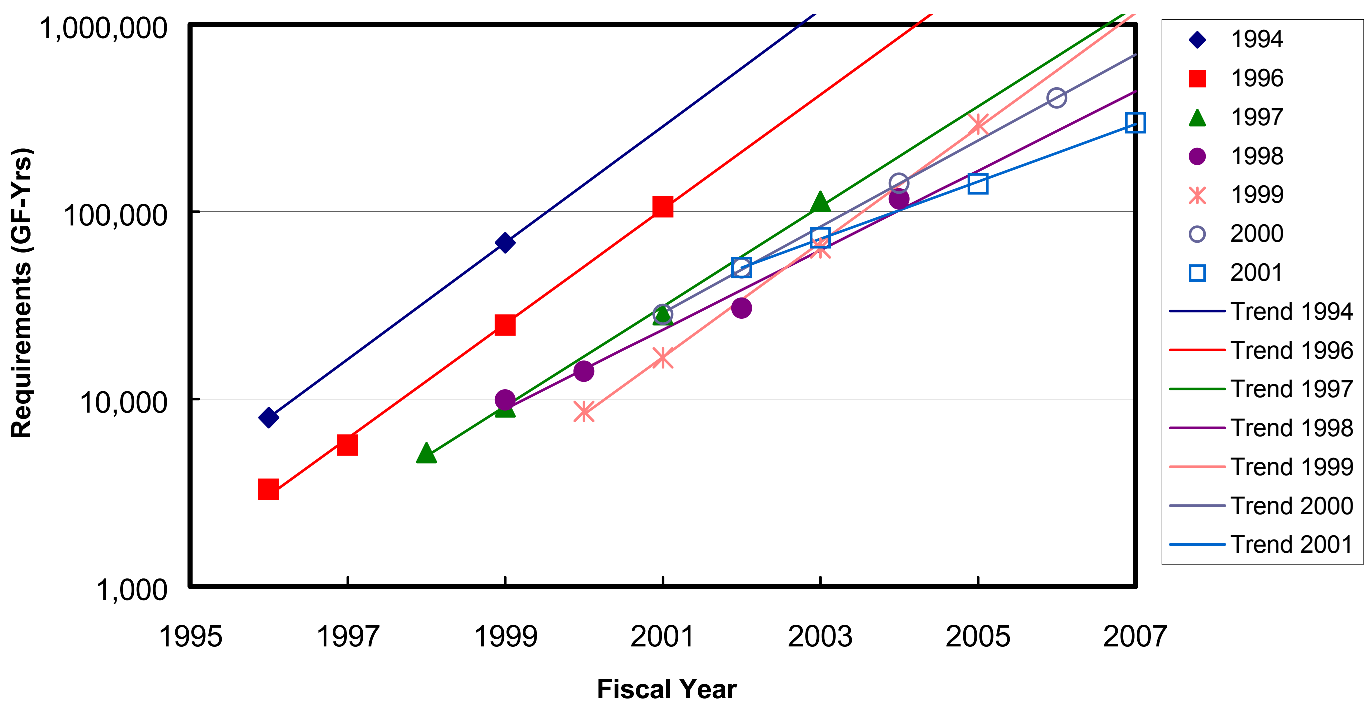

Figure 6. Aggregated Non-Real-Time Requirements for Requirements Surveys

It is also instructive to consider the distribution of individual project requirements. Figure 7 shows cumulative unclassified non-real-time requirements for projects with this kind of requirements that are rank-ordered from largest to smallest total requirements. Thus, the project with the largest requirements accounted for approximately 24 percent of the total requirements, the second ranked project accounted for 13 percent of the total, and the cumulative requirements for the first two projects accounted for 37 percent of the total. The graph shows that the top 50 projects (less than 10 percent of all projects with unclassified non-real-time requirements) account for about 83 percent of the total requirements. This group of projects accounts for approximately 28 percent of the total number of users from all projects with non-real-time unclassified requirements. This phenomenon has been noted in previous requirements reports and has been termed the “Breaux Hypothesis,” honoring Harold Breaux of Army Research Laboratory, who discoursed eloquently on this topic in the early days of the HPCMP. We have begun a more concentrated study on requirements and usage of, and allocations provided to this group of the 50 top projects to discern requirements trends of this set as compared with overall requirements. This set of top 50 requirements projects also encompasses approximately 75 percent of the FY 2001 DoD Challenge Projects.

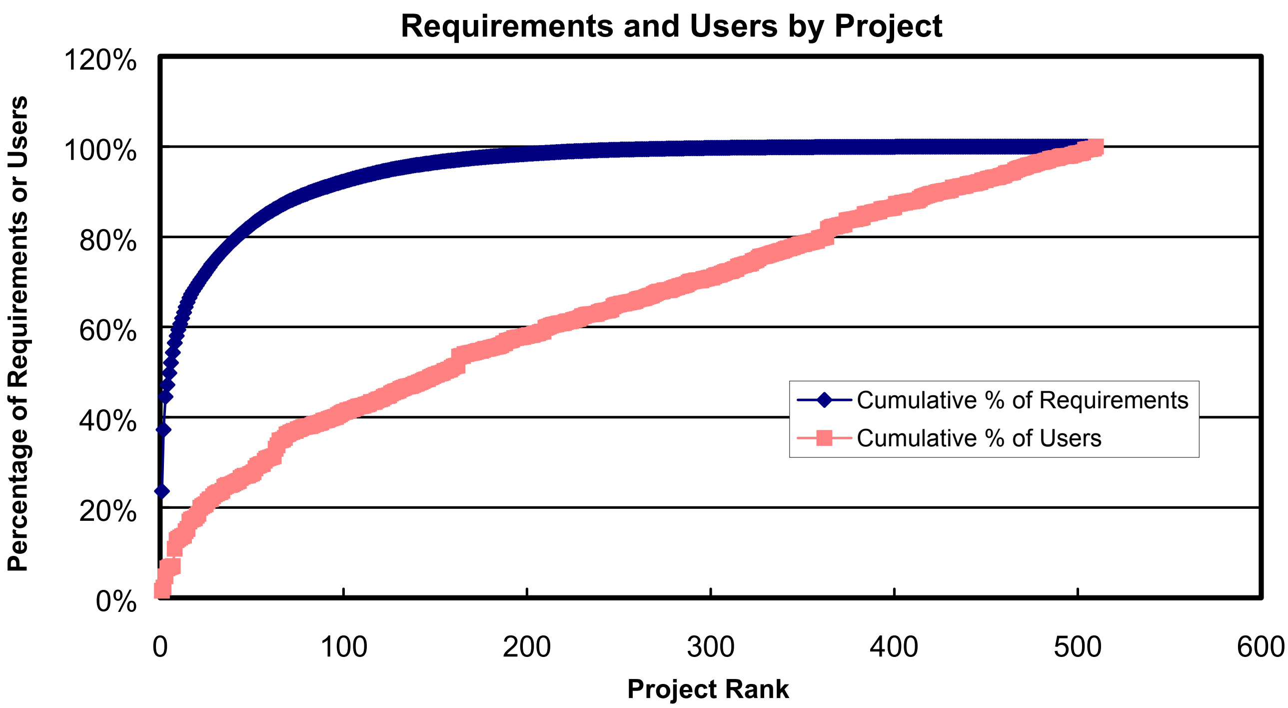

Figure 7. Requirements and Users by Project

Figures 8 and 9 show the projected overall unclassified and classified performance requirements, respectively, for non-real-time computing for the top five organizations and locations. For both classified and unclassified requirements, only a few organizations predominate. It should be noted that both NRL and ERDC have significant increases in their unclassified requirements for FY 2007. With respect to the classified requirements, ARL’s requirements far exceed all the other organizations in the top five.

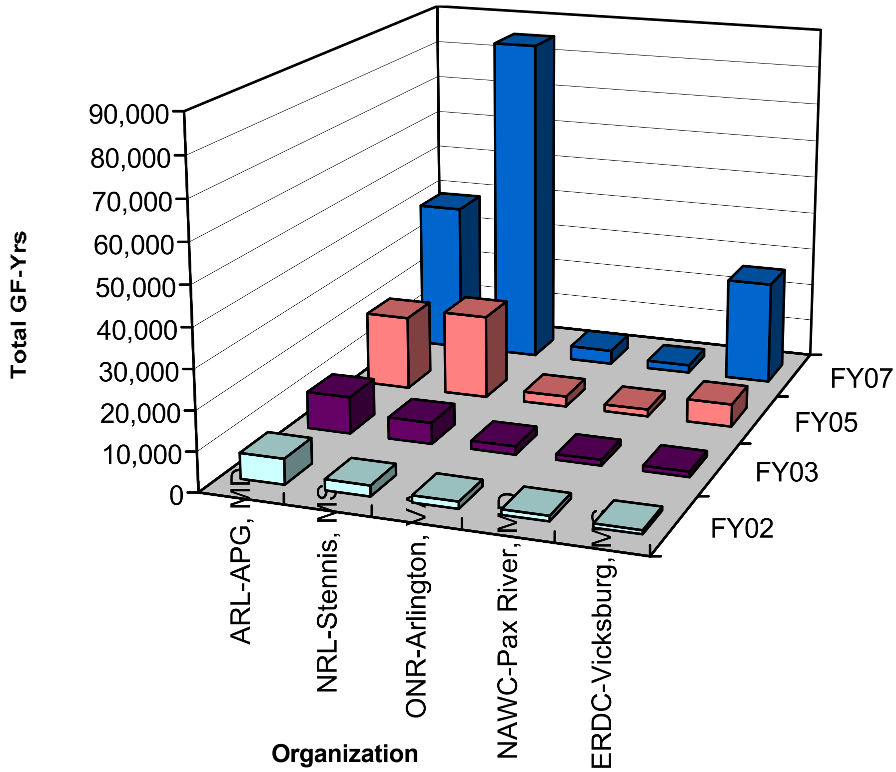

Figure 8. Overall Performance Requirements for Unclassified Non-Real-time Computing for User Organizations with the Largest Requirements

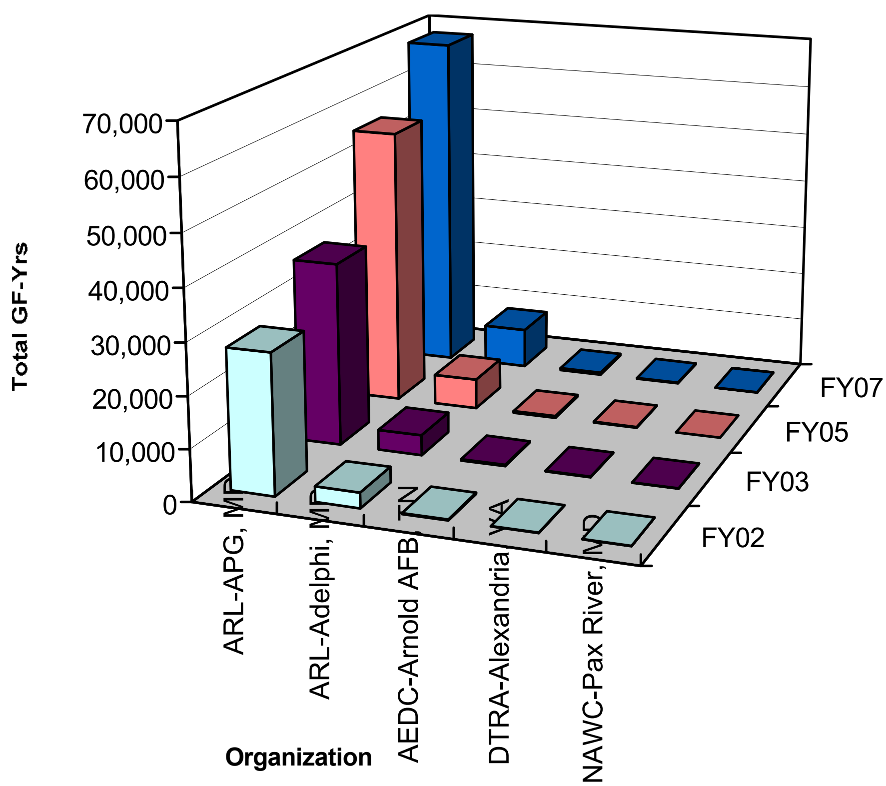

Figure 9. Overall Performance Requirements for Classified Non-Real-Time Computing for User Organizations with the Largest Requirements

3.1.2 Processor Requirements

For the first time, the HPC requirements questionnaire specifically asked the Project Leader to identify NRTC individual job requirements, both for the average and the maximum job, based on each HPC resource requested. Figures 10 and 11 show the average and maximum requirements (unclassified and classified combined) for scalable system processors in non-real-time computing.[2] The percentage of projects is calculated based on the number of processors an average or maximum job requires and the percentage of GF-yrs is based on the HPC system that the user expects to use to run that average job. Although some projects still run single-processor jobs (12% for average jobs, 4% for maximum jobs), it is clear that a majority of the projects (70% for average jobs and 40% for maximum jobs) require a large number of processors (65 or more) to obtain the overall performance necessary for their computational work. There is a significant difference in the total requirements (GF-yrs) for the typical and maximum job. For the typical job, 90% of the total requirements require 64 or fewer processors while for the maximum job, 94% of the total requirements require 65 or more processors with a majority of the work being projected on 257–512 processors.

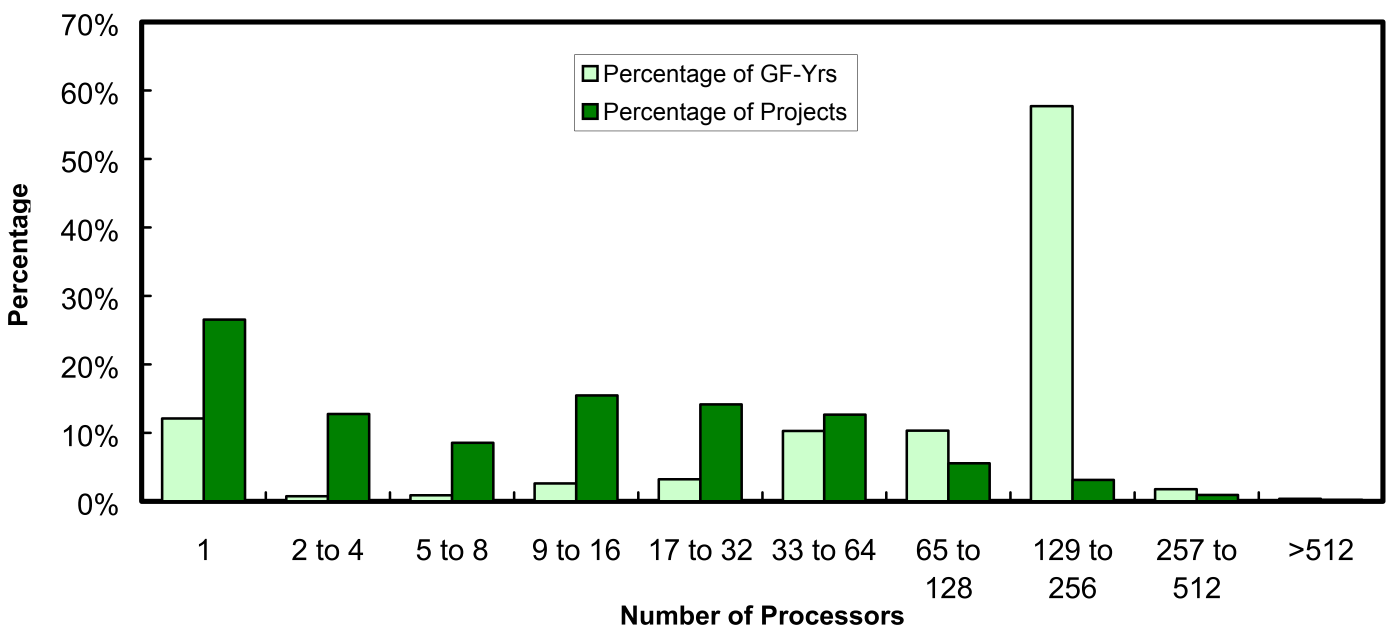

Figure 10. Requirements for Scalable System Processors in NRTC Average Jobs for FY 2002

[2] The total GF-yrs in these figures is larger than the overall total GF-yrs shown in Figures 4 and 5 since project leaders were asked to present their average and maximum processor requirements on all the systems they listed under NRTC requirements. In the past, the questionnaire only asked about average and maximum usage on the primary system utilized.

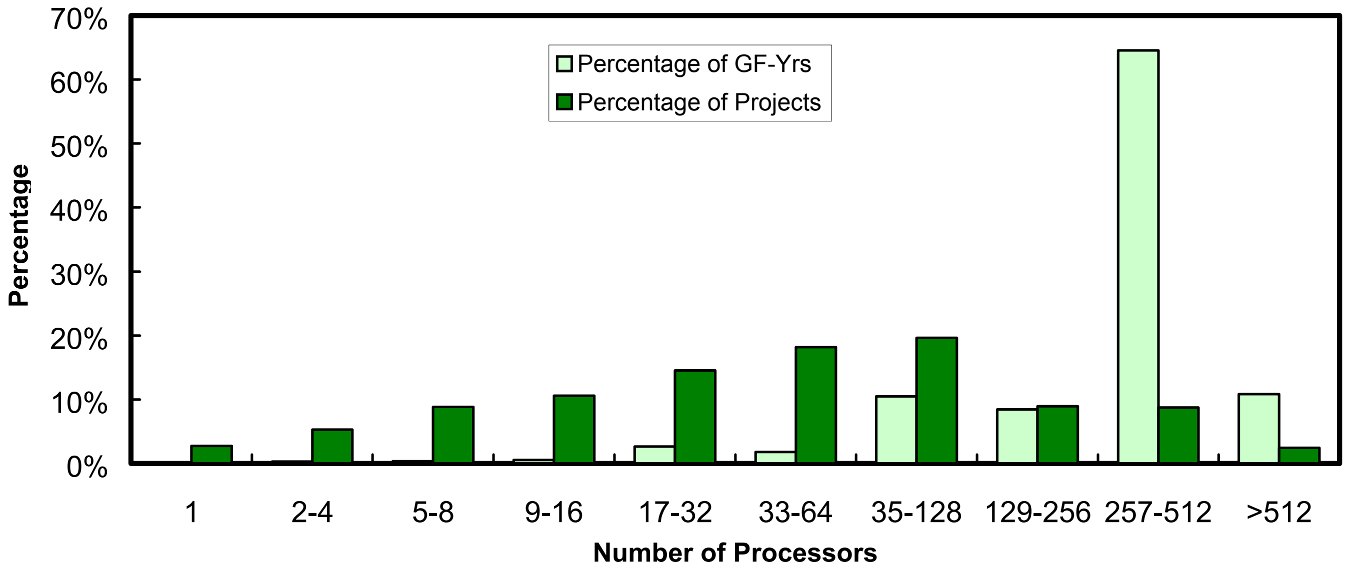

Figure 11. Requirements for Scalable System Processors in NRTC Maximum Jobs for FY 2002

3.1.3 Memory, File Size, and Archival Storage Requirements

In this section, individual and maximum job requirements were used to characterize HPC resources in terms of memory and file size. Project leaders were also asked to state their data archival storage requirements in GB for FY 2002 and the out years. This section describes central memory, file size, and data storage requirements for FY 2002.

Figure 12 gives the average and maximum memory requirements for non-real-time computing jobs in FY 2002. A comparison FY 2001 and FY 2002 data indicates that memory requirements above 512 GB have decreased; however, a large number of projects continue to have memory requirements below 64 GB.

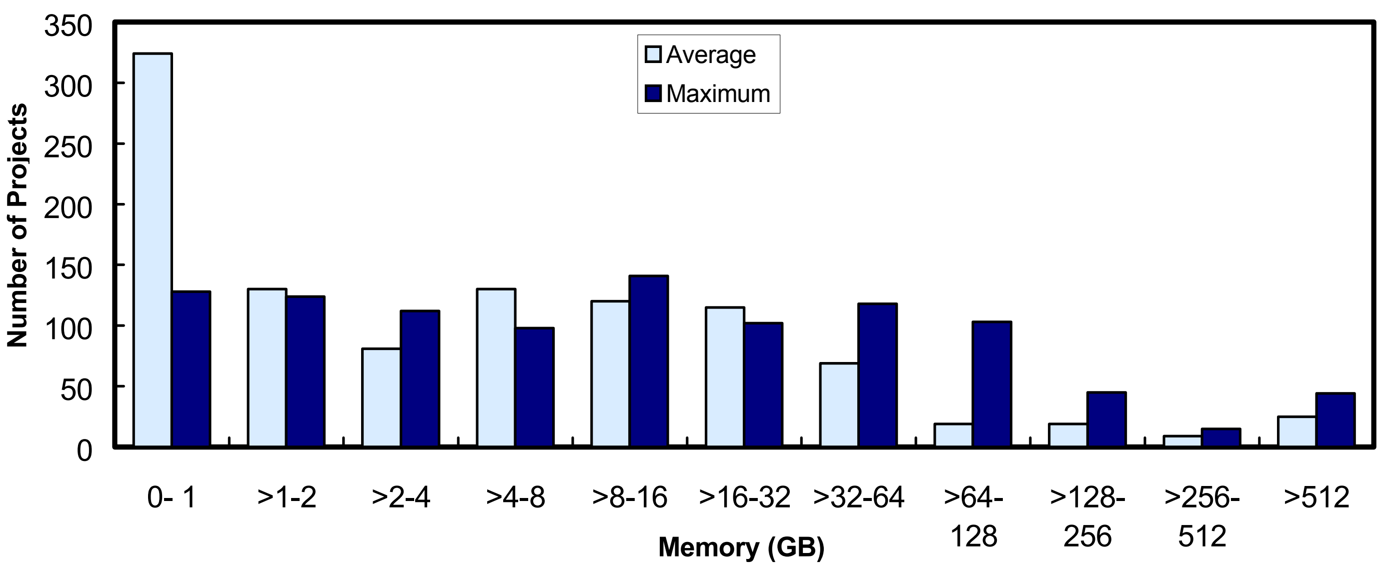

Figure 12. Memory Requirements for NRTC Jobs for FY 2002

Figure 13 shows the average and maximum file size requirements for unclassified non-real-time computing jobs. Comparison of FY 2001 and FY 2002 data indicates that file size requirements have remained fairly stable.

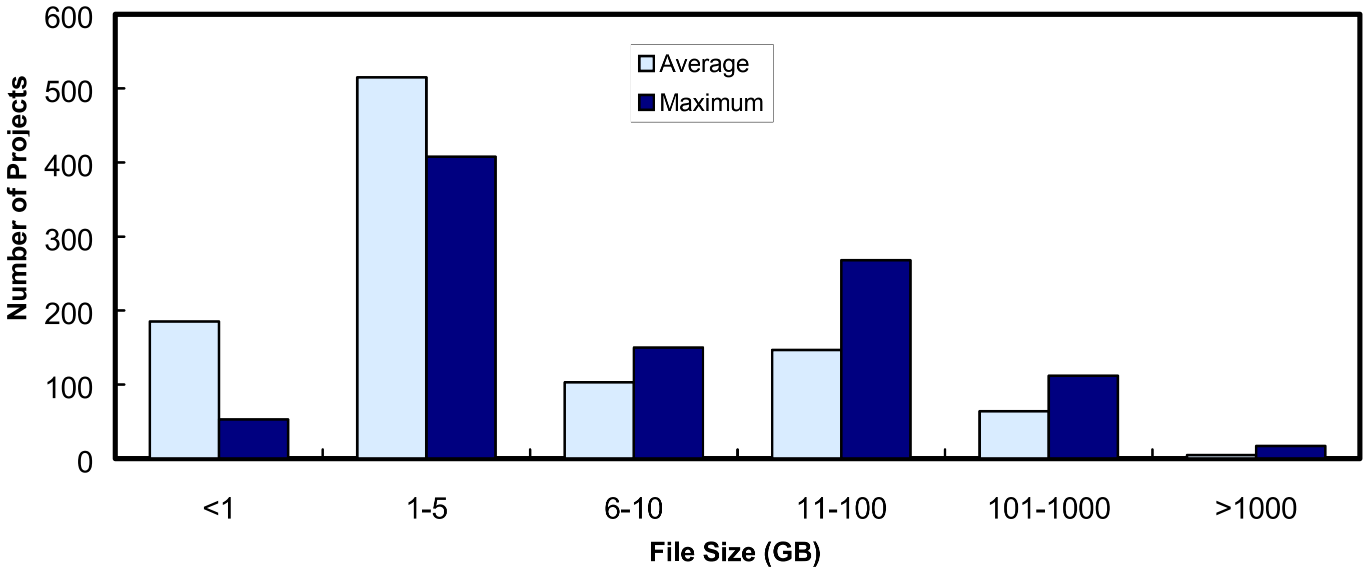

Figure 13. File Size Requirements for NRTC Jobs for FY 2002

Figure 14 shows archival requirements for FY 2002. We gathered the total archival storage requirements for each computational project (without separating non-real-time and real-time requirements). This is consistent with the archival storage requirements reported in the previous two years.

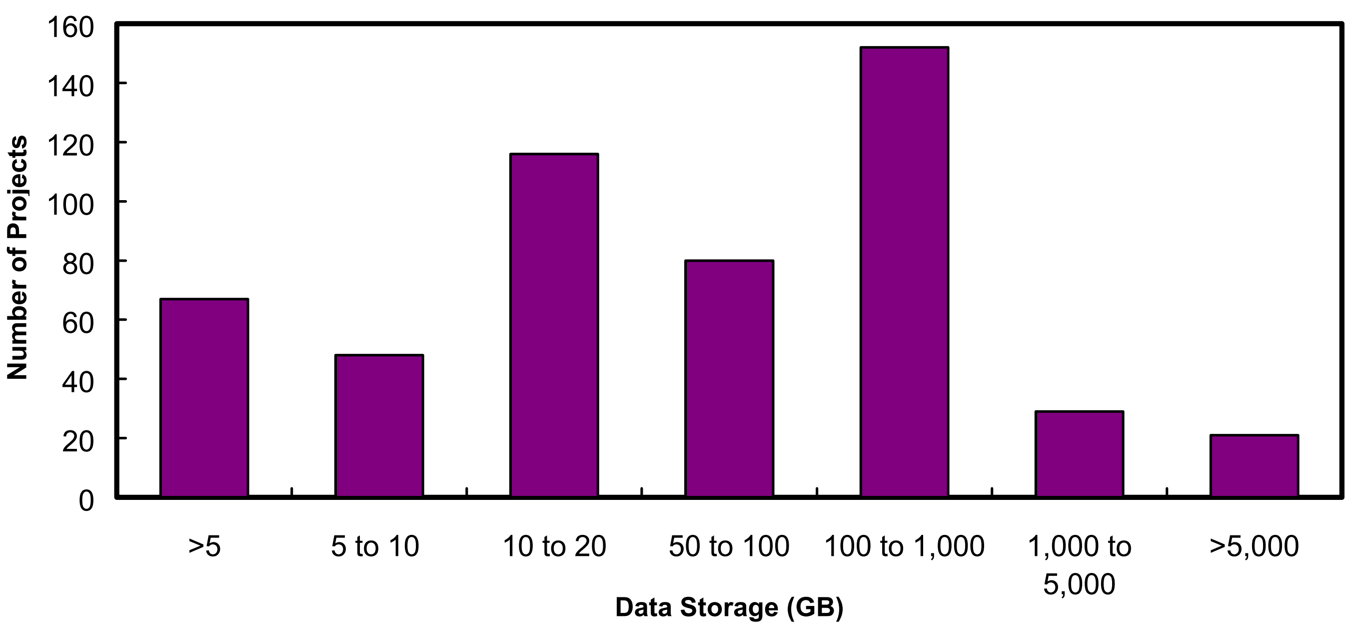

Figure 14. Archival Storage Requirements for FY 2002

3.2 Resource Requirements for Real-Time Computing

Section 1 defines real-time computing as the acquisition and production of data and their concurrent processing for interactive display and control purposes. This section summarizes the real-time HPC requirements of the DoD S&T and T&E communities. Many projects with real-time requirements also have non-real-time requirements.

3.2.1 Real-time Computing Requirements

Real-time HPC systems must be capable of accepting and processing data at the rate required by an external stimulus. This capability is required whether the data comes from an ongoing test, from a human operator interacting with the system, or from the hardware and personnel participating in an interactive simulation. Processing data at a rate even slightly less than the required data rate quickly results in either the loss of valuable data or the total shutdown of the system. Consequently, the most significant requirement for a real-time HPC system is maximum speed. Like electrical power production, computational cycles cannot be stored and used later. The instant these commodities are required, they must be available. Therefore, real-time HPC systems must be sized for the maximum speed necessary for the requirement they are designed to address.

In general, it is difficult to share real-time HPC systems during active test periods because the systems primarily operate in a dedicated mode. The appropriate quantity of allocable time for each of these systems is not total computational time but the total wall clock time used by that system for test, simulation, or experimentation (including setup), as well as other activities. There is an accepted method to combine separate non-real-time requirements with different system speeds. This is accomplished by integrating the computational speed requirement over time in order to generate overall performance requirements in appropriate units, such as GF-yrs. There is no similar way to total real-time requirements, so we summarize them for all projects at each location. DoD laboratories and test centers have 99 projects with real-time computing requirements for classified and unclassified work (Table 6). The T&E organizations perform most of the real-time computational work, though DoD laboratories have a number of real-time computing projects. Table 6 gives the required maximum system speed for each organization's set of real-time computing projects during FY 2002, FY 2003, FY 2005, and FY 2007. Some of the organizations listed in the table have maximum system speed requirements of several hundred gigaflops (GFs). As in past years, the maximum system performance for RTC remains fairly constant. This may be attributed to (1) unknown funding in the out years or (2) lack of vision for using HPC resources. The T&E community is new to the HPC world and still maturing in their use of HPC resources. In addition, although the number of HPC computational hours required is not captured in this table , these hours, on the average, do increase over the years.

Table 6. Maximum System Performance Requirements for Sets of RTC Projects at DoD Laboratories and Test Centers (GFs)

Organization	Projects	*Unclassified Maximum System Performance*				*Classified Maximum System Performance*			
		FY 2002	FY 2003	FY 2005	FY 2007	FY 2002	FY 2003	FY 2005	FY 2007
AEDC, Arnold AFB, TN*	6	128	128	128	128	128	128	128	128
AFRL – Information, Rome, NY*	10	384	384	384	384	276.5	276.5	276.5	276.5
AFWA, Offutt AFB , NE	1	83.2	-	-	-	-	-	-	-
Other US Air Force	9	-	82	82	82	276.5	276.5	276.5	82
ARL, Aberdeen Proving Ground, MD	2	409.6	409.6	409.6	409.6	-	-	-	-
ARL, Adelphi, MD	1	128	128	-	-	-	-	-	-
ATC, Aberdeen Proving Ground, MD	2	102.4	102.4	102.4	102.4	-	-	-	-
ATC, Fort Rucker, AL	1	12.8	12.8	12.8	12.8	-	-	-	-
CRTC, Delta Junction, AK	1	-	-	57.6	57.6	-	-	-	-
ERDC, Hanover, NH	1	163.2	163.2	163.2	163.2	-	-	-	-
RTTC, Redstone Arsenal, AL*	2	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8
SBCCOM, Aberdeen Proving Ground, MD	1	.7	.7	.7	.7	-	-	-	-
SMDC, Huntsville, AL*	6	64	64	64	64	256	256	256	256
TACOM, Warren, MI (TARDEC)*	2	21.8	21.8	21.8	21.8	-	-	-	-
WSMR, White Sands, NM*	6	-	-	-	-	51.2	51.2	51.2	51.2
NAWC, China Lake, CA*	13	-	-	-	-	12.8	12.8	12.8	12.8
NAWC, Patuxent River, MD*	25	-	-	-	-	145.6	145.6	145.6	145.6
NRL, Washington, DC*	1	12.8	12.8	-	-	-	-	-	-
NRL, Monterey, CA	1	0.5	0.5	0.5	0.5	-	-	-	-
NSWC, Carderock, MD	1	91.2	91.2	91.2	91.2	102.4	102.4	102.4	102.4
NSWC, Panama City, FL	1	-	-	-	-	28.2	28.2	28.2	28.2
SSCSD, San Diego, CA*	4	276.5	276.5	276.5	276.5	28.2	28.2	28.2	28.2
JNTF, Schriever AFB, CO*	2	-	-	-	-	64	64	125.4	0.4

*Current distributed center

3.2.2 Processor Requirements

Figure 15 shows the average and maximum number of processors requested for FY 2002 by computational projects using scalable systems. A number of projects[3] require a small number of processors, especially for the average jobs. There are a significant number of maximum size jobs that require close to 100 processors. The greatest number of processors requested for real-time computing was 512.

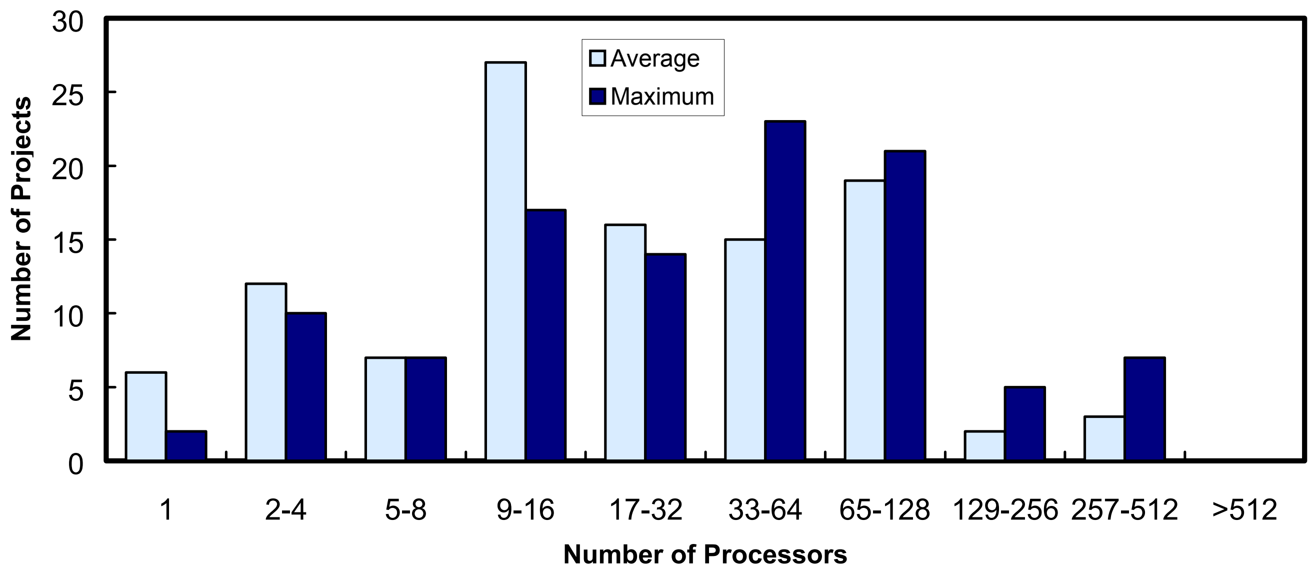

Figure 15. FY 2002 Requirements for Processors in RTC Projects Using Scalable Systems

3.2.3 Memory and File Size Requirements

Memory and file size requirements for real-time and non-real-time computing can be analyzed in much the same way. Figure 16 describes the average and maximum memory requirements for real-time computing projects during FY 2002. The memory requirements for FY 2002 appear to have dropped substantially from last year; last year there was at least one project with memory requirements great than 16,384 MB. One reason for this may be the fact that in this year's questionnaire, several project leaders did not complete these tables or only completed the "average" section of the table. The FY 2003 questionnaire will make it mandatory that the project leader complete the "average" section of the table and, if the "maximum" section is left blank, the assumption is that the average requirements and the maximum requirements are the same.

[3] The number of projects is larger than the total number of projects since project leaders were asked to present their individual and maximum requirements on all the systems they listed under RTC requirements. In the past, the questionnaire only asked about average and maximum usage on the primary system utilized.

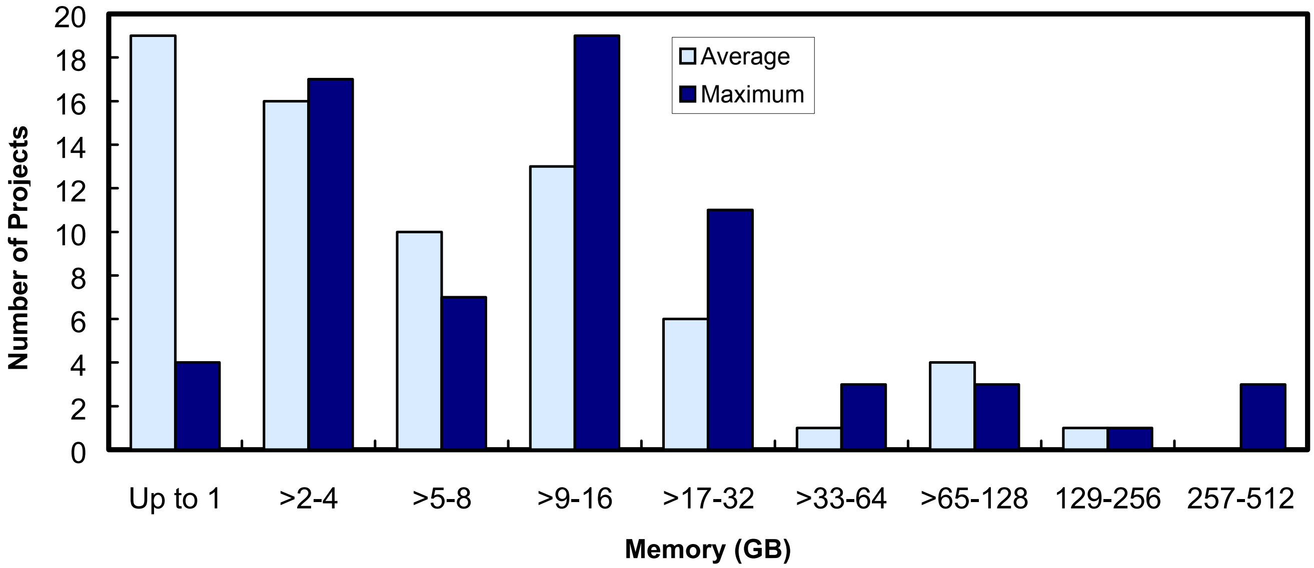

Figure 16. Memory Requirements for RTC Projects for FY 2002

Figure 17 shows the average and maximum file size requirements for RTC projects. As for non-real-time requirements, a substantial number of projects require files sizes in the 1 to 5 GB range. However, for RTC projects, there is a noticeable increase from NRTC projects in the number of projects with files sizes in the 11 to 100 GB range. Unlike last year, there were no projects with file size requirements greater than a terabyte.

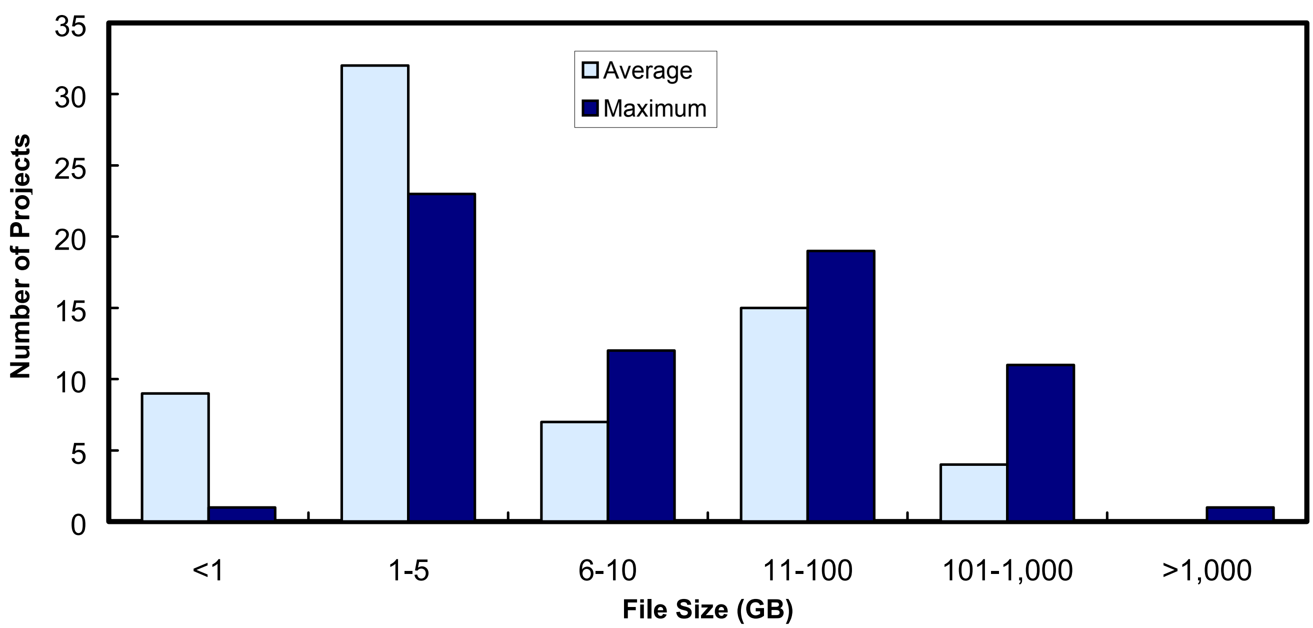

Figure 17. File Size Requirements for RTC Projects for FY 2002

4. SOFTWARE REQUIREMENTS

4.1 INTRODUCTION

The HPCMO gathered information on software requirements. Unlike past years, the HPCMO did not ask the Project Leaders to break their software requirements into specific categories or areas because of discrepancies in definitions of (a) categories such as commercial-off-the-shelf versus software tools, and (b) areas such as large-scale analysis software versus small-scale analysis software. Tables 7 and 8 present the major unclassified and classified software requirements for FY 2002. These tables, sorted in descending order based on number of users, include the number of projects and users requiring the software along with the number of users requiring training on each software package at one of three levels: beginner, intermediate, or advanced. The majority of the software packages listed in Tables 7 and 8 may be found on most of the architectures at the major HPCMP centers. Training requirements are also discussed in Section 5.

4.2 ASSESSMENT AND TRENDS

Overall, the software requirements have remained consistent the past two years. A substantial percentage of the projects require specific software, particularly in the area of compilers and languages (Fortran77, Fortran 90, and C). The number of users requesting Fortran 90 and Fortran 77 have increased from last year, while the requirement for Fortran, C++ and C have dropped significantly compared to the last two years. In the case of Fortran, it would appear that users are now specifying a specific version of Fortran when completing the requirements questionnaire.

The overall requirements for large-scale analysis software have decreased for FY 2002 although the requirements for MATLAB (both classified and unclassified) have increased significantly from last year. Specific software such as GAUSSIAN, GAMESS, and SPEEDES were in the top ten last year, but were not even in the top 30 this year. Visualization packages such as TECPLOT, 3D Visualization, FIELDVIEW, and OILSTOCK (classified requirement only) continue to be in high demand.

The results of the surveys for the past three years indicate that software tool requirements (i.e., ENSIGHT and FIELDVIEW) have remained constant, except for MPI. The reduction in the number of uses requesting MPI may be the result of users “assuming” that this type of software, because of its wide-spread use in the HPC community, will automatically be available on all systems. Requirements for functional libraries (such as IMSL and LAPACK) have declined for FY 2002 along with small-scale multipurpose software. In contrast, application codes tailored for individual projects continue to rise. Most of these codes are unique to a single project, but some may become common applications software in the future.

Table 7. FY 2002 Requirements for Software Requirements (Unclassified)

Unclassified Software Requirements			Training		
Software	**Number of Projects**	**Number of Users**	**Beginner**	**Intermediate**	**Advanced**
FORTRAN 90	216	1,098	38	264	308
C	106	681	56	164	149
MPI/MPI-2	88	520	72	124	129
FORTRAN 77	106	501	22	123	147
C++	71	376	26	84	69
MATLAB	80	346	54	111	91
TECPLOT	39	193	18	15	48
3D Visualization	27	134	37	35	45
Open MP	23	132	46	38	40
Ensight	22	125	25	19	7
ABAQUS	36	123	24	30	41
NCAR	16	117	0	31	26
FIELDVIEW	23	113	15	16	17
Gridgen	29	102	19	26	25
CTH	16	102	4	8	20
FORTRAN – High Performance	23	91	7	20	33
VSIPL	9	82	18	20	15
NASTRAN	19	80	9	18	37
3D Models	8	73	10	23	38
PATRAN	17	71	10	31	13
IMSL	21	70	1	14	15
COBALT-60	16	70	6	21	8
LS-DYNA3D	20	66	7	15	8
LAPACK	18	66	5	9	21
JAVA	8	66	17	10	19
BLAS	10	64	0	28	14
ANSYS	18	61	7	26	32
WIND	11	58	10	9	12
PTYRECON	4	57	0	0	0
TOTALVIEW	11	55	6	11	34
NXAIR	4	51	0	0	3
GASP	17	50	4	11	15
FRED	3	50	0	0	0
ARCVIEW	2	50	25	18	7

Table 8. FY 2002 Requirements for Software Requirements (Classified)

Classified Software Requirements			Training		
Software	Number of Projects	Number of Users	Beginner	Intermediate	Advanced
MATLAB	42	346	12	76	132
C++	34	303	16	79	62
3D Models	14	268	0	14	4
3D Visualization	12	259	2	3	4
C	38	236	19	71	77
FORTRAN 90	25	206	17	69	56
Vega	12	105	6	36	23
FORTRAN 77	14	89	3	29	31
JIMM	7	81	1	26	4
OILSTOCK	5	78	0	3	0
MUVES	1	70	0	0	0
HLA	2	65	10	10	10
CTH	6	61	0	0	8
Multigen	11	58	3	26	27
Xpatch	9	58	2	18	12
FIELDVIEW	5	55	3	6	11

The software requirements will continue to support a large investment in a variety of software on HPCMP systems, making it possible for DoD computational work to contribute effectively to S&T and T&E programs. The HPC Modernization Office continues to cross-reference software requirements data with actual utilization data at the shared resource centers including an investigation into the feasibility of program-wide licenses of the most heavily used software packages (such as MATLAB). The analysis should help to verify software requirements and ensure that expensive large-scale analysis software is well utilized.

5. TRAINING REQUIREMENTS

The 2001 requirements survey shows that the training and education of some of DoD's most critical resources—the computational scientists and engineers who use fielded HPC resources—continues to be a priority. As new systems are integrated into the set of HPCMP resources, the user community realizes the need for training to effectively leverage their capabilities. Given the current state of DoD manpower, it is also clear that training and education techniques must provide the user community with the appropriate training at the appropriate level.

This year's questionnaire specifically asked for training requirements, both the number of users and level of training, in five areas: software, specific HPC system platforms available in FY 2002, Defense Research Engineering Network (DREN), operating systems, and other training. The software requirements, captured in Tables 7 and 8, indicate that the majority of users need software training at the intermediate or advanced level. It is interesting to note that the software packages that the users requested training most often at each level are very similar (see Table 9). OpenMP and Fortran 77 are the only two software packages not requested all three levels.

Table 9. FY 2002 Requirements for Software Training

Beginner (Number of Users)	Intermediate (Number of Users)	Advanced (Number of Users)
C (75)	Fortran 90 (333)	Fortran 90 (364)
MPI (74)	C (235)	C (226)
MATLAB (66)	MATLAB (187)	MATLAB (223)
FORTRAN 90 (55)	C++ (163)	Fortran 77 (178)
Open MP (46)	Fortran 77 (152)	C++ (131)
C++ (42)	MPI (128)	MPI (130)

Table 10 provides a listing of the top ten training requirements on specific HPC systems for FY 2002. Training requirements for two of the principal architectures, the SGI Origin and the IBM SPs, remain strong. Compared with the last survey, the training requirements for most of the systems have decreased. One reason for this decrease may be that only a small percentage of the projects listed any type of training requirements in this year's questionnaire. This may be because most of the HPC users are familiar with the platforms the HPCMP now has on the floor. As new platforms are introduced in FY 2002–2003, training requirements may increase.

Table 10. FY 2002 Requirements for Training on System Platforms

HPC System Platform	Number of Users Requesting Training	Level of Training
SGI Onyx	114	Intermediate
SGI Origin 2000	83	Intermediate
SGI Origin 3800	46	Intermediate
SGI Onyx2	44	Advanced
IBM SPs	44	Intermediate
Sky	40	Intermediate
SGI Origin 3800	36	Beginner
IBM SPs	36	Beginner
SGI Origin 2000	30	Beginner

Table 11 shows the training requirements on operating systems available on the platforms at the shared resource centers. As in past years, most of the training requirements are for IRIX 6.X, UNIX, and LINUX. Unlike the other training areas, no level of training is predominant; there appears to be a strong need for training at all three levels.

Table 11. FY 2002 Requirements for Training on Operating Systems

HPC System Platform	Number of Users Requesting Training	Level of Training
IRIX 6.X	176	Intermediate
IRIX 6.X	84	Advanced
IRIX 6.X	72	Beginner
UNIX	40	Intermediate
LINUX	35	Intermediate
UNIX	29	Beginner
AIX 5.X	25	Beginner
SOLARIS 8	11	Beginner
LINUX (Redhat)	10	Intermediate
UNIX	9	Advanced
LINUX (Redhat)	9	Beginner
AIX 5.X	7	Intermediate
SOLARIS 8	6	Advanced
SOLAIS 8	5	Intermediate
LINUX (Redhat)	4	Advanced

Most DREN users are familiar with the network and have little or no problems accessing the network to run their computations. Of the 268 projects that responded to the question about DREN training, only 87 indicated the need for any type of training. Table 12 shows the breakdown of these projects and level of training requested.

Table 12. FY 2002 Requirements for DREN Training

Number of Projects	Number of Users Requesting Training	Level of Training
6	16	Advanced
39	142	Intermediate
42	170	Beginner

The list of "Other" training covered everything from specific software packages to parallel programming to operating systems in general. Table 13 provides the list of subject areas, number of users requesting training, and the level of training. Most of the training requirements are at the intermediate level. Note that many of these "Other" training requirements would normally have been included in the software training table.

Table 13. FY 2002 Other Training Requirements

Subject Area	Number of Users	Level of Training
New HPC Systems	39	Intermediate
Parallel MATLAB	30	Beginner
MATLAB	22	Intermediate
XPATCH	14	Intermediate
Parallel Programming	10	Beginner
Advanced Methods in CCM	8	Advanced
Auto Parallel Options	8	Beginner
FIELDVIEW, Ensight, TECPLOT	8	Beginner
Multigen	8	Beginner
SGI Dev. Suite	8	Beginner
GRD	8	Intermediate
MPI	8	Intermediate
Visualization Tools, Compilers	8	Intermediate
MATLAB	7	Advanced
GLOBUS, LEGION, TMIELINE, VAMPIR	7	Beginner
RTExpress	7	Beginner
SGI Auto Parallel Option	7	Beginner
General Use	7	Intermediate
Parallel Programming	7	Intermediate
Vega	7	Intermediate
LSF	6	Intermediate
Lightwave	5	Advanced
SGI Dev. Suite/Debugging Tools	5	Beginner

Subject Area	Number of Users	Level of Training
VAMPIR	5	Beginner
Compilers - C, C++, FORTRAN90	5	Intermediate
Efficient Programming for Cray SV2	5	Intermediate
GLOBUS, LEGION	5	Intermediate
Graphics (Open GL)	5	Intermediate
Gridgen	5	Intermediate
Parallelization of Existing FORTRAN Codes	5	Intermediate
Real Time Visualization	5	Intermediate
Speedshop	5	Intermediate
TOTALVIEW	5	Intermediate
Optimization Of Serial Code	4	Advanced
SIMULATIONS	4	Advanced
General Architecture, Efficient Programming	4	Beginner
Gridgen, FIELDVIEW, Ensight, TECPLOT	4	Beginner
SGI, IBM, SUN & Compaq Operating Systems + System Tools	4	Beginner
System Tools, Compilers (F90, C ,C++), Debuggers, & Operating Systems	4	Beginner
AVS	4	Intermediate
FORTRAN 90	4	Intermediate
Operating System	4	Intermediate
Parallel Programming Environment, C & C++	4	Intermediate
Parallel Programming Environments, Code Profiling	4	Intermediate
SGI Dev. Suite	4	Intermediate
Visualization Tools, Vega & Performer	4	Intermediate
ABAQUS	3	Advanced
Batch Processing	3	Intermediate
CFD++ Application Software	3	Intermediate
Parallel Coding Overall	3	Intermediate
SGI Performer	3	Intermediate
Visualization Tools	3	Intermediate
C++	2	Advanced
MATLAB SIG Proc	2	Advanced
Efficient Use of Quadrics Switch	2	Beginner
Legion, GLOBUS	2	Beginner
MPI	2	Beginner
Native Compilers, MPI-RT	2	Beginner
OVERGRID, OVERFLOW ROTOR, SAGE	2	Beginner

Subject Area	Number of Users	Level of Training
PRISM	2	Beginner
TOTALVIEW	2	Beginner
Probe (BBN)	2	Intermediate
TOTALVIEW, Speedshop, Timescan	2	Intermediate
XHPF	2	Intermediate
XPATCH	1	Advanced
COMPILER	1	Beginner
Fluent, CFD++, WIND	1	Beginner
MM5	1	Beginner
Perl	1	Beginner
COMPILER (AIX, TRU64)	1	Intermediate
LS-DYNA	1	Intermediate
Maple	1	Intermediate
Parallel Programming, Machine Architecture	1	Intermediate

6. NETWORK REQUIREMENTS

The HPCMO gathered information on wide area networking requirements during the 2001 requirements survey. The program uses this information to determine the locations of Defense Research and Engineering Network (DREN) connections and the bandwidth for each connection. For planning purposes, the DREN Project Manager has received detailed, quantitative data on the sizes of files to be transferred and the required transfer times. This report does not present that data but does contain information on other HPC project activities that affect the overall wide area networking requirements of sites.

Simultaneous computing is defined as using multiple computational assets to attack a problem simultaneously so that high-speed communications may be required. When using multiple systems at different sites, the user requires a high, wide area networking bandwidth that makes possible the timely communication needed to efficiently complete computations. Table 14 lists the number of projects and users at each site requiring simultaneous computing. Five of the six projects listed under OUSAF, Arlington are actually located at the Electronic Systems Center (ESC) at Hanscom AFB, MA. The sixth project is located at Kirtland AFB, NM.

Approximately 21% of the users expressed an interest in simultaneous computing. This is a slight decrease from the percentage of users (24%) who expressed an interest during the last survey.

Another major activity that could potentially require a large wide area network bandwidth is the use of remote HPC systems for rendering visualization files. The most common method of processing visualization files is to transfer the output file back to a local user system and then perform visualization rendering on that system. The HPCMO gathered information on the requirements for these file transfers as a part of the overall file transfer requirements mentioned earlier in this report. Table 15 displays the number of projects and users with requirements for remote visualization processing. Again, three out of the four projects listed under OUSAF are located at ESC at Hanscom AFB.

Only a limited number of organizations have a requirement for remote visualization processing; however, the number of users with plans to use a remote center to do on-line visualization post-processing or other real-time applications has decreased significantly from last year. Approximately 12% (as compared to 23% last year) of the users currently have a requirement for visualization processing on a remote system.

Table 14. Requirements for Simultaneous Computing

Organization	Projects	Users
Air Force		
AEDC, Arnold AFB, TN	1	8
AFRLDE, Kirtland AFB, NM	1	2
AFRLIF, Rome NY	1	56
AFRLML, Wright Patterson AFB, OH	1	6
AFOSR, Arlington, VA	1	7
OUSAF, Arlington, VA	6	331
TOTAL	**11**	**410**
Army		
ARL, Aberdeen Proving Ground, MD	2	73
ATTC, Fort Rucker, AL	1	4
SSCOM, Natick, MA	1	13
TACOM, Warren, MI	2	24
TOTAL	**6**	**114**
Navy		
NAWCWD, China Lake, CA	5	34
NAWCAD, Patuxent River, MD	22	222
NRL, Washington, DC	1	4
NSWC, Carderock, MD	1	2
NSWC, Panama city, FL	1	9
SSC, San Diego, CA	2	9
TOTAL	**32**	**280**
Agencies		
DTRA, Alexandria, VA	3	79
JNTF, Schriever AFB, CO	1	11
TOTAL	**4**	**90**
GRAND TOTAL	**53**	**894**

Table 15. Requirements for Visualization Processing on Remote Systems

Organization	Projects	Users
Air Force		
AEDC, Arnold AFB, TN	2	18
AFRLDE, Kirtland AFB, NM	2	9
AFRLIF, Rome NY	1	2
AFRLML, Wright Patterson AFB, OH	1	6
AFRLMN, Eglin AFB, FL	1	18
AFRLPR, Edwards AFB, CA	1	5
AFRLPR, Wright Patterson AFB, OH	4	34
AFRLVA, Wright Patterson AFB, OH	1	7
AFRLVS, Hanscom AFB, MA	1	3
OUSAF	4	24
TOTAL	**18**	**126**
Army		
ACCOM, Redstone Arsenal, AL	2	8
ARL, Aberdeen Proving Ground, MD	3	83
ARL, Adelphi, MD	1	55
ATTC, Fort Rucker, AL	1	4
CECOM, Fort Belvoir, VA	1	4
ERDC, Hanover, NH	2	15
RTTC, Redstone Arsenal, AL	1	6
SSCOM, Natick, MA	1	13
TACOM, Picatinny arsenal, NJ	1	1
TOTAL	**13**	**189**
Navy		
NAWCWD, China Lake, CA	5	31
NAWCAD, Patuxent River, MD	1	8
NPS, Monterey, CA	1	2
NRL, Washington, DC	5	18
NRL, Stennis Space Center, MS	1	23
NSWC, Carderock, MD	2	11
NSWC, Indian Head, MD	1	6
ONR, Washington, DC	1	2
SSC, San Diego, CA	1	5
TOTAL	**18**	**106**
Agencies		
DTRA, Alexandria, VA	4	110
JNTF, Schriever AFB, CO	1	1
TOTAL	**5**	**111**
GRAND TOTAL	**54**	**532**

7. SUMMARY OF REQUIREMENTS

The DoD HPCMP community clearly has extensive high performance computing requirements in addressing the mission of supporting the development of more capable war fighting systems. The results of the survey confirm again the large, growing set of HPC requirements that must be addressed to continue the program's robust support of DoD's S&T and T&E programs.

Tables 16 and 17 summarize the unclassified and classified non-real-time computing requirements of DoD's S&T and T&E communities. For the purpose of comparison, we have included the number of projects in the Services and Agencies with each kind of requirement. Real-time computing requirements are not included here because of the difficulty in meaningfully aggregating them across multiple projects.

Table 16 clearly shows the continuing growth in the non-real-time unclassified requirements of the DoD HPCMP community. In comparison to last year's FY 2002 projections, the Air Force requirements have decreased significantly (4,869 GF-yrs) and the Army requirements have decreased slightly (10,554 GF-yrs) while the Navy's requirements increased significantly from 5,424 GF-yrs to 7,300 GF-yrs. The total Agency requirements also decreased slightly from 362 GF-yrs

Table 16. Services and DoD Agencies: Overall Performance Requirements for Unclassified NRTC (GF-yrs)

Organization	Projects	FY 2002	FY 2003	FY 2005	FY 2007
Total Air Force	171	2,443.37	3,013.09	3,089.43	3,712.01
Total Army	73	9,342.49	13,100.90	27,425.93	69,425.50
Total Navy	235	7,300.09	10,979.83	28,484.36	93,944.78
Total Agencies	10	340.86	370.22	384.60	448.15
GRAND TOTAL	**489**	**19,426.81**	**27,464.04**	**59,384.32**	**167,530.44**

Table 17 indicates that over 60% of the total requirements for FY 2002 are classified non-real-time requirements, with the Army having the biggest increase in classified requirements. The projected requirements are consistent with the classified requirements show in the FY 2001 requirements report. Projections for classified requirements continue to rise substantially through FY 2007, but at a much slower rate than the unclassified requirements, resulting in an equal distribution by FY 2005 and a predominance of unclassified requirements by FY 2007.

Table 17. Services and DoD Agencies: Overall Performance Requirements for Classified NRTC (GF-yrs)

Organization	Projects	FY 2002	FY 2003	FY 2005	FY 2007
Total Air Force	23	277.59	339.80	448.06	499.48
Total Army	18	30,277.84	39,981.62	61,157.13	76,638.20
Total Navy	34	166.71	221.90	208.86	232.71
Total Agencies	5	94.16	105.95	137.95	178.56
GRAND TOTAL	**80**	**30,816.30**	**40,649.27**	**61,952.00**	**77,548.95**

The general conclusion of this report is identical to those of preceding requirements reports. A complete HPC environment must be provided to support the DoD's S&T and T&E communities. A variety of computational platforms, both at the unclassified and classified level, must be provided so that a wide range of DoD applications can be efficiently supported. These platforms must be balanced with respect to computational power, central memory, and file storage capabilities. A variety of systems and applications software that enable DoD computational scientists and engineers to perform their mission are required. A reliable high-speed network that connects the users to these resources and to each other is required, as is the continuation of an aggressive training program that broadens and educates DoD's HPC users. Progress must be balanced across all program activities to optimize the impact of HPC on the DoD S&T and T&E programs' support of the warfighting mission.

APPENDIX A

Air Force – HPC Users by Organization, Location, Affiliation and Functional Environment

Organization	Location	No. of Projects	Govt. Personnel	Contractors	Total Users	Real-Time Users	Non-Real-Time Users	Both	Other Users
AEDC	Arnold AFB, TN	25	1	116	117	72	9	36	
AFAAC	Eglin AFB, FL	2	3	8	11	11			
AFFTC	Edwards AFB, CA	6	12	24	36	36			
AFIT	Wright-Patterson AFB, OH	10	20	9	29	29			
AFOSR	Bolling AFB, DC	33	14	103	117	115		2	
AFRLDE	Kirtland AFB, NM	10	29	19	48	40			8
	Maui, HI	1	4	12	16			16	
AFRLIF	Rome, NY	25	85	98	183	45	5	127	6
AFRLML	Wright-Patterson AFB, OH	8	30	31	61	41		20	
AFRLMN	Eglin AFB, FL	2	10	10	20	20			
AFRLPR	Edwards AFB, CA	6	10	24	34	34			
	Wright-Patterson AFB, OH	15	27	36	63	61			2
AFRLSN	Hanscom AFB, MA	2	4	4	8	8			
	Wright-Patterson AFB, OH	6	14	41	55	51		4	
AFRLVA	Wright-Patterson AFB, OH	19	79	35	114	114			
AFRLVS	Hanscom AFB, MA	5	5	13	18	18			
AFWAC	Offutt AFB, NE	4	15	5	20	17		3	
ASC	Wright-Patterson AFB, OH	3	16		16	16			
Other Air Force	Various	18	80	312	392	39	4	349	
SMC	Los Angeles AFB, CA	6	1	20	21	21			
USAFA	Colorado Springs, CO	2	4	4	8	8			
TOTAL		**208**	**463**	**924**	**1,387**	**796**	**18**	**557**	**16**

Army – HPC Users by Organization, Location, Affiliation, and Functional Environment

Organization	Location	No. of Projects	Govt. Personnel	Contractors	Total Users	Real-Time Users	Non-Real-Time Users	Both	Other Users
AMCOM	Moffett Field, CA	4	7	16	23	23			
	Langley AFB, VA	1	3	4	7	7			
	Redstone Arsenal, AL	6	10	15	25	25			
AMSAA	Aberdeen Proving Ground, MD	1	12		12	12			
ARL	Aberdeen Proving Ground, MD	11	153	140	293	220		73	
	Adelphi, MD	1	36	19	55		55		
ARO	Research Triangle Park, NC	1		28	28	28			
ATC	Aberdeen Proving Ground, MD	5	59	35	94	74	20		
ATTC	Ft. Rucker, AL	1	1	3	4	4			
CECOM	Ft. Belvoir, VA	1	2	2	4	4			
CRTC	Delta Junction, AK	1	1		1		1		
ERDC	Hanover, NH	5	11	10	21	18		3	
	Vicksburg, MS	5	160	40	200	200			
MRMC	Frederick, MD	2	3	4	7	7			
NRDEC	Natick, MA	7	10	17	27	27			
RTTC	Redstone Arsenal, AL	13	19	56	75	51		19	5
SBCCOM	Aberdeen Proving Ground, MD	2	8	6	14	10		4	
SMDC	Huntsville, AL	19	35	199	234	88	58	88	
TACOM	Dover, NJ (ARDEC)	5	14	4	18	18			
	Warren, MI (TARDEC)	8	50	12	62	38	9	15	
USMA	West Point, NY	1	4		4	4			
WSMR	White Sands Missile Range, NM	12	20	25	45	15	7	23	
TOTAL		**112**	**618**	**635**	**1,253**	**873**	**150**	**225**	**5**

Navy – HPC Users by Organization, Location, Affiliation, and Functional Environment

Organization	Location	No. of Projects	Govt. Personnel	Contractors	Total Users	Real-Time Users	Non-Real-Time Users	Both	Other Users
NAWC	China Lake, CA	28	131	39	170	65	58	47	
	Patuxent River, MD	46	182	139	321	95	218	8	
NPS	Monterey, CA	7	24	4	28	28			
NRL	Monterey, CA	4	27	7	34	17		17	
	Stennis Space Center, MS	5	37	22	59	59			
	Washington, DC	67	137	87	224	220		4	
NSWC	Carderock, MD	10	53	3	56	54	2		
	Dahlgren, VA	13	20	25	45	45			
	Indian Head, MD	5	14	5	19	19			
	Panama City, FL	2	7	4	11	2	9		
NUWC	Newport, RI	18	37	5	42	42			
Other Navy	Various	10	1	46	47	47			
ONR	Arlington, VA	73	31	251	282	282			
SSCSD	San Diego, CA	21	38	31	69	50	4	15	
USNA	Annapolis, MD	2	3		3	3			
TOTAL		**311**	**742**	**668**	**1,410**	**1,028**	**291**	**91**	

DoD Agencies – HPC Users by Organization, Location, Affiliation, and Functional Environment

Organization	Location	No. of Projects	Govt. Personnel	Contractors	Total Users	Real-Time Users	Non-Real-Time Users	Both	Other Users
DARPA	Arlington, VA	3		6	6	6			
DOTE	Arlington, VA	2		2	2	2			
DTRA	Alexandria, VA	4	9	101	110				110
JNTF	Schriever AFB, CO	6	1	151	152	17	4	131	
TOTAL		**15**	**10**	**260**	**270**	**25**	**4**	**131**	**110**

APPENDIX B

Air Force – Correlation Between Computational Technology Areas and User Organizations (Projects:Users)

Organization	CTA										
	CSM	**CFD**	**CCM**	**CEA**	**CWO**	**SIP**	**FMS**	**EQM**	**CEN**	**IMT**	**Other**
AEDC	3:12	12:58		2:6		1:4				7:37	
AFAACE		2:11									
AFFTC	2:12	1:6								3:18	
AFIT	1:3	1:5	3:10	2:5	1:1	1:3			1:2		
AFOSR	1:1	18:69	9:32	2:9							3:6
AFRLDEK		3:11	1:4	5:31	1:2						
AFRLDEM						1:16					
AFRLIFR		3:10		1:3		15:130	3:30		1:1		2:9
AFRLMLW	4:38		4:23								
AFRLMNG	1:18										1:2
AFRLPRD		3:16	3:18								
AFRLPRW	3:14	11:48	1:1								
AFRLSNH		1:2							1:6		
AFRLSNW				3:42		3:13					
AFRLVAW	4:22	12:77	1:8	1:6							1:1
AFRLVSH		2:7			3:11						
AFWAC					4:20						
ASC	1:12	1:3									1:1
Other Air Force	1:3	2:4		2:16		2:2	6:32			5:335	
SMC	2:3	2:8		1:4							1:6
USAFA		1:6		1:2							
TOTAL	**23:138**	**75:341**	**22:96**	**20:124**	**9:34**	**23:168**	**9:62**	**0:0**	**3:9**	**15:390**	**9:25**

Army – Correlation Between Computational Technology Areas and User Organizations (Projects:Users)

Organization	CTA										
	CSM	**CFD**	**CCM**	**CEA**	**CWO**	**SIP**	**FMS**	**EQM**	**CEN**	**IMT**	**Other**
AMCOMA		4:23									
AMCOML		1:7									
AMCOMM		4:20		2:5							
AMSAA										1:12	
ARLAP	4:79	3:97	1:45	1:15						1:47	1:10
ARLMD				1:55							
ARO		1:28									
ATC										5:94	
ATTC						1:4					
CECOMB						1:4					
CRTC					1:1						
ERDCH	1:3			2:16	2:2						
ERDCV	3:67				1:23			1:110			
MRMC			2:7								
NRDEC	1:7	3:16	3:4								
RTTC	2:3	1:6		2:9		1:6				6:46	1:5
SBCCA			1:10			1:4					
SMDC		7:19		3:31		2:58	4:86			3:40	
TACOM	3:16	2:2									
TARDEC	4:27						2:11			2:24	
USMA		1:4									
WSMR		4:19		1:2						5:17	2:7
TOTAL	**18:202**	**31:241**	**7:66**	**12:133**	**4:26**	**6:76**	**6:97**	**1:110**	**0:0**	**23:280**	**4:22**

Navy – Correlation Between Computational Technology Areas and User Organizations (Projects:Users)

Organization	CTA										
	CSM	CFD	CCM	CEA	CWO	SIP	FMS	EQM	CEN	IMT	Other
NAWCC	3:13	3:16		3:9	1:1	6:31	1:5			11:95	
NAWCP	3:13	18:83		2:2			1:1			22:222	
NPS		1:6			6:22						
NRLDC	6:23	18:64	16:55	11:28	6:23	5:19		1:4	3:7	1:1	
NRLMR					4:34						
NRLSS		1:4		1:6	3:49						
NSWCC	5:29	4:25				1:2					
NSWCD	3:13	8:30		1:2			1:0				
NSWCI	2:8	2:9	1:2								
NSWCP		1:2					1:9				
NUWC	5:19	6:10		5:10		2:3					
Other Navy	1:5	6:36		3:6							
ONR	2:4	38:155	12:53	1:1	18:55				2:14		
SSCSD		1:5		3:7		13:39	1:5	1:6	1:3	1:4	
USNA			1:2		1:1						
TOTAL	**30:127**	**107:445**	**30:112**	**30:71**	**39:185**	**27:94**	**5:20**	**2:10**	**6:24**	**35:322**	**0:0**

DoD Agencies – Correlation Between Computational Technology Areas and User Organizations (Projects:Users)

Organization	CTA										
	CSM	CFD	CCM	CEA	CWO	SIP	FMS	EQM	CEN	IMT	Other
DARPA		3:6									
DOTE	1:1									1:1	
DTRA		3:79		1:31							
JNTF	1:1				1:6		3:141			1:4	
TOTAL	**2:2**	**6:85**	**0:0**	**1:31**	**1:6**	**0:0**	**3:141**	**0:0**	**0:0**	**2:5**	**0:0**

APPENDIX C
GLOSSARY

ACRONYMS

AEDC	Arnold Engineering Development Center
AFAAC	Air Force Air Armament Center
AFAACE	Air Force Air Armament Center at Eglin AFB, FL
AFB	Air Force Base
AFFTC	Air Force Flight Test Center
AFIT	Air Force Institute of Technology
AFOSR	Air Force Office of Scientific Research
AFRL	Air Force Research Laboratory
AFRLDE	Air Force Research Laboratory, Directed Energy
AFRLDEK	Air Force Research Laboratory, Directed Energy at Kirtland AFB, NM
AFRLDEM	Air Force, Directed Energy at Maui, HI
AFRLIF	Air Force Research Laboratory, Information
AFRLIFR	Air Force Research Laboratory, Information at Rome, NY
AFRLML	Air Force Research Laboratory, Materials/Manufacturing
AFRLMLW	Air Force Research Laboratory, Materials/Manufacturing at Wright-Patterson AFB, OH
AFRLMN	Air Force Research Laboratory, Munitions
AFRLMNG	Air Force Research Laboratory, Munitions at Eglin, AFB, FL
AFRLPR	Air Force Research Laboratory, Propulsions
AFRLPRD	Air Force Research Laboratory, Propulsions at Edwards AFB, CA
AFRLPRW	Air Force Research Laboratory, Propulsions at Wright-Patterson AFB, OH
AFRLSN	Air Force Research Laboratory, Sensors
AFRLSNH	Air Force Research Laboratory, Sensors at Hanscom AFB, MA
AFRLSNW	Air Force Research Laboratory, Sensors at Wright-Patterson AFB, OH
AFRLVA	Air Force Research Laboratory, Air Vehicles
AFRLVAW	Air Force Air Force Research Laboratory, Air Vehicles at Wright-Patterson AFB, OH
AFRLVS	Air Force Research Laboratory, Space Vehicles
AFRLVSH	Air Force Research Laboratory, Space Vehicles at Hanscom AFB, MA
AFWAC	Air Force Weather Agency Center
AMCOM	Army Aviation & Missile Command
AMCOMA	Army Aviation & Missile Command at Moffett Field, CA
AMCOML	Army Aviation & Missile Command, Langley, VA
AMCOMM	Army Aviation & Missile Command at Redstone Arsenal, AL
AMSAA	Army Materiel System Analysis Agency
ARDEC	Armament Research Development and Engineering Center

ARL	Army Research Laboratory
ARLAP	Army Research Laboratory at Aberdeen Proving Ground, MD
ARLMD	Army Research Laboratory at Adelphi, MD
ARO	Army Research Office
ASC	Aeronautical Systems Center
ATC	Air Training Command
ATTC	Aviation Technical Test Center
C3I	Command, Control, Communications, and Information
C4I	Command, Control, Communications, Computers, and Intelligence
CCM	Computational Chemistry and Materials Science
CEA	Computational Electromagnetics and Acoustics
CECOM	U.S. Army Communication-Electronics Command
CECOMB	U.S. Army Communication-Electronics Command at Ft. Belvoir, VA
CEN	Computational Electronics and Nanoelectronics
CFD	Computational Fluid Dynamics
CRTC	Cold Regions Test Center
CSM	Computational Structural Mechanics
CTA	Computational Technology Area
CWO	Climate/Weather/Ocean Modeling and Simulation
DARPA	Defense Advanced Research Project Agency
DoD	Department of Defense
DOTE	Director of Test and Evaluation
DREN	Defense Research and Engineering Network
DT&E	Developmental Test and Evaluation
DTRA	Defense Threat Reduction Agency
EQM	Environmental Quality Modeling and Simulation
ERDC	Engineer Research and Development Center
ERDCH	Engineer Research and Development Center at Hanover, NH
ERDCV	Engineer Research and Development Center, at Vicksburg, MS
ESC	Electronic Systems Center
FMS	Forces Modeling and Simulation/C4I
FY	Fiscal year
GB	gigabytes
GF	gigaflops
GF-hrs	gigaflops-hours
GF-yr	gigaflops-year
HPC	High performance computing
HPCMO	High Performance Computing Modernization Office
HPCMP	High Performance Computing Modernization Program

I/O	Input/Output
IBM	International Business Machines
IMT	Integrated Modeling and Test Environments
JNTF	Joint National Test Facility
MB	megabytes
MPI	Message passing interface
MRMC	Medical Research and Materiel Command
NAWC	Naval Air Warfare Center
NAWCC	Naval Air Warfare Center at China Lake, CA
NAWCP	Naval Air Warfare Center at Patuxent River, MD
NPS	Naval Postgraduate School
NRDEC	Natick Research, Development, and Engineering Center
NRL	Naval Research Laboratory
NRLDC	Naval Research Laboratory at Washington, DC
NRLMR	Naval Research Laboratory at Monterey, CA
NRLSS	Naval Research Laboratory at Stennis Space Center, MS
NRTC	Non-real-time computing
NSWC	Naval Surface Warfare Center
NSWCC	Naval Surface Warfare Center at Carderock, MD
NSWCD	Naval Surface Warfare Center at Dahlgren, VA
NSWCI	Naval Surface Warfare Center at Indian Head, MD
NSWCP	Naval Surface Warfare Center at Panama City, FL
NUWC	Naval Undersea Warfare Center
ONR	Office of Naval Research
RTC	Real-time computing
RTTC	Redstone Technical Test Center
S&T	Science and technology
S/AAA	Service/Agency Approval Authority
SBCCOM	Soldier and Biological Chemical Command
SGI	Silicon Graphics, Inc.
SIP	Signal/Image Processing
SMC	Space Missile Systems Center
SMDC	Space Missile Defense Command
SSCSD	Space and Naval Warfare Systems Center, San Diego, CA
T&E	Test and evaluation
TACOM	Tank-Automotive Command
TARDEC	Tank-Automotive Research, Development, and Engineering Center
USAFA	U.S. Air Force Academy
USMA	U.S. Military Academy

USNA	U.S. Naval Academy
WSMR	White Sands Missile Range

APPENDIX D

HPC Thresholds

An HPC project is defined as a project that meets at least one of the following thresholds:

- A system speed requirement of 10 gigaflops (GF)
- An integrated overall computational requirement of 10,000 gigaflops-hours (GF-hrs) over a year
- A memory requirement of 2 gigabytes (GB)
- An on-line storage requirement of 20 GB
- An archival storage requirement of 100 GB

In addition, a project must have an integrated overall computational requirement of at least one gigaflop-hour even if it meets one of the other four requirements. These thresholds for an HPC project are raised annually based on the advancement of desktop technology.