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Report to the Chairman, Subcommittee on International Security, Proliferation, and Federal Services, Committee on Governmental Affairs, U.S. Senate

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EXPORT CONTROLS

Information on the Decision to Revise High Performance Computer Controls

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The Honorable Thad Cochran
Chairman, Subcommittee on International Security,
Proliferation, and Federal Services
Committee on Governmental Affairs
United States Senate

Dear Mr. Chairman:

In January 1996, the executive branch revised controls on the export of U.S.-manufactured high performance computers (HPC) by raising thresholds of computer performance for which exporters must obtain a license. Subsequently, several unlicensed HPCs were exported to both China and Russia, including 17 computers illegally sent to a Russian nuclear weapons lab. You expressed concerns that U.S. national security interests may have been compromised by such sales[1] and requested that we (1) assess the basis for the executive branch's revision of HPC export controls and (2) identify changes in licensing activities and the implementation of certain U.S. licensing and export enforcement requirements since the revision. You also asked us to determine the current foreign availability of HPCs, particularly for certain countries of national security concern.

We are also issuing a related report entitled, Export Controls: National Security Issues and Foreign Availability for High Performance Computers (GAO/NSIAD-98-200, Sept. 16, 1998), pursuant to section 1214 of the Fiscal Year 1998 National Defense Authorization Act (P.L. 105-85).

Background

The U.S. export control system is about managing risk; exports to some countries involve less risk than to other countries and exports of some items involve less risk than others. Under U.S. law, the President has the authority to control and require licenses for the export of items that may pose a national security or foreign policy concern. The President also has the authority to remove or revise those controls as U.S. concerns and

[1]The circumstances surrounding these specific exports are being investigated by the U.S. Departments of Justice and Commerce and the Customs Service. On July 31, 1998, the Department of Justice announced that IBM East Europe/Asia Ltd. entered a guilty plea and received the maximum allowable fine of $8.5 million for violating 17 counts of U.S. export laws.

interests change.[2] In doing so, the President is not required under U.S. law to conduct a foreign availability analysis.

In 1995, as a continuation of changes begun in the 1980s, the executive branch reviewed export controls on computer exports to determine how changes in computer technology and its military applications should affect U.S. export control regulations. In announcing its January 1996 change to HPC controls, the executive branch stated that one goal of the revised export controls was to permit the government to tailor control levels and licensing conditions to the national security or proliferation risk posed at a specific destination.

A key element of the executive branch review of HPC export controls was a Stanford University study, jointly commissioned by the Commerce and Defense Departments.[3] Among other things, the study was tasked to provide an assessment of the availability of HPCs in selected countries and the capabilities of those countries to use HPCs for military and other national security applications. The study concluded that (1) U.S.-manufactured computer technology between 4,000 and 5,000 millions of theoretical operations per second (MTOPS)[4] was widely available and uncontrollable worldwide, (2) U.S.-manufactured computer technology up to 7,000 MTOPS would become widely available and uncontrollable worldwide by 1997, and (3) many HPC applications used in U.S. national security programs occur at about 7,000 MTOPS and at or above 10,000 MTOPS. The study also concluded that it would be too expensive for government and industry to effectively control the international diffusion of computing systems with performance below 7,000 MTOPS, and that attempts to control computer exports below this level would become increasingly ineffectual, would harm the credibility of export controls, and would unreasonably burden a vital sector of the computer industry. The

[2]In this report, revision of export controls refers to removal of licensing requirements for groups of countries based on the performance levels of HPCs.

[3]Building on the Basics: An Examination of High-Performance Computing Export Control Policy in the 1990's, Seymour Goodman, Peter Wolcott, and Grey Burkhart (Center for International Security and Arms Control, Stanford University, November 1995).

[4]MTOPS is the composite theoretical performance of a computer measured in millions of theoretical operations per second. In principle, higher MTOPS indicates greater raw performance of a computer to solve computations quickly, but not the actual performance of a given machine for a given application.

study also raised concerns about the ability to control HPC exports in the future in light of advances in computing technology.[5]

The export control policy implemented in January 1996 removed license requirements for most HPC exports with performance levels up to 2,000 MTOPS—an increase from the previous level of 1,500 MTOPS. The policy also organized countries into four "computer tiers," with each tier after tier 1 representing a successively higher level of concern to U.S. security interests. The policy placed no license requirements on tier 1 countries, primarily those in Western Europe and Japan. Exports of HPCs above 10,000 MTOPS to tier 2 countries in Asia, Africa, Latin America, and Central and Eastern Europe would continue to require licenses. A dual-control system was established for tier 3 countries, such as Russia and China. For these countries, HPCs up to 7,000 MTOPS could be exported to civilian end users without a license, while exports at and above 2,000 MTOPS to end users of concern for military or proliferation of weapons of mass destruction reasons required a license. Exports of HPCs above 7,000 MTOPS to civilian end users also required a license. HPC exports to terrorist countries in tier 4 were essentially prohibited. (See appendix II for details on the four-tier system of export controls.)

The January 1996 regulation also made other changes. It specified that exporters would be responsible for (1) determining whether an export license is required, based on the MTOPS level of the computer; (2) screening end users and end uses for military or proliferation concerns;[6] and (3) keeping records and reporting on exports of computers with performance levels of 2,000 MTOPS. In addition to the standard record-keeping requirements, the regulation added requirements for the date of the shipment, the name and address of the end user and of each intermediate consignee, and the end use of each exported computer. The Fiscal Year 1998 National Defense Authorization Act (P.L. 105-85) modified the policy for determining whether an individual license is required and now requires exporters to notify the Commerce Department of any planned sales of computers with performance levels

[5]In April 1998, authors of the 1995 Stanford study published a follow-on discussion paper, High-performance Computing, National Security Applications, and Export Control Policy at the Close of the 20th Century, as a contribution to the periodic review of HPC export controls. This paper noted (1) that rapid advances in computer technology were continuing but (2) that a proposed change in licensing procedure—to review each HPC at its highest attainable level, rather than its configuration at time of export—would remove the concern of HPCs being upgraded without the knowledge of exporters or the U.S. government. We did not evaluate the adequacy of the analysis and support of the second study.

[6]End-use screening is the process exporters follow to evaluate whether a transaction involves an unacceptable risk of use in, or diversion to, a proliferator or military end user.

greater than 2,000 MTOPS to tier 3 countries. The government has 10 days to assess and object to a proposed HPC sale. The law also now requires Commerce to perform post-shipment verifications (PSV) on all HPC exports with performance levels over 2,000 MTOPS to tier 3 countries.[7] The Commerce Department promulgated regulations implementing the law on February 3, 1998.

Results in Brief

The Stanford University study was a key element in the decision to revise HPC export controls. However, our analysis of the study showed that it had two significant limitations. First, the study lacked empirical evidence or analysis to support its conclusion that HPCs were uncontrollable based on (1) worldwide availability and (2) insufficient resources to control them. Second, the study did not assess the capabilities of countries of concern to use HPCs for military and other national security applications, as required by its tasking. The study's principal author said that U.S. government data was insufficient to make such an assessment, and the study recommended that better data be gathered so that such an analysis could be done in the future. In addition, the executive branch did not undertake a threat analysis of providing HPCs to countries of concern. Nonetheless, based on its undocumented view of the worldwide availability of computing power and on the technological advancements in this area, the executive branch raised the MTOPS thresholds for HPC export controls and established the four-tier control structure. Although the Stanford study had limitations, it made some observations regarding the potential to upgrade HPCs and the export control challenge this will present in the future. For example, it noted that the technological trend toward upgrading computer performance without vendor support or knowledge is reducing the effectiveness of U.S. export controls.

The 1996 revision to HPC export controls had three key consequences. First, the number of computer export licenses issued declined from 395 in fiscal year 1995 to 42 in 1997. Second, U.S. HPC exporters were charged with responsibilities previously conducted by the government. New U.S. HPC exporters' responsibilities included screening and reporting on the end use and end user of HPCs. In essence, the exporters had to decide whether a license was required since the decision is made on the basis of the end use, the end user, and the computer performance capability. This decision could be particularly difficult for exports to tier 3 countries, such as China, where identifying the distinction between a civilian and military end user

[7]PSVs are on-site visits, generally by U.S. government officials, to locations where goods are shipped.

can be difficult without information that is sometimes available only to the U.S. government. This situation was partly reversed by the Fiscal Year 1998 National Defense Authorization Act, which requires exporters to notify the Commerce Department of all HPC sales over 2,000 MTOPS to tier 3 countries prior to their export. Third, the regulation required HPC manufacturers to keep records of the end users of all their HPC exports over 2,000 MTOPS. To date, information on these exports reported to the government has been incomplete. Responsibility for PSV checks remained with the government. However, because of how PSVs for computers are implemented, their value is reduced because they verify the physical location of an HPC, but not how it is used. Also, some governments, such as China, have not allowed the United States to conduct them.

With regard to foreign availability of HPCs,[8] we found that subsidiaries of U.S. computer manufacturers dominate the overseas HPC market and they must comply with U.S. controls. Three Japanese companies are global competitors of U.S. manufacturers, two of which told us that they had no sales to tier 3 countries. The third company did not provide data on such sales in a format that was usable for our analysis. Two of the Japanese companies primarily compete with U.S. manufacturers for sales of high-end HPCs at about 20,000 MTOPS and above. Two other manufacturers, one in Germany and one in the United Kingdom, also compete with U.S. HPC suppliers, but primarily within Europe. Only the German company has sold HPCs to tier 3 countries. Japan, Germany, and the United Kingdom each have export controls on HPCs similar to those of the United States, according to foreign government officials. Russia, China, and India have developed HPCs, but the capabilities of their computers are believed to be limited. Thus, our analysis suggests that HPCs over 2,000 MTOPS are not readily available to tier 3 countries from foreign sources without restrictions.

Key Study Used as Basis for Changing HPC Controls Had Limitations

The Stanford study, used as a key element by the executive branch in its decision to revise HPC export controls, had significant limitations. It lacked empirical evidence or analysis regarding its conclusion that HPCs were uncontrollable and, although tasked with doing so, it did not assess the capabilities of countries of concern to use HPCs for military and other national security applications. The study itself identified as a major limitation, its inability to assess capabilities of countries of concern to use HPCs for their military programs or national security applications, on the basis that such information was not available, and recommended that such

[8]We used a description of foreign availability in the Export Administration Act (EAA) of 1979, as amended, as our criteria.

an assessment be done. The study noted that trends in HPC technology development could affect U.S. security and the ability to control HPC exports in the future and need to be further studied. Despite the study's limitations, the executive branch decided to relax HPC export controls.

The Stanford Study Lacked Evidence of HPC Uncontrollability

The Stanford study accumulated information from computer companies on U.S. HPC market characteristics and concluded—without empirical evidence or analysis—that computers between 4,000 and 5,000 MTOPS were already available worldwide and uncontrollable and that computers at about 7,000 MTOPS would be widely available and uncontrollable by 1997.[9] Using the findings from the Stanford study, executive branch officials set the computer performance control thresholds for each tier. However, these officials could not explain nor provide documentation as to how the executive branch arrived at the decision to set the license requirements for exports of HPCs to tier 3 countries for military or proliferation end users at 2,000 MTOPS, even though the study concluded that computing power below 4,000 or 5,000 MTOPS was already "uncontrollable."

The study identified the following six factors as affecting controllability of HPCs: computer power, ease of upgrading, physical size, numbers of units manufactured and sold, sources of sales (direct sales or through resellers), and the cost of entry level systems. It described uncontrollability as the relationship between the difficulty of controlling computers and the willingness of government and industry to meet the costs of tracking and controlling them. The study asserted that as U.S. HPCs were sold openly for 2 years, their export would become uncontrollable. Part of the study's rationale was that, as older HPCs are replaced by newer models 2 years after product introduction, original vendors may no longer have information on where replaced HPCs are relocated. The study also presumed a level of "leakage" of computers to countries of concern from U.S. HPC sources and asserted that costs of controlling such leakage were no longer tolerable. However, the study did not attempt to calculate or specify those costs. In addition, the study suggested only vague thresholds for these six factors to determine "uncontrollability." For example, it noted that the threshold at which it becomes difficult to track numbers of units could vary from 200 to several thousand. The study did not provide analysis or empirical evidence to support its assumptions or conclusions.

[9]The Commerce Department stated that Department of Defense (DOD) information, which showed that a number of significant military applications are run at performance levels above 7,000 MTOPS, also supported the Stanford study's conclusion that an HPC control threshold at this level could be justifiable.

National Security and Proliferation Risks of HPCs Not Assessed

Although the Stanford study was tasked with assessing the capabilities of countries of concern to use HPCs for military and other national security applications, it did not do so. The study discussed only U.S. applications of HPCs for military purposes. According to the study's principal author, data on other countries' use of HPCs for military and other national security purposes was insufficient to make such assessments because the U.S. government does not gather such data in a systematic fashion. The report recommended that such an analysis be done.

Despite the study's limitations and recommendations to gather better data in the future on other countries' use of HPCs for military and other national security purposes, the executive branch raised the MTOPS thresholds for HPC export controls and established the four-tier export control structure. The former Deputy Assistant Secretary of Defense for Counterproliferation Policy explained that because DOD was not tasked to conduct a threat assessment, it did not do so. Instead, the executive branch assessed countries on the basis of six criteria and assigned them to a particular tier. The six criteria were (1) evidence of on-going programs of national security concern, including proliferation of weapons of mass destruction with associated delivery systems and regional stability and conventional threats; (2) membership in or adherence to non-proliferation and export control regimes; (3) an effective export control system, including enforcement and compliance programs and an associated assessment of diversion risks; (4) overall relations with the United States; (5) whether U.N. sanctions had been imposed; and (6) prior licensing history.

Prior to the executive branch's decision to change computer thresholds, scientists at Department of Energy (DOE) national laboratories and other U.S. government officials had accumulated information to show how countries of concern could use HPCs to facilitate the design of nuclear weapons and to improve advanced nuclear weapons in the absence of tests of nuclear explosives. However, this information was not used as part of the decisionmaking process for revising HPC export controls, according to the Commerce Department. In December 1997 the House Committee on National Security directed the DOE and DOD to assess the national security impacts of exporting HPCs with performance levels between 2,000 and 7,000 MTOPS to tier 3 countries. In June 1998, 2 and 1/2 years after the executive branch revised HPC export controls, DOE concluded its study on how countries like China, India, and Pakistan can use HPCs to improve their nuclear programs.

According to the DOE study, the impact of HPC acquisition depends on the complexity of the weapon being developed and, even more importantly, on the availability of high-quality, relevant test data. The study concluded that "the acquisition and application of HPCs to nuclear weapons development would have the greatest potential impact on the Chinese nuclear program—particularly in the event of a ban on all nuclear weapons testing." Also, the study indicated that India and Pakistan may now be able to make better use of HPCs in the 1,000 to 4,000 MTOPS range for their nuclear weapons programs because of the testing data they acquired in May 1998 from underground detonations of nuclear devices. The potential contribution to the Russian nuclear program is less significant because of its robust nuclear testing experience, but HPCs can make a contribution to Russia's confidence in the reliability of its nuclear stockpile. An emerging nuclear state is likely to be able to produce only rudimentary nuclear weapons of comparatively simple designs, for which personal computers are adequate. We were told that DOD's study of national security impacts had not been completed as of September 1, 1998, in part because the Department had not received requested information from the Commerce Department until after July 1.

Advances in Computing Technology May Pose Long-Term Security Challenges

The Stanford study noted that trends in HPC technology development may pose security and export control challenges and recommended further study to determine their implications for national security and export controls.

The technology trends of concern include other countries' ability (1) to upgrade the performance of individual computers and (2) to link individual computers to achieve higher performance levels. The Stanford study team reviewed the computer industry's technological advances in parallel processing and concluded that such advances as "scalability" and "clustering" contributed to the uncontrollability of high performance computing worldwide and are inevitably reducing the effectiveness of U.S. export controls.[10] "Scalability" refers to the capability to increase computer performance levels of a system by adding processor boards or by acquiring increasingly powerful microprocessors. "Clustering" refers to connecting many personal computers or workstations to achieve higher computing performance in a network of interconnected systems, working cooperatively and concurrently on one or several tasks.

[10]Parallel processing means breaking computational problems into many separate parts and having a large number of processors tackle those parts simultaneously. Greatly increased processing speed is achieved largely through the sheer number of processors operating simultaneously, rather than through any exceptional power in each processor.

Scalability and clustering offer opportunities to increase computer power without the need to develop custom-built single processors traditionally used in HPCs. Some types of HPCs are designed today to allow scalability without the need for vendor support or even knowledge.[11] As a result, some HPCs could be exported below MTOPS thresholds without an individual license, and, in theory, later covertly scaled up to levels that exceed the threshold. We asked government agencies for information about diversions and violations of U.S. HPC export controls, but they provided no evidence that countries of concern have increased the computing power of U.S. exported machines in violation of export restrictions.

We found no U.S. government reviews of alternatives to address these security concerns, although authors of the Stanford study and others with whom we spoke identified various options that could be assessed. These include (1) requiring government review and consideration of machines at their highest scalable MTOPS performance levels and (2) requiring that HPCs exported to tier 3 countries be physically modified to prevent upgrades beyond the allowed levels.

Changes in U.S. Licensing and Export Enforcement Since the Revision

The executive branch's January 1996 export control revision (1) increased thresholds for requiring licenses, which resulted in a reduction in the numbers of licensed HPCs; (2) shifted some of the government's end-use screening responsibility from the government to the computer industry, until this policy was revised in 1998; and (3) required HPC manufacturers to keep records of the end users of their HPC exports. The government continued to have responsibility for post-shipment verifications for HPCs, which have reduced value as traditionally conducted.

License Applications Have Decreased Since Revision

Since the export controls for computers were revised in 1996, HPC export license applications have declined from 459 applications in fiscal year 1995 to 125 applications in fiscal year 1997. In fiscal year 1995, the Commerce Department approved 395 license applications for HPC exports, and denied 1. In fiscal year 1997, Commerce approved 42 license applications for HPC exports, and denied 6. The remainder of the applications in each year were withdrawn without action. Changes in the numbers of both licensed and unlicensed exports might not be attributed entirely to the change in export controls. However, we did note some characteristics of U.S. HPC exports

[11]Many HPC designs use commercial, off-the-shelf processors, such as those found in personal computers or scientific workstations, and may include hundreds or even thousands of processors.

since the revision. For example, while HPC exports increased to each tier from January 1996 through September 1997, 72 percent of machines were sold to tier 1 countries. Also during this period, 77 HPCs were exported to China and 19 were exported to India, all without individual licenses. Most U.S. HPCs exported in this period (about 85 percent) had performance levels between 2,000 and 5,000 MTOPS. (See appendix III for details on HPC exports.)

End-Use Screening Responsibility Shifted to Computer Industry

The executive branch shifted some government oversight responsibility to the computer industry, especially for tier 3 countries. Exporters became responsible for determining whether exports required a license by screening end users and end uses for military or proliferation concerns (end-use screening).[12] However, some industry and government officials concluded that the computer industry lacked the necessary information to distinguish between military and civilian end users in some tier 3 countries—particularly China.

Because of concerns about U.S. HPCs being obtained by countries of proliferation concern for possible use in weapons-related activities, the Congress enacted a provision in Public Law 105-85 that required exporters to notify the Commerce Department of all proposed HPC sales over 2,000 MTOPS to tier 3 countries. The law gives the government an opportunity to assess these exports within 10 days to determine the need for a license and it can use information that may not be available to the exporter.

U.S. Companies' Records on Resales of HPCs Are Incomplete

Pursuant to the Export Administration Regulations, exporters are required to keep accurate records of each licensed and unlicensed export of a computer over 2,000 MTOPS to any destination. These records are to include names and addresses of each end user and each "intermediate consignee" (resellers or distributors). Exporters must also provide quarterly reports to Commerce on license-exempt exports—almost 96 percent of the total HPC exports in the past 2 years.

The government relies on the exporters' data for end-use information, but we found that companies had reported inconsistent and incomplete data

[12]To aid exporters in making end user determinations, Commerce created specific guidance to educate exporters about signs they need to be aware of that can be of concern to the government. Companies also were urged to contact the Commerce Department when in doubt about an end user's activities. According to Commerce, the end user could then be researched by the government and the exporter advised to seek a license if any strategic concerns were present.

for intermediate consignees (resellers or distributors) as end users. For example, one company reported data for only one intermediate consignee, even though company officials told us that the company uses multiple resellers. Company officials noted that the company sells computers to companies in other countries, which then sell the computers to other, unknown end users. A second company provided "end-use statements" from its resellers, rather than the actual end users, and identified computers' end use for several overseas sales as "resale." In contrast, a third company shows its resellers as resellers, rather than as end users. Company officials said that the company contractually requires its resellers to identify and provide end-use statements from the ultimate end-users.

Safeguards Procedures for Verifying the End Use of HPCs Are Limited

The revision of HPC export controls did not reduce the government's responsibility for certain safeguards procedures, notably conducting PSVs. Under current law, Commerce is required to conduct PSVs for all HPC exports over 2,000 MTOPS to tier 3 countries. While PSVs are important for detecting and deterring physical diversions of HPCs, PSVs, as traditionally conducted, do not verify computer end use. Also, some countries do not allow the United States to conduct them. China, for example, had not allowed PSVs,[13] but in June 1998, it reportedly agreed to do so.

U.S. government officials agreed that the way PSVs of computers have been traditionally conducted have reduced their value because such PSVs establish only the physical presence of an HPC. However, this step assures the U.S. government that the computer has not been physically diverted. According to DOE laboratory officials, it is easy to conceal how a computer is being used. They believed that the U.S. government officials performing the verifications cannot make such a determination, partly because they have received no computer-specific training. Although it is possible to verify how an HPC is being used through such actions as reviewing internal computer data, this would be costly and intrusive, and require experts' sophisticated computer analysis.

Another limitation of PSVs concerns sovereignty issues. Host governments in some countries of greatest concern, notably China, have precluded or restricted the U.S. government's ability to conduct PSVs. Three European countries that we visited—United Kingdom, Germany, and France—also

[13]In the last 3 calendar years, U.S embassy officials conducted 20 PSVs of digital computers. In addition, during 1997, Commerce officials on special teams from headquarters also conducted 19 visits to HPC locations.

do not allow U.S. government officials to do PSVs. However, they perform the checks themselves and provide the results to the U.S. government.

The government makes limited efforts to monitor exporters' and end users' compliance with explicit conditions attached to export licenses. It relies largely on HPC exporters for end use monitoring and may require them or the end users to safeguard the exports by limiting access to the computers or inspecting computer logs and outputs. The end user may also be required to agree to on-site inspections, even on short notice, by U.S. government or exporting company officials, who would review programs and software used on the computer, or to remote electronic monitoring of the computer. Commerce officials stated that they may have reviewed computer logs in the past, but do not do so anymore, and said that they have not conducted any short notice visits, and that they do not do remote monitoring. They said that, ultimately, monitoring safeguards plans is the exporter's responsibility.

Current Foreign Availability of HPCs

As requested, we evaluated the current foreign availability of HPCs. Using the EAA's general description of foreign availability as our criteria, our analysis showed that subsidiaries of U.S. companies dominate the overseas sales of HPCs. These companies primarily compete against one another with limited competition from foreign suppliers in Japan and Germany. We also obtained information on the capability of certain tier 3 countries to build their own HPCs and found it to be limited in the capability to produce machines in comparable quantity, quality, and power as the major HPC-supplier countries.

The EAA describes foreign availability as goods or technology available without restriction to controlled destinations from sources outside the United States in sufficient quantities and comparable quality to those produced in the United States so as to render the controls ineffective in achieving their purposes. We found that the only global competitors for general computer technology are three Japanese companies, two of which compete primarily for sales of high-end computers—systems sold in small volumes and performing at advanced levels. Two of the companies reported no HPC exports to tier 3 countries, while the third company reported some exports on a regional, rather than country, basis. One German company sells HPCs primarily in Europe and has reported several sales of its HPCs over 2,000 MTOPS to tier 3 countries. One British company said it is capable of producing HPCs above 2,000 MTOPS, but company officials said it has never sold a system outside the European Union.

A 1995 Commerce Department study of the HPC global market showed that American dominance had prevailed at that time, as well. The study observed that American HPC manufacturers controlled the market worldwide, followed by Japanese companies. It also found that European companies controlled about 30 percent of the European market and were not competitive outside Europe.

The other countries that are HPC suppliers to countries outside Europe also restrict their exports. The United States and Japan since 1984 have been parties to a bilateral arrangement, referred to as the "Supercomputer Regime," to coordinate their export controls on HPCs. Also, both Japan[14] and Germany, like the United States, are signatories to the Wassenaar Arrangement, which has membership criteria of adherence to non-proliferation regimes and effective export controls.[15] Each country also has national regulations that generally appear to afford levels of protection similar to U.S. regulations for their own and for U.S.-licensed HPCs. For example, both countries place export controls on sales of computers over 2,000 MTOPS to specified destinations, according to German and Japanese government officials. However, foreign government officials said that they do not enforce U.S. reexport controls on unlicensed U.S. HPCs. In fact, a study of German export controls noted that regulatory provisions specify that Germany has no special provisions on reexport of U.S.-origin goods. According to German government officials, the exporter is responsible for knowing the reexport requirements of the HPC's country of origin. We could not ascertain whether improper reexports of HPCs occurred from tier 1 countries.

Because some U.S. government and HPC industry officials consider indigenous capability to build HPCs a form of foreign availability, we examined such capabilities for tier 3 countries. Available information indicates that the capabilities of China, India, and Russia to build their own HPCs still lag well behind that of the United States, Japan, and European countries. Although details are not well-known about HPC developments in each of these tier 3 countries, most officials and studies showed that each country still produces machines in small quantities and of lower quality and power compared to U.S., Japanese, and European computers. For example,

[14]We also obtained information from the Japanese government and HPC vendors. We identified controls in force, but did not assess their implementation.

[15]The 1996 Wassenaar Arrangement of Export Controls for Conventional Arms and Dual-Use Goods and Technologies is an arrangement to exchange export information between 33 states with the purpose of contributing to regional and international security by enhancing cooperation among export control systems and international regimes.

- China has produced at least two different types of HPCs, called the Galaxy and Dawning series, based on U.S. technology and they are believed to have a performance level of about 2,500 MTOPS. Although China has announced its latest Galaxy at 13,000 MTOPS, U.S. government officials have no confirmation of this report.
- India has produced a series of computers called Param, which are based on U.S. microprocessors and are believed by U.S. DOE officials to be rated at about 2,000 MTOPS. These officials were denied access to test the computer's performance.
- Russia's efforts over the past three decades to develop commercially viable HPCs have used both indigenously-developed and U.S. microprocessors, but have suffered from economic problems and a lack of customers. According to one DOE official, Russia has never built a computer running better than 2,000 MTOPS, and various observers believe Russia to be 3 to 10 years behind the West in developing computers.

Conclusions

A key element in the 1996 decision to revise HPC export controls was the findings of the Stanford study which did not have adequate analyses of critical issues. In particular, the study used to justify the decision did not assemble empirical data or analysis to support the conclusion that HPCs below specific performance levels were uncontrollable and widely available worldwide. Moreover, the study did not analyze the capabilities of countries of concern to use HPCs to further their military programs or engage in nuclear proliferation, but rather recommended that such data be gathered and such analysis be made. Despite the limitations of the study, the executive branch revised the HPC export controls. Since the executive branch's stated goals for the revised HPC export controls included tailoring control levels to security and proliferation risks of specific destinations, it becomes a vital factor to determine how and at what performance levels specific countries would use HPCs for military and other national security applications and how such uses would threaten U.S. national security interests in specific areas. In addition, the Stanford study identified trends in HPC technology development which may pose security and export control challenges for national security and export controls. Some alternatives to address these security challenges have been identified by authors of the Stanford study and others with whom we spoke, and could be assessed.

Recommendations

To complement the studies undertaken by DOD and DOE for the House Committee on National Security, we recommend that the Secretary of

Defense assess and report on the national security threat and proliferation impact of U.S. exports of HPCs to countries of national security and proliferation concern. This assessment, at a minimum, should address (1) how and at what performance levels countries of concern use HPCs for military modernization and proliferation activities; (2) the threat of such uses to U.S. national security interests; and (3) the extent to which such HPCs are controllable.

We also recommend that the Secretary of Commerce, with the support of the Secretaries of Defense, Energy, and State, and the Director of the U.S. Arms Control and Disarmament Agency, jointly evaluate and report on options to safeguard U.S. national security interests regarding HPCs. Such options should include, but not be limited to, (1) requiring government review and control of the export of computers at their highest scalable MTOPS performance levels and (2) requiring that HPCs destined for tier 3 countries be physically modified to prevent upgrades beyond the allowed levels.

Agency Comments and Our Evaluation

Commerce and DOD each provided one set of general written comments on a draft of this and a companion report[16] and the Departments of State and Energy and the Arms Control and Disarmament Agency provided oral comments. Commerce, Defense, and State raised issues about various matters discussed in the report. The Department of Energy had no comments on the report but said it deferred to Commerce and Defense to comment on the Stanford study. The Arms Control and Disarmament Agency agreed with the substance of the report. Commerce, State, Energy, and the Arms Control and Disarmament Agency did not comment on our recommendations, but Defense did. Defense said that our recommendation concerning the assessment of national security threats and proliferation impact of U.S. exports to countries of concern was done in connection with the 1995 decision to revise HPC export controls, and that it would consider additional options to safeguard exports of HPCs as part of its ongoing review of export controls. As noted below, we believe the question of how countries of concern could use HPCs to further their military and nuclear programs was not addressed as part of the executive branch's 1995 decision.

Commerce commented that the President's decision was intended to change the computer export policy from what it referred to as "a relic of

[16]Export Controls: National Security Issues and Foreign Availability for High Performance Computer Exports (GAO/NSIAD-98-200, September 1998)

the Cold War to one more in tune with today's technology and international security environment." Commerce said the decision was based on (1) rapid technological changes in the computer industry, (2) wide availability, (3) limited controllability, and (4) limited national security applications for HPCs. Commerce provided additional views about each of these factors. Commerce commented that our report focused on how countries might use HPCs for proliferation or military purposes and on what it called an outdated Cold War concept of "foreign availability," rather than these factors.

Our report specifically addresses the four factors Commerce said it considered in 1995. These four factors are considered in the Stanford University study upon which the executive branch heavily relied in making its decision to revise HPC export controls. Our report agreed with the study's treatment of technological changes in the computing industry and that advances in computing technology may pose long-term security and controllability challenges.

Commerce commented that our analysis of foreign availability as an element of the controllability of HPCs was too narrow, stating that foreign availability is not an adequate measure of the problem. Commerce stated that this "Cold War concept" makes little sense today, given the permeability and increased globalization of markets. We agree that rapid technological advancements in the computer industry have made the controllability of HPC exports a more difficult problem; however, we disagree that foreign availability is an outdated Cold War concept that has no relevance in today's environment. While threats to U.S. security may have changed, they have not been eliminated. Commerce itself recognized this in its March 1998 annual report to the Congress which stated that "the key to effective export controls is setting control levels above foreign availability." Moreover, the concept of foreign availability, as opposed to Commerce's notion of "worldwide" availability, is still described in EAA and the Export Administration Regulations as a factor to be considered in export control policy.

Commerce also commented that the need to control the export of HPCs because of their importance for national security applications is limited. It stated that many national security applications can be performed satisfactorily on uncontrollable low-level technology, and that computers are not a "choke point" for military production. Commerce said that having access to HPCs alone will not improve a country's military-industrial capabilities. Commerce asserted that the 1995 decision was based on

research leading to the conclusion that computing power is a secondary consideration for many applications of national security concern. We asked Commerce for its research evidence, but none was forthcoming. The only evidence that Commerce cited was contained in the Stanford study.

Moreover, Commerce's position on this matter is not consistent with that of DOD. DOD, in its Militarily Critical Technologies List,[17] has determined that high performance computing is an enabling technology for modern tactical and strategic warfare and is also important in the development, deployment, and use of weapons of mass destruction. High performance computing has also played a major role in the ability of the United States to maintain and increase the technological superiority of its war-fighting support systems. DOD has noted in its High Performance Computing Modernization Program[18] annual plan that the use of HPC technology has led to lower costs for system deployment and improved the effectiveness of complex weapons systems. DOD further stated that as it transitions its weapons system design and test process to rely more heavily on modeling and simulation, the nation can expect many more examples of the profound effects that the HPC capability has on both military and civilian applications. Furthermore, we note that the concept of "choke point" is not a standard established in U.S. law or regulation for reviewing dual-use exports to sensitive end users for proliferation reasons.

In its comments, DOD said that the Stanford study was just one of many sources of information and analysis used in the 1996 executive branch decision. We reviewed all of the four sources of information identified to us by DOD, DOE, State, Commerce, and Arms Control and Disarmament Agency (ACDA) officials as contributing to their assessment of computer export controls. However, the Stanford study was a key analytical study used in the decision-making process and the only source whose findings were consistently and repeatedly cited by the executive branch in official announcements, briefings, congressional testimony, and discussions with us in support of the HPC export control revision.

[17]The Militarily Critical Technologies List, required by EAA, is a compendium of the technologies DOD assesses as critical to maintaining superior U.S. military capabilities. According to DOD, it should be used as a reference for evaluating potential technology transfers and to determine if the proposed transaction would permit potential adversaries access to technologies with specific performance levels at or above the characteristics identified as militarily critical.

[18]The High Performance Computing Modernization Program is the major force designed to improve DOD's ability to exploit the computation necessary to sustain technological superiority on the battlefield. Managed by the Director, Defense Research and Engineering, the program is intended to establish a nationwide integrated infrastructure to support the defense research, development, test, and evaluation communities.

In its comments, DOD stated that our report inaccurately characterized DOD as not considering the threats associated with HPC exports. DOD said that in 1995 it "considered" the security risks associated with the export of HPCs to countries of national security and proliferation concern. What our report actually states is that (1) the Stanford study did not assess the capabilities of countries of concern to use HPCs for military and other national security applications, as required by its tasking and (2) the executive branch did not undertake a threat analysis of providing HPCs to countries of concern. DOD provided no new documentation to demonstrate how it "considered" these risks. As the principal author of the Stanford study and DOD officials stated during our review, no threat assessment or assessment of the national security impact of allowing HPCs to go to particular countries of concern and of what military advantages such countries could achieve had been done in 1995. In fact, the April 1998 Stanford study on HPC export controls by the same principal author also noted that identifying which countries could use HPCs to pursue which military applications remained a critical issue on which the executive branch provided little information.

In its comments, the Department of State disagreed with our presenting combined data on HPC exports to China and Hong Kong in appendix III because the U.S.-Hong Kong Policy Act of 1992 calls for the U.S. government to treat Hong Kong as a separate territory regarding economic and trade matters. While, in principle, we do not disagree with State, it should be noted that we reported in May 1997 that given the decision to continue current U.S. policy toward Hong Kong, monitoring various indicators of Hong Kong's continued autonomy in export controls becomes critical to assessing the risk to U.S. nonproliferation interests.[19] Our presentation of the combined HPC export data for China and Hong Kong is intended to help illustrate a potential risk to U.S. nonproliferation interests regarding HPCs should Hong Kong's continued autonomy in export controls be weakened. We believe that monitoring data on HPC exports to Hong Kong becomes all the more important since Hong Kong is treated as a tier 2 country, whereas China is a tier 3 country.

Commerce also provided technical comments which we have incorporated as appropriate. Commerce and DOD written comments are reprinted in appendixes IV and V, respectively, along with our evaluation of them.

[19]Hong Kong's Reversion To China: Effective Monitoring Critical to Assess U.S. Nonproliferation Risks (GAO/NSIAD-97-149, May 1997).

ACDA provided oral comments on this report and generally agreed with it. However, it disagreed with the statement that "according to the Commerce Department, the key to effective export controls is setting control levels above the level of foreign availability of materials of concern." ACDA stressed that this is Commerce's position only and not the view of the entire executive branch. ACDA said that in its view (1) it is difficult to determine the foreign availability of HPCs and (2) the United States helps create foreign availability through the transfer of computers and computer parts.

Our scope and methodology are in appendix I. Appendix II contains details on the four-tier system of export controls and appendix III shows characteristics of HPC exports since the revision.

We conducted our review between August 1997 and June 1998 in accordance with generally accepted government auditing standards.

We will provide copies of this report to other congressional committees; the Secretaries of Commerce, Defense, Energy, and State; the Director, U.S. Arms Control and Disarmament Agency; and the Director, Office of Management and Budget. Copies will be provided to others upon request.

Please contact me on (202) 512-4128 if you or your staff have any questions concerning this report. Major contributors to this report are listed in appendix IV.

Sincerely yours,

Harold J. Johnson, Associate Director
International Relations and Trade Issues

Contents

Tables

Figures

Abbreviations

ACDA	Arms Control and Disarmament Agency
DOD	Department of Defense
DOE	Department of Energy
EAA	Export Administration Act
HPC	high performance computer
MTOPS	millions theoretical operations per second
PSV	post-shipment verification

Scope and Methodology

To assess the basis for the U.S. government's 1996 decision to change HPC controls, we reviewed a 1995 Stanford University study on high performance computing and export control policy commissioned by the Commerce and Defense Departments and evaluated the executive branch's assessment of national security risks of HPCs. We reviewed several classified charts and briefing slides prepared by the intelligence community and DOD that were identified as important support for the revision of controls. We also talked with the Stanford study's principal authors to discuss their methodology, evidence, conclusions, and recommendations. In addition, we met with the Department of Defense (DOD), the Department of Energy (DOE), State and Commerce Department officials to discuss the interagency process used leading up to the decision to revise controls on HPCs. We also requested, but were denied access to, information from the National Security Council on data and analyses that were used in the interagency forum to reach the final decision to revise controls.

To determine how the government assessed the national security risks of allowing the high performance computers (HPC) to be provided to countries of proliferation and military concern as part of the basis for the decision to revise the controls, we reviewed DOD and DOE documents on how HPCs are being used for nuclear and military applications. We discussed high performance computing for both U.S. and foreign nuclear weapons programs with DOE officials in Washington, D.C., and at the Lawrence Livermore, Los Alamos, and Sandia National Laboratories. We also met with officials of the DOD HPC Modernization Office and other officials within the Under Secretary of Defense Acquisition and Technology, Office of the Secretary of Defense, the Joint Chiefs of Staff, and the intelligence community to discuss how HPCs are being utilized for weapons design, testing and evaluation and other military applications. Furthermore, to understand the trends occurring in computer technology, we analyzed HPC model descriptions and technical means for increasing computing performance.

To identify changes in licensing activities and the implementation of certain U.S. licensing and export enforcement requirements since the revision:

- We reviewed two sets of data from the Commerce Department, as noted above, in order to determine trends in American HPC exports since the 1996 revision of controls. We examined all U.S. high performance computer-related license applications worldwide. We analyzed the data for

trends and changes in MTOPS levels of HPC exports before and after revision of controls, numbers of licenses approved, denied, and withdrawn without action, and HPC exports by countries and country tiers. We did not review the data for completeness, accuracy, and consistency.

- We reviewed the end user and end-use screening systems of major American HPC manufacturers, Commerce Department implementation of the revised regulations, and selected foreign government export controls in order to determine licensing changes affecting U.S. HPC exporters since the revision of controls. We also reviewed applicable U.S. laws and regulations governing HPC export licensing and enforcement and discussed these laws and regulations with Commerce Department officials. We obtained Commerce Department procedures on end use and end user determinations as well as records on HPC vendor inquiries to Commerce on end users. In addition, we reviewed information on intelligence community assessments of foreign end users receiving HPC exports. We also discussed end user and end use screening procedures with officials from major U.S. HPC manufacturers—Digital Equipment Corporation, Hewlett Packard/Convex, International Business Machines, and Sun Microsystems—at their corporate offices in the United States and sales offices overseas. We also visited representatives of these companies' foreign subsidiary offices from China, Germany, Russia, Singapore, South Korea, and the United Kingdom to review end use screening procedures and documentation for selected exports. In addition, we visited selected HPC sites in China and Russia. However, the Chinese government refused us permission to visit one of three requested sites in Beijing. The Russian government, while not denying us permission to visit one site in-country, required an extended period of notification that went beyond our timeframes. Silicon Graphics, Inc./Cray refused to meet with us pending the outcome of an ongoing criminal investigation.
- We reviewed Commerce Department data on pre-license and post-shipment verification (PSV) checks on HPCs and related technology and safeguards security plans associated with HPC export licenses in order to examine affects of licensing changes on government oversight. We discussed the implementation and utility of these checks with officials of the U.S. government, American computer companies, and host governments in the countries we visited.

To determine foreign availability of HPCs, we reviewed the Export Administration Act (EAA) and Export Administration Regulations for criteria and a description of the meaning of the term. We then reviewed market research data from an independent computer research organization. We also reviewed lists, brochures, and marketing

information from major U.S. and foreign HPC manufacturers in France (Bull, SA), Germany (Siemens Nixdorf Informationssysteme AG and Parsytec Computer GmbH), and the United Kingdom (Quadrics Supercomputers World, Limited) and met with them to discuss their existing and projected product lines. We also obtained market data, as available, from three Japanese HPC manufacturers. Furthermore, we met with government officials in China, France, Germany, Singapore, South Korea, and the United Kingdom to discuss each country's indigenous capability to produce HPCs. We also obtained information from the Japanese government on its export control policies. In addition, we obtained and analyzed from two Commerce Department databases (1) worldwide export licensing application data for fiscal years 1994-97 and (2) export data from computer exporters provided to the Department for all American HPC exports between January 1996 and October 1997. We also reviewed a 1995 Commerce Department study on the worldwide computer market to identify foreign competition in the HPC market prior to the export control revision.[1] To identify similarities and differences between U.S. and foreign government HPC export controls, we discussed with officials of the U.S. embassies and host governments information on foreign government export controls for HPCs and the extent of cooperation between U.S. and host government authorities on investigations of export control violations and any HPC diversions of HPCs to sensitive end users. We also reviewed foreign government regulations, where available, and both foreign government and independent reports on each country's export control system.

[1]Part III, Global Supercomputer Industry and Market Assessment, June 2, 1995, Department of Commerce, Bureau of Export Administration, Office of Strategic Industries and Economic Security, Economic Analysis Division

Current Export Licensing Requirements for High Performance Computers

Table II.1 and the description that follows summarize the terms of the revised export controls for HPCs and according to their MTOPS levels and destinations.

Table II.1: Current Export Licensing Requirements for High Performance Computers[a]

MTOPS	Tier 1	Tier 2	Tier 3	Tier 4
20,000 and up	No license required under license exception[b]	License and additional safeguards may be required	License required	License required Presumption of denial Various terrorist and boycott restrictions apply
10,000 to 20,000		License required		
up to 10, 000		No license required under license exception		
2,000 to 7,000			License required for military or proliferation end users or end use No license required for civilian end user under license exception Ten-day review period for government review	
Up to 2,000			No license required under license exception	License required to Sudan & Syria at or over 6 MTOPS and for any MTOPS to rest of tier

[a] For each tier, exporters must maintain and provide records to the Commerce Department and reexport and retransfer restrictions apply.

[b] A license exception for HPCs is a regulatory authorization that allows exporters to export or reexport, based on MTOPS levels and destination, computers that otherwise would require a license.

The Revised Controls

The revised controls announced by the President divide into four country groups, as follows:

- Tier 1 (28 countries: Western Europe, Japan, Canada, Mexico, Australia, New Zealand). No prior government review (license exception) for all computers, but companies must keep records on higher performance shipments that will be provided to the U.S. government, as directed.

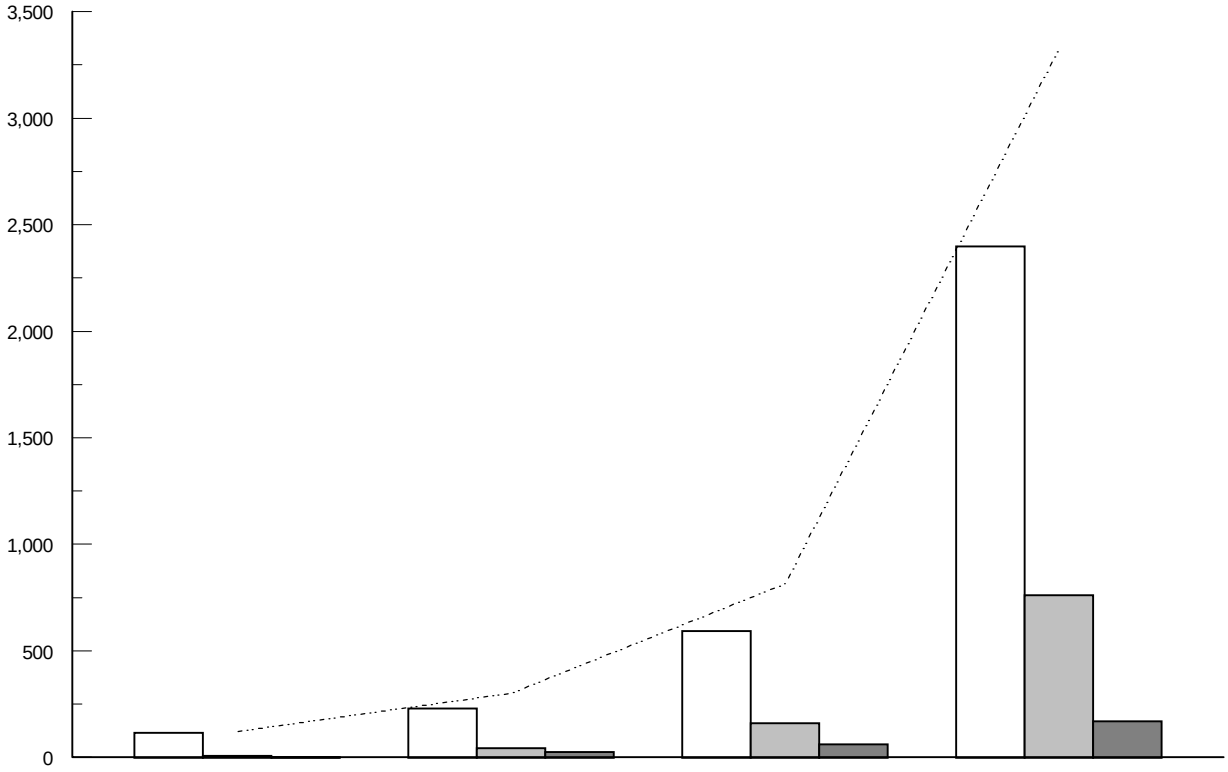
- Tier 2 (106 countries: Latin America, South Korea, Association of Southeast Asian Nations or ASEAN, Hungary, Poland, Czech Republic, Slovak Republic, Slovenia, South Africa). No prior government review (license exception) up to 10,000 MTOPS with record-keeping and reporting, as directed; individual license (requiring prior government review) above 10,000 MTOPS. Above 20,000 MTOPS, the government may require certain safeguards at the end-user location.
- Tier 3 (50 countries: India, Pakistan, all Middle East/Maghreb, the former Soviet Union, China, Vietnam, rest of Eastern Europe). No prior government review (license exception) up to 2,000 MTOPS. Individual license for military and proliferation-related end uses and end users and license exception for civil end users between 2,000 MTOPS and 7,000 MTOPS, with exporter record-keeping and reporting, as directed. Individual license for all end users above 7,000 MTOPS. Above 10,000 MTOPS, additional safeguards may be required at the end-user location.
- Tier 4 (7 countries: Iraq, Iran, Libya, North Korea, Cuba, Sudan, and Syria). Current policies continue to apply (i.e., virtual embargo on computer exports).

For all these groups, reexport and retransfer provisions continue to apply. The government continues to implement the Enhanced Proliferation Control Initiative, which provides authority for the government to block exports of computers of any level in cases involving exports to end uses or end users of proliferation concern or risks of diversion to proliferation activities. Criminal as well as civil penalties apply to violators of the Initiative.

U.S. High Performance Computer Exports Since the 1996 Export Control Revision

HPC exports have increased significantly since the 1996 export control revision. Figure III.1 shows the numbers of U.S. HPCs exported to all tiers from fiscal year 1994 through fiscal year 1997. In fiscal year 1996, U.S. computer vendors exported almost twice as many HPCs as they had in fiscal years 1994 and 1995 together. In fiscal year 1997, U.S. exports of HPCs more than quadrupled the fiscal year 1996 level. Figure III.1 also shows that growth in export volume was strong for tier 1 countries. Although tier 2 growth remained ahead of tier 1 for the whole period, the greatest volume of U.S. exports has been with the tier 1 countries. Table III.1 shows the largest importers of U.S. HPCs. U.S. allies and friends remained the largest market for U.S. HPC exports, but tier 2 countries were the fastest growing market. Figure III.2 summarizes the share of U.S. HPC exports that each tier took in this period. Figure III.3 shows the top five customers for U.S. HPCs and the portion of the exports they received. Finally figure III.4 shows that most HPCs exported in the past 2 years were rated between 2,000 and 3,000 MTOPS.

Figure III.1: Numbers of U.S. High Performance Computers Exported to All Tiers, Fiscal Years 1994 Through 1997



	FY94	FY95	FY96	FY97
Tier I	115	231	594	2,398
Tier 2	7	45	161	761
Tier 3	1	25	60	171
Annual Total	123	301	815	3,330

Note: This shows the number of items licensed for export rated at above 1,500 MTOPS for fiscal years 1994 and 1995, as well as the number of items at or above 2,000 MTOPS for fiscal years 1996 and 1997 reported as exported. The regulations changed in January 1996, so that first quarter fiscal year 1996 data includes HPCs at above 1,500 MTOPS and the second quarter includes 18 machines rated at between 1,500 and 2,000 MTOPS licensed for export in January 1996.

Since the January 1996 revision, 68 countries worldwide, out of 193 in the tier system, purchased 3,967 U.S. HPCs,[2] as of September 1997. These machines represent a total HPC computing power, as calculated in MTOPS, of over 15 million MTOPS. Twenty-six countries lead the world as the dominant customers for U.S. HPCs. These countries purchased 91 percent of all HPCs sold worldwide. Together they purchased over 14 million MTOPS, representing 93 percent of the HPC computing power exported from the U.S. in the period. Table III.1 ranks the countries by the quantities of MTOPS they purchased. It also shows the number of HPCs they purchased. The countries that purchased the most machines also purchased relatively more powerful machines as rated by MTOPS. (See table III.1.)

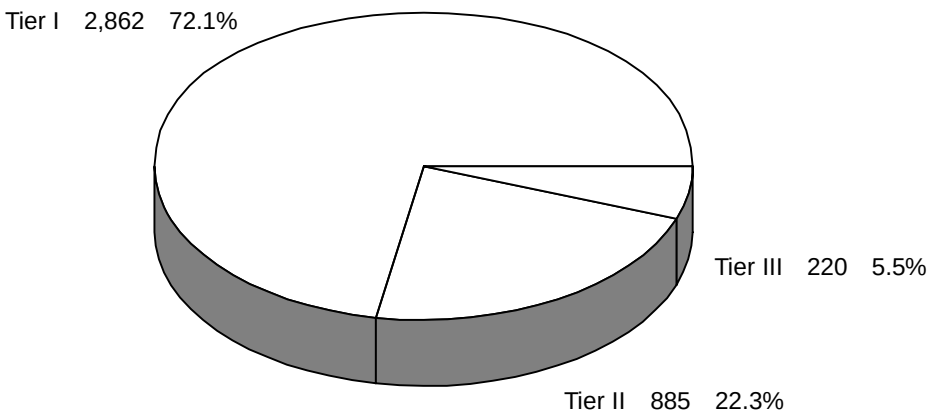
[2]Depending on a personal computer's configuration, a PC with an Intel Pentium II 350 megahertz chip is rated at 408.33 MTOPS. Each of the 3,967 HPC machines is rated at least 2,000 MTOPS. The 3,967 HPCs shipped from the United States are equivalent to about 37,000 Pentium II computers in terms of MTOPs.

Table III.1: Largest Importers of U.S. HPCs, Fiscal Years 1996 - 1997, Ranked by Total MTOPS Exported

Country	FY96 Machines	FY97 Machines	Total Machines for FY96-97	Total MTOPS Exported to Country FY96-97	Tier
Germany	111	488	599	2,600,949	1
United Kingdom	87	489	576	2,359,761	1
Japan	74	233	307	1,667,745	1
South Korea	62	269	331	1,128,945	2
France	29	229	258	1,070,385	1
Italy	16	142	158	601,979	1
Switzerland	23	147	170	500,327	1
Spain	10	123	133	484,862	1
Sweden	20	77	97	441,541	1
Australia	32	88	120	398,198	1
Netherlands	10	95	105	321,352	1
Belgium	12	88	100	288,194	1
Hong Kong	9	73	82	259,072	2
China	23	54	77	239,037	3
Brazil	2	68	70	214,350	2
Israel	7	41	48	200,177	3
Mexico	12	45	57	199,133	1
Malaysia	23	53	76	194,805	2
Singapore	5	60	65	189,729	2
South Africa	8	28	36	132,675	2
Thailand	2	35	37	110,536	2
Austria	6	25	31	108,449	1
Norway	1	15	16	107,388	1
Indonesia	0	27	27	91,561	2
Russia	7	21	28	84,961	3
Finland	1	23	24	81,571	1
Total	**588**	**3,040**	**3,628**	**14,077,682**	

As table III.1 shows, tier 1 countries, mainly U.S. friends and allies, were by far the largest market for U.S. HPCs. Figure III.2 summarizes the share of U.S. HPC exports that each tier received in the past 2 years.

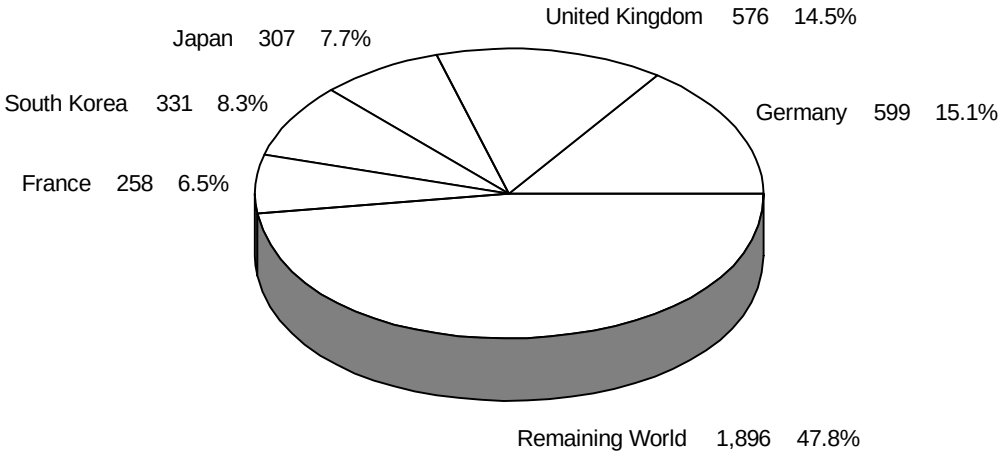
Figure III.2: Quantity and Percent of U.S. HPC Exports to Each Tier, January 1996 -September 1997



Source: Department of Commerce and GAO Analysis.

Since the export controls were revised, HPCs have been sold to more countries, but 26 countries account for 91 percent of all U.S. HPCs sold worldwide. Not only have the Tier 1 countries dominated as U.S. HPC customers, five U.S. allies were the largest customers for U.S. HPCs: Germany, the United Kingdom, Japan, South Korea, and France. As figure III.3 shows, these five countries together received over 52 percent of the machines exported. These countries also bought the most powerful machines, purchasing 58.36 percent of the MTOPS exported in HPCs.

Figure III.3: Quantity and Percent of Total Machines Purchased by Five Largest Customers for U.S. HPCs, From January 1996 - September 1997



Source: U.S. Department of Commerce and GAO Analysis.

The large majority of U.S. HPCs exported since the revision and the largest number of most powerful computers were sent to tier 1 and 2 countries. For example, 50, 5, and 1 HPCs with computing power greater than 13,000 MTOPS went to tiers 1, 2, and 3, respectively. Of the 50 countries in tier 3, five—China, Israel, Russia, India, and Saudi Arabia—account for about 84 percent of the computers exported to tier 3. Table III.2 shows the numbers of computers each country has received.

Table III.2: Numbers of Machines Exported to Top Five Tier 3 Recipients, January 1996-September 1997[a]

Country	1996	1997	Total	Percent of total
China	23	54	77	35.0
Israel	7	41	48	21.8
Russia	7	21	28	12.7
India	6	13	19	8.6
Saudi Arabia	2	11	13	5.9
Other Tier 3	4	31	35	15.9
Total	**49**	**171**	**220**	**100**

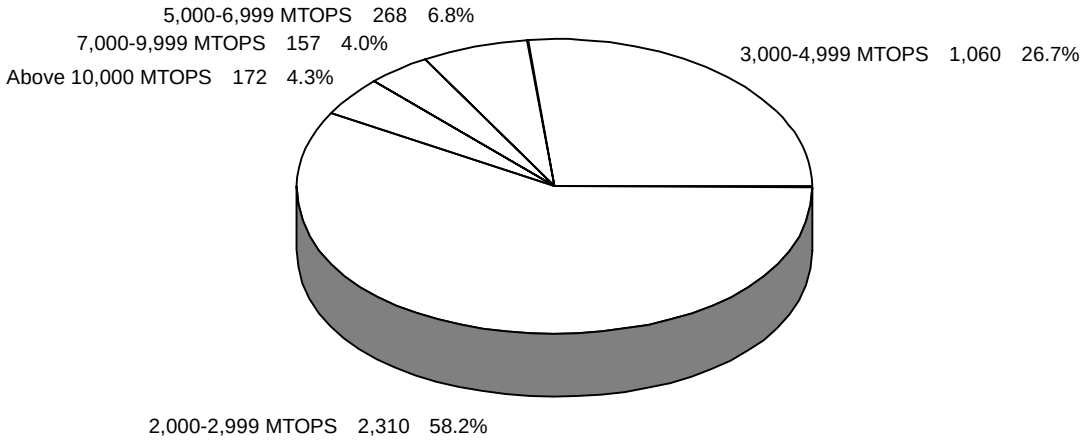
[a]HPCs to China and India were exported with no individual licenses. Russia and Saudi Arabia received 1 licensed HPC each, while Israel received 18 licensed machines.

China, which ranks first in the number of HPCs received by a tier 3 country, would have received even higher numbers of HPCs if its HPC totals were combined with those of its Hong Kong Special Administrative Region. Hong Kong and China rank 13th and 14th, respectively, on the HPC purchasers' list. (See table III.1) If Hong Kong and China were treated as one for purposes of U.S. export controls and statistics[3], the combined region would have purchased more machines than Italy, which ranked seventh in U.S. machines exported, and almost as many machines as Switzerland, which ranked sixth.

The largest numbers of U.S. HPCs exported were less powerful HPCs. HPCs at the 2,000 to 3,000 MTOPS level made up the bulk of machines exported, about 58 percent of all HPC exports. HPCs at the 2,000 to 7,000 MTOPS level constitute the large majority of U.S. HPC exports, about 92 percent of all U.S. HPC exports, or 3,638 machines exported. The remaining 8 percent of HPC exports, 329 machines, were above 7,000 MTOPS. Figure III.4 shows these relationships. (See fig. III.4.)

[3]In our report Hong Kong's Reversion To China: Effective Monitoring Critical to Assess U.S. Nonproliferation Risks (GAO/NSIAD-97-149, May 1997), we emphasized the need to monitor the continuation of Hong Kong's separate and autonomous export controls. U.S. officials agreed that monitoring Hong Kong's autonomy in the conduct of export controls is necessary, given the potential risks involved and the U.S. policy commitment to ensure that exports of sensitive technology to Hong Kong are protected.

Figure III.4: Quantity and Percentage of U.S. HPC Exports by MTOPS Levels, January 1996-September 1997



Source: U.S. Department of Commerce and GAO analysis.

Comments From the Department of Commerce

Note: GAO comments supplementing those in the report text appear at the end of this appendix.

THE SECRETARY OF COMMERCE
Washington, D.C. 20230

AUG - 7 1998

Mr. Harold J. Johnson
Associate Director
International Relations and Trade Issues
General Accounting Office
Washington, D.C. 20548

Dear Mr. Johnson:

Thank you for the opportunity to comment on the draft GAO reports on the 1995 decision to revise export controls for high performance computers (HPCs). My general view is that the reports are too limited in their scope and should be expanded to reflect better the rationale that led to the President's decision to change computer export policy from a relic of the Cold War to one more in tune with today's technology and international security environment. The President based his decision on several factors -- rapid technological change, wide availability, limited controllability, and limited national security application -- that played critical roles in the Administration's decision to create an effective export policy for computers at various performance levels. Instead of analyzing this rationale, the reports focus on an outdated, Cold War concept of "foreign availability."

The United States currently dominates the high performance computer market, in part because of the computer export policy adopted by this Administration in 1995. That policy was carefully crafted and was realistic in designating what could be controlled. The 1995 computer review was a model for how export controls should be approached and adjusted in the Post-Cold War security environment. I have provided recommendations to expand the reports and make them more reflective of this discussion. I ask that you include the following comments in your reports and that you consider our recommended changes to the text.

Thank you again for soliciting the Department's views on the draft reports.

Sincerely,

William M. Daley

Enclosures

Comments and Recommended Changes
GAO Draft Report
"More Information Needed for Decision to Revise High Performance Computer Controls"

General Comment

While many factors contributed to the decision to liberalize export controls on computers, four major factors stand out -- technological progress, availability, controllability, and the strategic applications of high performance computers (HPCs). Each of these factors plays a critical role in determining the viability of imposing export controls on computers at various computing levels. The principal flaw in this study, and its conclusions, is its narrow and selective focus on computer applications and foreign availability.

Rapid Technological Change

Four years ago, the United Sates controlled as "supercomputers" machines with a performance of 195 millions of theoretical operations per second (MTOPS). Today, the average personal computer on a desk is more powerful. We could not afford in 1995 to ignore market trends and technology advancements that were affecting the development of computers. Rapid progress in microprocessor architecture was a critical element. Improvements in microprocessor design made HPCs smaller, cheaper, and faster. Computer chips are produced in the millions in plants in the United States and overseas. A 1995 report prepared by the Institute for Defense Analysis for the Defense Department projected correctly, based on reliable historical trends and industry projections, that microprocessor performance would double by 1997. Performance increases were the result of both improved design and improved manufacturing techniques that continue to drive down the prices of computers, making them more affordable and more practical for an ever-increasing variety of uses. By 1995, rapid advances in microprocessors and software meant that the performance levels once associated with giant machines could be obtained by smaller and relatively inexpensive computers marketed around the world by the tens-of-thousands. HPCs are smaller, cheaper, simpler to install and maintain, and more reliable. These attributes, desirable in the marketplace, constrain our ability to control the export of many HPCs.

Availability of HPCs

The GAO report focuses primarily on foreign availability as it relates to the indigenous production capabilities of foreign producers. This is not an adequate measure of the problem. Foreign availability -- the availability of high performance computers built by foreign manufacturers with foreign parts and technology -- was a key determinant of our export policy during the Cold War. A Cold War concept of foreign availability makes little sense today in determining policy for commodities like computers, given the permeability and increased globalization of markets. Assessments of the global market for computers in 1995 indicated that roughly 25 percent of HPCs were sold outside the United States, primarily to Japan and Europe, with a smaller percentage of exports targeted at East European, Asian, and Latin American markets. In 1994 alone, over a half million HPCs, as they were then defined, were sold worldwide. Considering a huge installed base of computers, we realized early in our analysis that requiring a license for thousands of HPCs would not prevent their spread.

Controllability

The feasibility of effectively controlling items is an important consideration in the development of export control policy. To set controls in 1995 at a level that could not realistically be enforced would have been irresponsible and hurt U.S. industry when foreign suppliers make comparable products. This is particularly true for systems below 4,000 MTOPS, where European and Japanese manufacturers produce quality systems that can compete with U.S. companies. The Internet has also complicated computer controllability by facilitating the market in used HPCs and making remote access easy. Many Internet sites offer powerful HPCs for resale. This market is accessible to anyone throughout the world. Many of our European allies do not enforce U.S. reexport controls, as they consider them to be extraterritorial. In light of this, we cannot realistically expect to keep the organizations responsible for weapons development in states of concern, organizations that are technically sophisticated, well-funded and which enjoy strong government support, from clandestinely, or even openly, obtaining HPCs with performance levels up to 7,000 MTOPS.

The nature of the computer market has strong implications for export controls, and the Administration took into account the global availability of HPCs and their components in our assessment of those controls. The old style HPC, with its extensive requirements for support equipment and for maintenance, was easily controllable. This is, however, not the case for modern HPCs. We concluded in 1995 that given the computers that were then available worldwide (taking into account computing power, scalability, size, production levels, availability of basic technologies and the number and form of distribution channels), governments could not effectively control the international diffusion of computing systems at the licensing thresholds then in effect. These thresholds were far too low. The 1995 decision to raise control thresholds, and the thresholds associated with that decision, were thus based on a realistic assessment of the ability to control the global distribution of computers.

Applications

In 1995, the Administration concluded, based on a variety of research, that computer power is a secondary consideration for many applications of national security concern. Many national security applications can be performed in a satisfactory manner based on uncontrollable, low level technology. In our analysis, countries of national security concern cannot threaten U.S. military superiority by gaining access to HPCs below the levels defined by the Administration's 1995 policy. The military services identified only a few high end applications of concern in developing the new policy. Information provided by the Department of Defense as part of the 1995 policy review confirmed the conclusion that most military research and development applications require fewer than 1,000 MTOPS of computational power. Performance levels around 1,000 MTOPS can be achieved with affordable computer systems widely available today.

Computers are not a choke point for military production. The weapon systems found in the U.S. arsenal today -- the tanks, airplanes, weapons, missiles and ships -- were designed and built with

computers whose performance was below 1,000 MTOPS -- in many cases with only 500 MTOPS. These were supercomputers in the 1980's, but by 1995 one could find single microprocessors that were more powerful, such as the 64-bit Alpha EV5, individually capable of more than 700 MTOPS of processing power.

Having access to high performance computers alone will not provide improved military-industrial capabilities. The amount of computing power needed to design and manufacture modern weapons, once one exceeds a few hundred MTOPS, is not significant. Other factors -- skill in software design, access to sophisticated manufacturing techniques, experience and test data in weapons design -- are much more important than computer performance. The level of computational power used to develop all the bombs in the current U.S. nuclear arsenal, for example, is less than that found today in many workstations. An HPC is only one piece of the puzzle to create a strategic weapon. There are many other pieces (e.g., knowledge, skill, equipment, etc.) that are essential in the manufacturing process.

Specific Comments

See comment 1. Now on p. 3.

Page 4, line 15. Amend to read: "...(3) keeping records and reporting on exports of computers with performance levels of 2,000 MTOPS. In addition to the standard record keeping requirements, the regulation added record keeping requirements for the date of shipment, the name and address of the end-user and of each intermediate consignee, and the end use of each exported computer."

Rationale: Factual.

See Comment 1. Now on p. 4.

Page 6, line 1. Amend to read: "Nonetheless, based on the worldwide availability of computing power and in consideration of the technological advancements in this area, the executive branch raised the MTOPS thresholds for HPC export controls and established the four-tier control structure."

Rationale: The U.S. Government had consistently referred to the effects of technological trends as being a predominant factor in the decision to decontrol computers.

See comment 1. Now on p. 4.

Page 6, line 10. Amend to read: "First, the number of computer export licenses issued declined from 395 in fiscal year...."

Rationale: Information about licensing statistics provided on page 15 indicates that 395 refers to licenses approved and not applications processed.

See comment 1. Now on p. 4.

Page 6, line 15. Amend to read: "... decision is made on the basis of the end use, the end user, and the computer performance capability."

Rationale: Factual.

See comment 1.
Now on p. 10.

Page 6, line 18. Prior to "This situation...", add new sentences: "To aid exporters in making end user determinations, the Department of Commerce created a specific list of "red flags" and "know your customer" guidance to educate exporters about signs they need to be aware of that can be of concern to the government. This guidance has been taught in seminars for several years and made available on the Bureau of Export Administration web site. Companies were also urged to contact the Commerce Department when in doubt about an end user's activities. The end user could then be researched by the government and the exporter advised to seek a license if any strategic concerns were present."

Rationale: Although some of the screening burden was placed on the exporter, it was done while simultaneously educating the public on screening procedures and signs to be aware of. This was a tremendous effort by the Bureau of Export Administration that should not be overlooked.

See comment 1.
Now on p. 5.

Page 7, footnote 8. Add "of 1979" after "the Export Administration Act" and add the following second sentence to the footnote: "Department of Commerce officials believe that this determination is an outdated Cold War concept that has little applicability in the current world environment.

See comment 2.

Page 7, line 6. Replace the first sentence of the 2nd paragraph with the following: "With regard to foreign availability of HPCs, a number of computer manufacturers exist outside the United States. In addition to subsidiaries of U.S. computer manufacturers, other manufacturers are located in Canada, Japan, Europe, and Asia. In Europe, Germany, France, the United Kingdom and Switzerland, indigenously manufacture computers that compete with those of the United States. In Asia, India is a significant producer and capabilities also exist in Taiwan and Singapore, where export controls resembling those of the United States do not exist.

It is important to note, however, that for proliferators, the issue is not a mass market capability to compete with U.S. producers but rather the capacity to make a small number of HPCs, regardless of the costs, to meet national needs. India is a prime example of this situation. In the late 1980's, India sought a HPC from the United States but was denied an export license. Bent on proving that it could still satisfy computing desires despite our refusals, India invested millions of dollars in the creation of the Param computer. Although the Param is not as sophisticated as U.S. computers, it can provide the processing capability needed for weapons of mass destruction applications. After the introduction of the Param, India publicly stated that it created this capability only after we refused to sell the country an HPC and in order to evade our controls.

Most of the systems indigenously produced in Europe and Asia have computing powers that are less than 5,000 MTOPS to target a portion of the HPC market that is large and affordable. The Japanese have concentrated on manufacturing higher end HPCs that compete directly with those of the United States. Yet, for more powerful HPCs over 5,000 MTOPS, the United States dominates the world market. However, the threat of competition is strong for lower end systems below 5,000 MTOPS, which provides some insight to the types of systems for which the United

States is most vulnerable to lose market share if it is unable to compete in the world market. The evidence supports the conclusion that the United States is not a monopolist in this industry. Others have the capability to produce, and will likely improve on this capability if afforded the opportunity to do so. This supports the findings of the 1995 Stanford University study."

Rationale: Not enough attention is given to the existence of foreign producers that have the ability to produce high level computers indigenously. These systems are typically not captured by U.S. controls. It is also important to realize that the computer market is driven largely by demand. If the United States does not supply computers at satisfactory levels, foreign producers will pick up the slack.

See comment 1.
Now on p. 6.

Page 8, line 19. Delete the first sentence of the 2nd paragraph and replace with the following: "The Stanford study accumulated information from computer companies on U.S. HPC market characteristics and information from the Defense Department regarding national security applications. This data supported the study's conclusion that a CTP threshold of 7,000 MTOPS could be justifiable as a point above which a number of significant strategic applications exist."

Rationale: Factual. The Stanford University study did not say that computers at 7,000 MTOPS were uncontrollable. It reported that computers at 4,000 - 5,000 MTOPS were uncontrollable based on evidence of availability throughout the world.

See comment 3.

Page 11, line 15. At the end of first paragraph, add the following: "This information obtained by DOE laboratories and other U.S. Government officials was never provided to policy makers for consideration. Some parts of DOE, however, are not in agreement regarding the contribution that HPCs make to nuclear programs in countries of concern. This issue is still under dispute within DOE. The Stanford University study indicated that first-generation nuclear weapons can successfully be designed using less than 1,500 MTOPS. Although second- and later-generation nuclear weapon design requires more than 1,500 MTOPS of computing power, evidence has proven that systems at this level and higher are available from foreign countries that do not implement export controls similar to those of the United States."

Rationale: Additional facts regarding this issue need to be revealed to reflect this situation accurately.

See comment 4.

Page 19, line 15. Add a new 2nd paragraph as follows: "Worldwide availability of computers, however, indicates there is a large installed base of systems with availability in the tens of thousands and even millions for smaller systems. This complicates and severely limits the ability of the U.S. Government to control the export of all computers effectively. License requirements will not prevent diversion of HPCs unless realistic controls levels are set that can be enforced effectively."

Rationale: The installed base of computers worldwide also plays an important role in the consideration of the availability of computers outside the United States.

See comment 5.

Page 21, line 4. Following "U.S.-origin goods." insert, "The United Kingdom Government's authorities instruct their exporters to ignore U.S. reexport controls. The European Union believes our reexport controls are extraterritorial and therefore most EU countries will not enforce them. These facts support the findings of the Stanford University study with regard to the difficulty of controlling computers effectively throughout the life of the product."

Rationale: Factual.

See comment 2.

Page 22, line 4. Insert at end of 1st paragraph the following: "Research and information from other U.S. Government sources and U.S. computer manufacturers indicate that Param computing capabilities range from 4,000 MTOPS to 10,000 MTOPS."

Rationale: Additional factual evidence. The Param system has been reported to be more powerful than the GAO report reveals.

The following are GAO's comments on the Department of Commerce letter dated August 7, 1998. Commerce provided one set of written comments for this report. We addressed Commerce's general comments relevant to this report on page 15 and its specific comments below.

GAO Comments

1. We have made the suggested changes, as appropriate.

2. Commerce also commented that a number of foreign manufacturers indigenously produce HPCs that compete with those of the United States. Evidence cited by Commerce concerning particular countries with HPC manufacturing capabilities came from studies that were conducted in 1995 and that did not address or use criteria related to "foreign availability." As stated in our report, we gathered data from multiple government and computer industry sources to find companies in other countries that met the terms of foreign availability. We met with major U.S. HPC companies in the United States, as well as with their overseas subsidiaries in a number of countries we visited in 1998, to discuss foreign HPC manufacturers that the U.S. companies considered as providing foreign availability and competition. We found few. Throughout Europe and Asia, U.S. computer subsidiary officials stated that their competition is primarily other U.S. computer subsidiaries and, to a lesser extent, Japanese companies. Our information does not support Commerce's position on all of these manufacturers. For example, our visit to government and commercial sources in Singapore indicated that the country does not now have the capabilities to produce HPCs. We asked Commerce to provide data to support its assertion on foreign manufacturers, but we received no documentary support. In addition, although requested, Commerce did not provide documentary evidence to confirm its asserted capabilities of India's HPCs and uses.

3. Commerce stated that policy makers did not receive DOE information prior to the revision of the HPC controls in 1995 and, further, there is current disagreement within DOE over the contribution that HPCs make to nuclear programs in countries of concern. We agree that Commerce did not obtain available information on this issue from DOE laboratories, although such information was available and provided to us upon request. In addition, we found no dissent or qualification of views identified in DOE's official study on this matter.

4. Commerce stated that worldwide availability of computers indicates that there is a large installed base of systems in the tens of thousands or

even millions. Commerce further stated that license requirements will not prevent diversion of HPCs unless realistic control levels are set that can be enforced effectively. While we agree, in principle, that increasing numbers of HPCs makes controllability more difficult, a realistic assessment of when an item is "uncontrollable" would require an analysis of (1) actual data, (2) estimated costs of enforcing controls, and (3) pros and cons of alternatives—such as revised regulatory procedures—that might be considered to extend controls. Such an analysis was not done by the executive branch before its 1995 decision. In addition, Commerce provided no documentary evidence for its statement that there is a large installed base of HPCs in the millions.

5. Commerce stated that most European governments do not enforce U.S. export control restrictions on reexport of U.S.-supplied HPCs. We agree that at least those European governments that we visited (Germany and United Kingdom) hold this position. However, although requested, Commerce provided no evidence to support its statement that the government of the United Kingdom has instructed its exporters to ignore U.S. reexport controls.

Comments From the Department of Defense

Note: GAO comments supplementing those in the report text appear at the end of this appendix.

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Mr. Benjamin D. Nelson
Director, International Relations and Trade Issues
National Security and International Affairs Division
U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Nelson:

Thank you for the opportunity to comment on the General Accounting Office (GAO) draft reports, "More Information Needed for Decision to Revise High Performance Computer Controls" and "National Security Issues and Foreign Availability for High Performance Computer Exports," dated July 1998 (GAO/NSIAD-98-196 and 200/OSD Case # 1648/1648-A). The Department of Defense has reviewed the reports and has the following comments:

See comment 1.

- The Stanford University study referred to in the GAO report was just one of many inputs considered by the Executive Branch in its 1995 assessment of computer export controls. Information and analysis was also provided by various Defense components as well as other USG agencies, including the Intelligence Community.

See comment 2.

- The GAO draft report inaccurately states that DoD did not consider the threats associated with high performance computer (HPC) exports. DoD did take into account the security risks associated with the export of HPCs to countries of national security and proliferation concern. DoD identified numerous national security applications that require various levels of computing power, which helped to determine licensing policies for the various country groups and to establish specific safeguards on computer exports. Countries of greatest national security and proliferation concern are subject to the most stringent licensing and safeguard requirements.

See comment 3.

- The GAO recommends that the Secretary of Defense assess how and at what performance levels countries of concern use HPCs for military modernization and proliferation activities. These factors were taken into account by DoD and the interagency process in the 1995 review of computer export controls, and will be part of any future review. As pointed out in the Stanford University study, there are a wide

variety of national security applications that can benefit in one form or another from computers with performance levels well below current thresholds for export licensing. For example, the F-117 military aircraft was designed, developed, and produced using computers well below 500 million theoretical operations per second. However, it is equally important to assess the degree of controllability of computers. In the 1995 computer export control review, we determined that computers with performance below the current license threshold for Tier III countries are widely available globally and are easily scalable so that attempts to control them would be ineffective. In short, the President decided in 1995 on a system of graduated controls that reflects both the controllability of computers at various thresholds and the national security/proliferation risks for each destination.

- The GAO recommends that the USG consider certain additional options to safeguard exports of high performance computers. The Administration will be conducting a review of computer controls and these suggestions will be considered in the course of that review.

If you have any questions, please contact Dr. Oksana Nesterczuk or Mr. Richard Soskin of my staff at (703) 604-8038.

Sincerely,

Dave Tarbell
Director

The following are GAO's comments on the Department of Defense letter dated July 16, 1998. DOD provided one set of written comments for this report. We addressed DOD's general comments relevant to this report on page 17. We address DOD's specific comments below.

GAO Comments

1. DOD stated that the Stanford study was only one of many inputs considered by the executive branch in its 1995 assessment of computer export controls. We agree, and our report states, that there were other inputs to the decision. However, officials at Commerce, DOD, State, DOE, and ACDA referred us to the Stanford study in explaining the basis for the executive branch decision to revise the controls. Moreover, in announcing the 1996 HPC export control changes, the executive branch highlighted two conclusions of its review: (1) U.S.-manufactured computer technology up to 7,000 MTOPS would become widely available worldwide by 1997 and (2) many HPC applications used in U.S. national security programs occur at or above 10,000 MTOPS. Both conclusions were based on information provided only in the Stanford study. Also, DOD provided briefing slides on the HPC export control revision to the House Committee on National Security dated October 17, 1995, using information drawn almost exclusively from the Stanford study. Finally, a March 1998 Commerce Department report on foreign policy export controls noted only one source—a new Stanford study—as part of a 1998 review of HPC export controls.

2. DOD stated that it identified numerous national security applications used by the United States that require various levels of computing power, which helped to establish the revised licensing policies. We agree, and our report discusses the fact that DOD identified how the U.S. government uses HPCs for national security applications. However, this misses the point because these applications did not refer to particular countries of concern. As we noted in our report, the principal author of the Stanford study and DOD officials said that they had not performed a threat assessment or analysis of other countries' use of HPCs for military and other national security purposes. The current DOD analysis of how countries of concern can use HPCs is being done at the request of the House National Security Committee and might provide the information needed to perform our recommended assessment.

3. We disagree that the executive branch fulfilled the intent of our recommendations. Specifically, it did not have information on how and at what performance levels countries of concern, such as China, India, and

Pakistan, use HPCs for military modernization and nonnuclear proliferation activities. Regarding the degree of controllability of computers, neither the Stanford study nor any of the other inputs used in the 1995 computer export control review provided any empirical evidence or analysis to support assertions that HPCs with certain performance levels are widely available and uncontrollable. In fact, the 1998 Stanford study recommends procedural export licensing changes that would make such HPCs controllable again.

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