

U.S. EXPORT CONTROL POLICY IN THE HIGH PERFORMANCE COMPUTER SECTOR

by Robert Johnston

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Since the end of the Cold War, successive U.S. administrations have struggled to create and enforce an export control policy that balances the conflicting demands of promoting trade and countering the proliferation of weapons of mass destruction (WMD). The high performance computer (HPC) industry presents a major challenge in this respect. HPC technology is highly profitable, creating powerful incentives for export, while it also has numerous potential military applications, making it a significant proliferation threat. In its policies toward the regulation of dual-use technology exports such as HPCs, the Clinton administration has generally won laurels from trade promoters and darts from champions of nonproliferation. While administration officials argue that current policy strikes a balance between competing interests in trade and non-

proliferation, they have liberalized the export control regime for HPCs markedly.¹

Nonproliferation advocates have blamed these changes for the appearance of American-made HPCs in Russian nuclear weapons labs and Chinese research facilities that may be military-related.

This struggle between nonproliferation advocates and trade promoters has taken place in a conceptual vacuum caused by the end of the Cold War, and the failure of any overarching concept to assume the role played by containment in U.S. foreign policy prior to 1991. Various concepts, including nonproliferation and trade promotion, continue to compete for dominance in American foreign policymaking. The Clinton administration has declared that both nonproliferation and trade promotion are major foreign

policy goals. Despite their inherent appeal, neither nonproliferation nor trade promotion has been able to assume the central role held by containment during the Cold War. In fact, no concept has been able to generate the consensus needed to assume this role. Instead, American foreign policy since the end of the Cold War has largely been reactive, responding to immediate crises without being clearly guided by a broader strategy.

The development of HPC export controls under the Clinton administration reflects this broader pattern of drift. The early years of the administration were marked by an almost unbroken string of victories by those who favored liberalization of HPC export controls, despite the warnings of nonproliferation advocates, who feared the consequences of the rapid spread of this technol-

ogy. Bolstered by the absence of any urgent security threats, the trade promoters were able to convince the Clinton administration to launch two significant liberalizations of HPC export controls in 1993 and 1995.

More recently, revelations in 1997 about exports of American-made HPCs to Russia and China may shift the balance of forces in the other direction. By dramatically liberalizing HPC export controls, the Clinton administration has changed the nature of the debate among nonproliferation advocates and trade promoters. During the Bush administration, the debate on U.S. HPC export control policy tended to be couched in terms of whether U.S. high technology manufacturers were losing export revenues. Today, new emphasis is being placed on how U.S. technology might be contributing to WMD programs in foreign countries. The trade promoters, despite their success in shaping export control policy during the Clinton administration, have now lost the initiative, and are being asked uncomfortable questions about how their HPC technology products have ended up in Chinese or Russian weapons labs. As a result of these revelations, nonproliferation advocates in Congress were able to include language in the 1998 Defense Authorization Act (Public Law 105-85), passed in November 1997, that tightened HPC export controls.² Nevertheless, the battle over HPC export controls continues. Draft regulations on end-user verification of HPC exports issued by the Commerce Department in January 1998, which were harshly criticized by nonproliferation advocates, suggest that trade promoters remain a powerful political force in Washington.³

This article examines the development of U.S. HPC export control policy since the end of the Cold War. It begins by discussing the potential proliferation and security implications of HPC exports. It then sketches the history of U.S. export controls on dual-use technologies, before detailing the development of U.S. export controls on HPCs, with particular emphasis on the Bush administration (1989-1993) and the early years of the Clinton administration (1993-1995). Next, the article examines the as yet unsuccessful attempts in Congress to reform the export control process by passing a revised Export Administration Act and discusses the importance of multilateral arms control regimes in the formulation of U.S. export control policy. It concludes with a detailed examination of the 1997 revelations about the export of U.S.-made HPCs to Russian nuclear weapons labs and Chinese facilities with possible military links, and discusses the impact of these revelations on current and future HPC export control policy.

HIGH PERFORMANCE COMPUTERS AS A SECURITY ISSUE

An HPC is a "general purpose computer that is faster than commercial competitors and that has sufficient central memory to compute problem sets of general scientific interest,"⁴ or a computer "designed specifically to achieve the highest execution rate possible in scientific computation for a given technology."⁵ HPC systems are also frequently referred to as "supercomputers."⁶ However, given the complexity of the technologies involved, HPC is perhaps the best term. Seymour Goodman uses this

term to describe:

the technology, or collection of technologies that make it possible to address the most computationally demanding problems...this term recognizes that a computing system today depends not only on a powerful computational engine, but also high speed networks, advanced storage systems, sophisticated graphics, collections of less than the most powerful computers, etc.⁷

The primary measurement of the capabilities of a computer is Millions of Theoretical Operations Per Second, or MTOPS. The rapid growth in the MTOPS capabilities of HPCs during the 1990s has been reflected in certain policy actions by the Clinton administration. In September 1993, the Clinton administration raised the definition of a supercomputer from 195 to 2,000 MTOPS.⁸ By the October 1995 review of export control policy, the level of 3,000 to 5,000 MTOPS was already being considered as "mid-range."⁹ Just two months later, in a further review of policy, the very MTOPS standard was on the verge of becoming obsolete, because processing speed could be achieved at supercomputer levels by using widely-available parallel processing technology.¹⁰ Revolutions in miniaturization meant that the desktops of the 1990s matched the capabilities of the supercomputers of the 1980s, complicating efforts to design an export licensing policy that could keep pace with technological advances.¹¹

As with other "dual-use" technologies, HPC export licensing policy must balance commercial and security interests. Commercially, the HPC industry is viewed as "strategic," since "higher profits will not be competed away by new entrants,

because huge start-up costs, economies of scale, and learning curve advantages create high barriers to entry.”¹² These entry barriers, together with lucrative government procurement opportunities, have fostered a strong HPC industry in the United States. The major competitor to the United States is Japan, where the HPC industry has also benefited from government trade protection as well as funding through *keiretsu*.¹³ Among the leading commercial applications of HPC are managing the operation of precision machine tools and helping in the design of aircraft and motor vehicles.

HPC technology also has a number of military uses, including the development of WMD, the design of so-called “smart” conventional weapons, and the management of information warfare. Each of these areas affects American nonproliferation and arms control policy. For example, HPC systems make it possible for nuclear weapons designers to test nuclear devices through simulation, rather than explosive testing. In the United States, this capability is under the direction of the Accelerated Strategic Computing Initiative of the Department of Energy (DOE), which is responsible for meeting the “stockpile stewardship” needs of the American nuclear arsenal under the terms of the Comprehensive Test Ban Treaty (CTBT).¹⁴ The Defense Nuclear Agency is also a primary user of HPC technology for “weapon systems lethality, operability, and safety.”¹⁵ In this vein, one major worry of nonproliferation advocates is that exporting HPC systems could facilitate efforts by other states to either improve existing nuclear weapons or facilitate the design of new ones.

HPCs are also useful for designing and testing advanced conventional weaponry. They have played a key role in the design of critical American defense systems such as stealth aircraft, infrared trackers to detect incoming missiles, acoustic detectors for use in shallow water, airborne lasers, and rocket motors.¹⁶ HPC systems are also central to “information warfare” and “information dominance” strategies that are becoming a key concern of American military strategy.¹⁷ As information warfare becomes a more critical aspect of conflict, the possible spread of HPC systems to rogue states will raise additional security concerns.¹⁸ Collectively, the use of HPC systems in the design, testing and maintenance of nuclear, conventional and information warfare weapons technology creates a serious arms control issue.

THE DEVELOPMENT OF HPC EXPORT CONTROLS

Recent difficulties in reforming the U.S. export licensing process for HPC technology resulted from efforts to replace the Cold War era Coordinating Committee on Multilateral Export Controls (COCOM) while pursuing two conflicting policies: the 1991 Enhanced Proliferation Control Initiative and the September 1993 Trade Promotion Coordinating Committee initiative.¹⁹ An examination of the liberalization of export controls for HPC technology undertaken by the Clinton administration in 1993 and again in 1995 shows that the debate has been driven primarily by supporters of trade promotion. When compared to the Cold War system of export controls for HPC, the ascendancy of commercial interests in shaping

post-Cold War HPC export control policy becomes even more striking.

During the Cold War, COCOM provided the primary structure for the organization of U.S. export license processing. COCOM had clear, broad lists of controlled dual-use technology items that required licenses for export to the Eastern bloc.²⁰ Under the 1949 *Export Control Act*, the president had considerable autonomy to establish strong export controls lists, even above and beyond COCOM standards. The president initially enjoyed “deference” from allies, Congress, and industry, but consensus support for a tight technology embargo against the Eastern bloc began to collapse in the 1960s.²¹ Several trends contributed to the eroding consensus, including: overuse of sanctions and export controls; increased competition for U.S. manufacturers from European rivals; a new emphasis on controlling “critical technologies” instead of products; and, more intense interagency disputes over export licenses among U.S. government agencies.²² All of these issues continue to confront U.S. export control policy.

HPC technology entered the export control debate in the mid-1970s, when Cray Research, Inc., began to introduce the first HPC products.²³ The U.S. government quickly recognized the military potential of this technology, and when Japan achieved HPC manufacturing capability in the early 1980s, a “Supercomputer Safeguard Plan” was negotiated in 1984 to control exports of HPCs to countries other than Japan, the United States, and Canada. The system consisted of informal guidelines and negotiations between U.S. manufacturers and the “Supercomputer Interagency Work-

ing Group” headed by the Department of Commerce, aimed at controlling HPC exports. A similar system was created in Japan, although U.S. HPC manufacturers complained that the Japanese government was more lax in enforcing control guidelines, thus enabling its manufacturers to sell in markets forbidden to American companies.²⁴

Until the mid- to late-1980s, this system was effective. The large size of early HPCs, the small number produced, and the need for prolonged vendor support made covert acquisition and use difficult.²⁵ Controlling HPC exports became more difficult in the late 1980s, however, as alternative means of achieving “supercomputer” performance emerged. Under these conditions, American manufacturers of HPC-equivalent technology grew increasingly frustrated with the threshold limitations imposed on their exports, as European and Japanese competitors began to capture markets that were denied to them. Industry representatives began to lobby for a specific definition of supercomputers for export licensing purposes. The *Omnibus Trade and Competitiveness Act* of 1988 included such a definition, consisting of specific technical guidelines and a threshold performance level of 160 MFLOPS (Millions of Floating Level Operation Points per Second).²⁶ American manufacturers hoped that the definition would limit the ability of the Department of Defense (DOD) to disrupt trade through its efforts to control “re-exports” of U.S. HPC-equivalent desktops and mainframes from allies to Eastern bloc countries.²⁷ However, subsequent attempts to further liberalize controls were undone by the Department of Defense which “managed to delay,

water down, or turn back several liberalizing initiatives.”²⁸

The Bush Administration

Subsequently, the Bush administration faced the difficult task of reforming HPC export controls in the tumultuous environment of the end of the Cold War, the 1991 Gulf War with Iraq, and accelerated technological breakthroughs by the HPC industry. As the centerpiece of its export control policy, the Enhanced Proliferation Control Initiative (EPCI) was launched by the Bush administration in 1990. Under the EPCI, exporters must apply for a license when informed by the Department of Commerce that the end use of an item may be intended for proliferation purposes. The EPCI seeks to identify and control dual-use goods and technologies useful for the production of chemical and biological weapons, ballistic missiles, and nuclear weapons technology. The initiative became a basis for the expansion of the Australia Group and Nuclear Suppliers Group control lists to include precursor components for WMD.²⁹

With the disintegration of the Soviet bloc and the collapse of the Soviet Union itself in the early years of the Bush administration, concern about HPC exports began to shift away from the Eastern bloc and focus on the threat posed by proliferation of WMD in other areas of the world. Senator John Glenn (Democrat-Ohio), a leading advocate of tight export controls on HPC technologies, warned in 1989 against “complacency” about nuclear proliferation resulting from an absence of observed nuclear test explosions. In a reference to “virtual” testing of nuclear weapons, he pointed out that

“proliferation also takes place through a more insidious route; nations can acquire both a weapons capability and a nuclear arsenal without having to take the step of actually exploding, or even assembling one of these devices.”³⁰ Like other nonproliferation advocates, Glenn feared the use of HPC by rogue regimes—such as Iraq, Iran, Libya, and North Korea—to design and test nuclear weapons without conducting physical tests.

Even after the 1991 Gulf War, when the discovery of clandestine WMD programs in Iraq boosted awareness of the dangers of WMD proliferation, the Bush administration had to juggle security and commercial interests in setting HPC export control policy. A senior Bush administration official responsible for nonproliferation stated that the “policy dilemma facing the administration is to find a balance between excessive controls that would impede legitimate export trade and those controls which the US and other major world suppliers find necessary to support common security objectives.”³¹ A central aspect of the Bush administration effort to strike this balance involved COCOM. During the final years of the Cold War, the Bush administration had to balance its desire to facilitate economic and political reform in the Soviet Union by expanding technological cooperation with a continuing desire to prevent any new arms breakthroughs by the Soviet military.³² In May 1991, at a High Level Meeting of the COCOM, member nations reviewed the International Industrial List of controlled dual-use items and decided to decontrol commodities with wide availability outside COCOM nations.³³ In the computer area, COCOM decided that available

capabilities outside COCOM peaked at a Composite Theoretical Performance (CTP) of 26 MTOPS. As a result of the bilateral and COCOM reforms, powerful computing capability began to be transferred to the former Soviet Union and other Eastern bloc countries.

According to a joint study by the National Academy of Sciences and the Russian Academy of Sciences in 1991, Russian computer manufacturing capability had yet to reach the equivalent of the 386 microprocessor, at that time practically ubiquitous in American-made desktop computers.³⁴ This gap represented a potentially significant market opportunity for U.S. exporters, but also raised important security questions concerning Russia's end use of HPC technologies. The joint study urged a further liberalization of U.S. HPC controls, particularly with respect to systems of which 100,000 or more had already been sold, and recommended that confidence-building measures be implemented to monitor Russian end use of U.S. HPC.³⁵ Under this proposed system, U.S. officials would be able to monitor detailed logs about the use of American-made HPCs exported to Russia, ensuring that they were not diverted to military purposes.³⁶

The Bush administration also confronted rapid technological progress in the HPC sector. In 1990, the Department of Commerce revised the 1988 supercomputer definition to reflect three appropriate thresholds for different sets of countries, depending on proliferation risk and safeguard requirements. The three new thresholds were set at 100, 150, and 300 MFLOPS, depending on the country involved.³⁷ The performance capabilities of HPC-equiva-

lent systems still continued to grow, triggering increased pressure to raise the threshold limits again. The Bush administration implemented further reforms through the bilateral Supercomputer Control Regime agreement with Japan, which was modified so that security safeguards would be applied to all exports of HPCs with capabilities above 195 MTOPS. This liberalization initially pleased HPC manufacturers, but technological progress marched on, and by 1993, U.S. workstation producers, whose products had not previously been powerful enough to reach the threshold limits, found their sales restricted by the 195 MTOPS threshold.³⁸

The Clinton Administration

In January 1993, the Clinton administration took office and inherited the unresolved conflict between the policy objectives of trade promotion and export control. Under the Clinton administration, significant shifts have occurred in HPC export controls and in the responsibilities of agencies involved in export review. In October 1993, the Clinton administration announced that all computers with capabilities up to 194 MTOPS would be decontrolled for all countries except the former Eastern bloc, China, and the so-called rogue states. With agreement from COCOM states, controls would also be removed on previously HPC-equivalent machines with capabilities up to 500 MTOPS. Furthermore, the administration also aimed to reduce license processing time for more powerful computers by 25 percent. Finally, and most dramatically, the definition of a supercomputer was upgraded from 195 MTOPS to 2,000 MTOPS.³⁹ These changes cre-

ated a clearer division between supercomputers and upper-end workstations and advanced personal computers. The Clinton administration argued that these changes "leveled the playing field" for U.S. personal computer and workstation manufacturers, who could now freely compete in a \$35 billion market with European and Asian rivals.⁴⁰

The October 1993 licensing reforms represented a victory for free trade advocates over nonproliferation advocates. The electronics and computer industry had lobbied vigorously for these reforms during the 1992 campaign and throughout the first year of the Clinton administration, and Clinton had criticized Bush for failing to recognize the importance of economic security issues. Clinton also received significant support from high technology producers in California. During the first year of his administration, Clinton was sympathetic to complaints from industry about the burden of export controls. A Sun Microsystems executive complained in June 1993 that U.S. workstations and personal computers were losing market share to Taiwanese and Korean manufacturers operating outside the COCOM system. Moreover, the American Electronics Association complained that despite export controls, mid-range workstations could be turned into supercomputers like "a Lego set" by substituting a motherboard with faster microprocessors.⁴¹

In introducing these reforms, the Clinton administration largely ignored nonproliferation advocates such as Stephen Bryen, who cautioned that looser controls were a "prescription for proliferation." Without a strong international re-

gime focused on WMD proliferation, Bryen warned the House Foreign Relations Committee in September 1993, the mistakes leading to the Iraqi WMD buildup would only be repeated. "Had there been an agreement that all licenses approved by each government still had to stand up to international review," he stated, "more care would have been given about approving some exports in the first place."⁴² By contrast, after the changes were announced, a grateful U.S. computing industry heaped praise on the White House. Robert C. Haven, vice chairman of the American Electronics Association, termed the changes "the most progressive action taken to rationalize the export control regime since the end of the Cold War," while Sun Microsystems called the changes a "bold step to bolster our high-tech exports."⁴³

Despite these reforms, the computer industry and other trade promoters remained dissatisfied with the consultative process required by the licensing procedure for computers above the threshold limits. The problem arose from the interplay of the two conflicting Clinton administration policy initiatives: the Counter-Proliferation Initiative (CPI—an updated version of the Bush EPCI) and the Trade Promotion Coordinating Committee (TPCC), designed to bolster American exports. The institutional sponsor of the CPI was the Department of Defense, while the TPCC had its origins in the Department of Commerce. Efforts to pass a revised Export Administration Act in the 104th and previous Congresses floundered because of a failure to achieve a compromise that reconciled the objectives of these sometimes conflicting programs. In their effort to

promote the objectives of their respective programs, supporters of the TPCC and CPI, both within and outside of government, have highlighted particular cases that either unfairly restrict trade or recklessly overlook proliferation-related end uses. The arguments focus on what are viewed as either the shortcomings or the excesses of the consultation process.

The reports of the TPCC have been instrumental in supporting the arguments of those who advocate more liberal export controls on HPC systems. One of the key goals of the TPCC is "reducing government obstacles to exporting" through the streamlining of the export control licensing process.⁴⁴ Representative Norman Mineta (Democrat-California) called for a National Export Strategy in September 1993, complaining that "when United States high technology companies try to compete in world markets, we do so with one hand tied behind our back much of the time."⁴⁵ In October 1993, Representative Barney Frank (Democrat-Massachusetts) called for "unshackling American businesses" and characterized opponents of decontrol as those "who still object to the efforts to free American business to compete on equal terms in the world."⁴⁶ It is not coincidental that these Congressional advocates of looser export controls come from two states with high concentrations of computer firms.

Supporters of the TPCC point with considerable frustration to the delays that often occur when the Department of Commerce refers a license application to the Defense Technology Security Administration (DE TSA) at the DOD or the Office of Export Enforcement (OEE) at the

Department of Energy for inter-agency review. These delays, they claim, cost American manufacturers sales, and hurt American dominance in the HPC sector. The most frequently cited case is a 1990 license request by Cray for the export of a supercomputer to India. The deal collapsed in 1993, when after four years of license review, the Indians succeeded in developing a supercomputer of their own, which they then marketed to compete with Cray.⁴⁷ Trade promoters such as Willard Workman of the U.S. Chamber of Commerce called this case "a horror story."⁴⁸ Senator David Durenberger (Republican-Minnesota) called the decision a "total failure of the United States export licensing process."⁴⁹ Within the non-proliferation community, by contrast, the India case is often described as a "straw man." Nonproliferation advocates argue that although India did construct a supercomputer when denied access to equivalent American equipment, the four-year delay postponed covert nuclear weapons development by India. They also contend that since India had to develop its own capabilities, equivalent equipment was not available on the open international market, so American firms did not surrender a potential market to foreign competitors.⁵⁰

Still dissatisfied with the restrictions imposed by export controls after the October 1993 reforms, representatives from the computer industry pressured Congress to urge the Clinton administration to further liberalize controls over HPC technology exports.⁵¹ The pro-trade Council on Competitiveness reported that remaining controls over HPC technology cost American companies some \$640 million in

sales and 12,240 jobs.⁵² Howard Lewis, vice president of the National Manufacturers Association, complained that U.S. export control policy was still “sidetracked by arcane debates” over issues such as HPC threshold limits, while failing to address systemic issues like the “gridlocked” licensing review process and the misuse of unilateral controls.⁵³

Advocates of further liberalization frequently referred to specific cases where the time-consuming process of interagency consultation had hurt the competitiveness of their products. International trade consultant Paul Freedenberg referred in Congressional testimony to the losses of the U.S. machine tool industry in the potentially lucrative Russian market in the 1970s as a result of unilateral export controls. He argued that this example was typical of the “Kafkaesque horror stories” that resulted from lengthy interagency export license review.⁵⁴ Luke Alexander of Sun Microsystems struck a similar tone in his May 1994 testimony, where he objected to Sun Microsystems having its exports used as “pawns in foreign policy power plays,” when its products have an “average life of only 18 months.”⁵⁵

In the wake of this lobbying campaign, the computer industry won another victory in October 1995, when the Clinton administration launched a second wave of export control liberalization in the HPC sector.⁵⁶ Under the new standards, countries were placed into four “tiers,” and export licensing requirements were based on the country of destination. Controls were lifted on *all* computer sales to countries in “tier 1,” which consists of North Atlantic Treaty Organization allies,

Australia, and Japan. On the other end of the scale, countries in “tier 4,” like Iran, Iraq, and other “rouge” states cannot receive any HPC exports. Exports to countries in “tier 2,” including South and Central America, the Pacific Rim, and Eastern Europe, were assigned a threshold limit of 10,000 MTOPS, above which an individual license is required. “Tier 3” countries, including non-allied nuclear weapon states and other states suspected of nuclear proliferation, including Russia, China, Pakistan, and Israel, were assigned a threshold limit of 2,000 MTOPS for military end users and a threshold limit of 7,000 MTOPS for civilian end users.⁵⁷

Most significantly, however, the October 1995 reforms effectively allowed the exporter, rather than the U.S. government, to determine if the representations made by the purchaser about the planned end use of the computer were accurate. Thus an exporter would not even need to apply for an export license to export a 7,000 MTOPS computer to Russia if it believed that the computer would be used for civilian purposes.⁵⁸ These changes reversed the temporary gains made by nonproliferation advocates at the Arms Control and Disarmament Agency (ACDA) in February 1994, whose vociferous lobbying had led to the lowering of the threshold limit for HPC exports from 2,000 MTOPS to 1,500.⁵⁹

The general consensus within the entire executive branch, most of Congress, and the computer industry, however, was that the 1993 reforms had been an unqualified success and that further liberalization of HPC technology was necessary. Advocates of this view drew

intellectual support from a November 1995 report issued by the Center for International Security and Arms Control at Stanford University on the issue of export controls for HPC. The report found that “the efficacy of the [HPC] control regime will weaken significantly over the longer term” because of the “rapid rate of technological development and diffusion” and suggested that “it remains unclear” if the current threat posed by HPC applications are “as compelling a justification for export controls as were nuclear, cryptographic, and anti-submarine warfare applications during the Cold War.”⁶⁰

Those concerned with nonproliferation immediately criticized this latest liberalization of export restrictions. House National Security Committee Chairman Floyd Spence (Republican-South Carolina) complained that the liberalization of HPC controls “has serious proliferation implications and was made without any opportunity for Congressional review.”⁶¹ Nonproliferation advocates brushed aside the complaints of the computer industry, arguing that the needs of national security justify occasional, if not systematic, delays in the export licensing approval process. Moreover, they also criticized the Department of Commerce, accusing it of sometimes failing to refer dual-use items for interagency review. In particular, these critics have pointed to cases in which HPCs and other dual-use technologies have ended up in either rogue states, threshold states, or traditional U.S. adversaries such as China and Russia. For example, a 1994 General Accounting Office (GAO) report requested by Senator Glenn was highly critical of a wide array of dual-use export licenses that had been granted during the period

of study from 1985 to 1992.⁶² In particular, the report highlighted specific examples of U.S. license approvals that appeared questionable, such as the 1988 approval for export to Iraq of computers that may have subsequently been used “in fabricating nuclear weapons design work.”⁶³ Licensing procedures and policies were also criticized by the report, which said that the Department of Commerce “did not always refer nuclear-related dual-use license applications to the Department of Energy as required by regulations.”⁶⁴

Nonproliferation advocates in Congress unsuccessfully used the 1994 GAO report to try to restrain the liberalization of HPC export controls. Senator Glenn in particular argued that the report showed the need for more robust and thorough export controls on HPC that reflect the letter and the spirit of American treaty commitments under the Treaty on the Non-Proliferation of Nuclear Weapons (NPT).⁶⁵ The shortcomings of the post-shipment verification process that checks overseas end uses of dual-use technology exports have been equally worrisome to nonproliferation advocates. The 1994 GAO report found that unsupervised foreign nationals are often used to verify post-shipment end uses, which increases the risk of deception.⁶⁶ It also expressed concern about the lack of technical training among embassy officials responsible for post-shipment verification. The Clinton administration liberalized export controls in 1995 despite the 1994 GAO report and the arguments based on its conclusions.

THE EXPORT ADMINISTRATION ACT AND LICENSING REFORM PROPOSALS

The post-Cold War U.S. export control process assigns responsibility for HPC and other dual-use technology licensing to the Department of Commerce, under the auspices of the Commodity Control List (CCL). Exporters apply to Commerce for a license, whereupon the matter is referred to the Bureau of Export Administration, an agency within Commerce that bears responsibility for the administration of export licensing. Although controlled dual-use items are subject to formal approval by Commerce, other agencies are consulted in cases of sensitive export license applications. Key agencies include DETSA at DOD, OEE at DOE, and the Office for Defense Trade Controls (DTC) at the Department of State. Other agencies involved in the consultative process include the intelligence community, the Nuclear Regulatory Commission and ACDA.⁶⁷

The proposed Export Administration Act put forward in the 104th Congress and again in the 105th is designed to streamline the licensing process.⁶⁸ However, neither trade promoters nor nonproliferation advocates are completely satisfied with the proposed legislation. Trade promoters are upset because the new legislation still allows consultative agencies to appeal Bureau of Export Administration decisions to the president on the grounds of national security. Leading trade promoters, such as Representative Sam Gejdenson (Democrat-Connecticut), argue that the appeals process is still an impediment to fair trade, because it lengthens the time necessary for

companies to bring new products to market.⁶⁹

Nonproliferation advocates respond that the agencies involved do not deliberately delay licenses, but are obligated to fulfil multilateral treaty commitments. They also reject the “artificial speed” of the new process, which they argue is inadequate to ensure that allies are consulted, the identities of end users are confirmed, and accurate information is collected.⁷⁰ The dissatisfaction among both sides of the debate with respect to the attempt to restructure the interagency review process is typical of the broader difficulty of designing post-Cold War export controls.

Trade promoters have also requested looser interpretations of “foreign availability” as part of the proposed Export Administration Act. In November 1993 Congressional testimony, Richard Lehman, head of the Emergency Committee for American Trade, lauded the concept of “anticipatory list construction” included in the October 1993 liberalization of HPC and called for the codification of this policy in the proposed Export Administration Act. Lehman argued that U.S. decontrol decisions should be based on *future* foreign availability “because you cannot prove foreign availability until you have already lost significant market share to your foreign competition.”⁷¹ The foreign availability of HPCs is particularly difficult to establish because multiple alternative systems can be used to achieve controlled levels of performance. While “supercomputers” are only made in the United States and Japan, numerous countries produce computers and software that can be arrayed to achieve HPC threshold

limit performance.

MULTILATERALISM AND INTERNATIONAL ARMS CONTROL REGIMES

The issue of multilateral arms control export regimes has been a central aspect of the debate over HPC technology export controls in the post-Cold War era.⁷² The United States has a series of commitments to a variety of multilateral arms control agreements, which range from formal treaties like the NPT to informal arrangements like the post-COCOM Wassenaar Arrangement.⁷³ These agreements have varying compliance requirements and cover a wide range of issue areas. The differing levels of compliance requirements can be critical for American export control policy, because the stronger the commitment to tight export controls on a multilateral level, the less pressure generated domestically with respect to the costs of unilateral export controls and foreign availability.

Those who favor liberalized export controls for dual-use technologies such as HPC contend that controls are only effective when a product is not available in another country that does not adhere to the relevant arms control regime. In other words, if would-be proliferators in the area of chemical weapons or ballistic missiles can get the desired dual-use technology from another country, than the United States only hurts the short-term profitability and long-term competitiveness of its industries by adopting broad unilateral export controls.⁷⁴

Those who favor tight export controls criticize this point of view from two perspectives. First, they argue that foreign availability is irrelevant

if the United States has a treaty commitment not to proliferate.⁷⁵ For example, Article One of the NPT states that each signatory shall not transfer to “any recipient whatsoever” nuclear weapons and shall “not in any way to assist, encourage or induce any non-nuclear weapon State to manufacture or otherwise acquire nuclear weapons.”⁷⁶ Consequently, if a technology is controlled as a nuclear dual-use commodity, then the issue is clear cut for the nonproliferation advocates: the United States should not export the product to “any recipient whatsoever,” regardless of foreign availability.

The second argument advanced by advocates of nonproliferation in defense of unilateral export controls concerns international leadership. They argue that bearing the economic costs of unilateral export controls is necessary while Washington “raises diplomatic hell” to bring other countries around to its point of view.⁷⁷ As an example, they cite the American unilateral insistence on International Atomic Energy Agency safeguards for all U.S. nuclear exports following the passage of The Nuclear Non-Proliferation Act of 1978. European and Russian nuclear exporters did not adopt this policy for 12 years, but eventually recognized the necessity of the policy in a world of increasing proliferation risks under the aegis of the Nuclear Suppliers Group.⁷⁸

These issues are critical in the attempt to create a new multilateral export control regime in the area of dual-use technologies to replace the COCOM regime of the Cold War era. The current replacement, the Wassenaar Arrangement, is quite weak in comparison to the former

COCOM, as provisions that allowed a single member to veto sales by other members have been eliminated.⁷⁹ Consequently, the United States may be forced to make a stark choice between strict unilateral export controls and consequent trade losses, or more lax controls over dual-use technologies such as HPC and consequent security losses. Trade consultant Paul Freedenberg argues that in the absence of a strong security threat like that faced during the Cold War, the Wassenaar Arrangement will not “have anywhere near the discipline, the structure, and the coherence that its COCOM predecessor had.”⁸⁰ Without a strong multilateral regime, the economic costs of unilateral export controls on HPC are less politically tenable in the United States. Indeed, one supporter of tight dual-use controls admitted that only “one-half to one percent of Congress supports unilateral controls—competitiveness wins the rest.”⁸¹ One important determinant of the willingness of U.S. exporters and their supporters in Congress to accept stronger controls on HPC systems will likely be the ability of the Clinton administration to strengthen the Wassenaar Agreement and other multilateral export control arrangements.

1997: U.S. HPC TECHNOLOGY SURFACES IN RUSSIAN AND CHINESE WEAPONS LABS

Despite their victory in 1995, the position of advocates of trade promotion has been undermined by revelations during 1997 about supercomputer exports to unauthorized facilities in Russia and China. The issue was first raised when Representative Duncan Hunter (Republican-California) indicated in

October 1996 that he was “astounded and dismayed” to learn that the Clinton administration was considering licensing the Hewlett-Packard Convex SPP-2000 computer for sale to the Russian Ministry of Atomic Energy (Minatom).⁸² Indicating the lack of consensus within the administration itself on this issue, one senior American official claimed that the Minatom weapons laboratories “are the worst places in Russia to send a supercomputer.”⁸³ The administration eventually turned down the Hewlett-Packard request, along with a similar application by IBM. Russian officials argued that they needed the computers in order to maintain the reliability and safety of their nuclear stockpile after the conclusion of the CTBT, but American critics feared that Russia would use HPC technology to design new and improved nuclear weapons.

As a result, U.S. officials were flabbergasted when in February 1997, Russian Minister of Atomic Energy Viktor Mikhailov announced that Minatom had obtained several HPC systems from Silicon Graphics Industries of Mountain View, California, without an export license. Silicon Graphics, one of the leading U.S. manufacturers of HPC, had acquired Cray Research in 1996. Media reports indicated that the computers sold to Minatom had a capability of about 4,500 MTOPS, over the 2,000 MTOPS threshold limit for exports to military end users in Russia.⁸⁴ Mikhailov freely admitted that the machines were intended for use in the Chelyabinsk-70 nuclear weapons laboratory, and boasted that the computers were “10 times faster than any previously available in Russia.”⁸⁵ The GAO subsequently reported that if these

computers were arrayed in a single cluster, the nuclear weapons lab would have a computer with capabilities of 9,000 MTOPS, or possibly even 14,000 MTOPS—well above even the 7,000 MTOPS threshold established in 1995 for exports to civilian end users in Russia.⁸⁶

After Mikhailov’s revelations, the head of Silicon Graphics, Edward McCracken, said the company had been told by Russian officials that the computers were to be used “for environmental science.” McCracken admitted to making some “serious judgmental errors” in selling the computers, adding that “we were naïve here in Silicon Valley not to know” that the customer, the All-Russian Scientific Research Institute for Technical Physics (VNIITF), is another name for the Chelyabinsk-70 nuclear weapons lab.⁸⁷ “We didn’t even know it was going to Minatom,” claimed Chris Blumenthal, the director of customer transactions at Silicon Graphics.⁸⁸

Nonproliferation advocate Gary Milhollin told a Congressional inquiry that the illegal sale was the result of the replacement of old export controls over HPC with a “dishonor system, in which the exporter makes money if it closes its eyes and holds its nose,” suggesting that he did not believe the company’s assertions that it had not known the true identity of the intended end user. He added that the current system of allowing exporters to determine the identity of end users was so ineffective that if “Mr. Mikhailov hadn’t bragged to the press about getting his supercomputers, we probably wouldn’t know about these sales today.”⁸⁹ Other critics of the sale later pointed out that VNIITF is listed as

a nuclear weapons design facility in a 1995 handbook published by the Commerce Department, *The Russian Defense Business Directory*, designed to acquaint exporters with Russian military facilities. VNIITF’s own home page on the World Wide Web also clearly indicates that the institute is involved in the design of nuclear explosives.⁹⁰ As of January 1998, Silicon Graphics Inc. was under investigation by the Department of Justice for possible export control violations.

The second instance of controversial HPC exports that may undercut the previously strong position of the trade promoters on the HPC export control issue involves China. In April 1997, Bureau of Export Administration chief William Reinsch testified before a Congressional hearing that 47 U.S.-made supercomputers were in use in the People’s Republic of China.⁹¹ Arms control advocates expressed great concern about the impact of this revelation on U.S. security interests, specifically avoiding a high-tech arms race with China, which could potentially use the HPC systems to design improved nuclear weapons and ballistic missiles. William Schneider, a senior strategic trade official in the Reagan administration, testified before a Senate hearing that “end-user verification—a routine feature of advanced technology exports to China in the 1980s—has been abandoned.”⁹² Without satisfactory end-user verification, nonproliferation advocates argued that HPC technology sold to the Chinese Academy of Sciences, including a Silicon Graphics Challenge XL HPC system linking some 32 processors, could be used for weapons design purposes. Moreover, the HPC technology is now incorporated into

the "hidden network of the supercomputer complex," protected by electronic firewalls within the Chinese Academy of Sciences: this makes it difficult to monitor which computers within the Academy are being used for military purposes and which are being used for civilian science research.⁹³ Reflecting worries that the post-shipment verification system has completely collapsed, a January 1998 report by the Republican majority of the Subcommittee on International Security, Proliferation, and Federal Affairs of the Senate Governmental Affairs Committee complained: "Astonishingly, not a single supercomputer exported to China had either a pre-license check or a post-shipment verification."⁹⁴ Even Assistant Secretary of Commerce Roger Majak, head of Bureau of Export Administration, admitted in January 1998 that "we are not satisfied with the access that we have received, especially on post-shipment verification to China."⁹⁵

The Clinton administration, however, has defended its licensing policy toward China. William Reinsch responded to the reports about the Chinese Academy of Sciences by stating that "the administration rejects the view, held by some of our critics, that China is an enemy...our export control policy seeks to support our engagement strategy and creation of higher-paying, export-based jobs in the United States, while denying licenses for items whose export would pose significant national security risks to the U.S."⁹⁶ This rhetoric failed to satisfy nonproliferation advocates in Congress, however, particularly when it was reported in June 1997 that China actually possessed "hundreds" of U.S. HPC systems above

the threshold limit of 2,000 MTOPS. China had obtained these by buying systems just under the threshold limit at about 1,900 MTOPS and adding expansion motherboards to boost capabilities well above the 2,000 MTOPS limit.⁹⁷ This level of capability is described as "ten times the speed of the fastest personal computer," and available only in the United States and Japan.⁹⁸ Trade promoters thus had a hard time making a credible case for "foreign availability," since these machines could not have been acquired elsewhere by the Chinese.

The Chinese government responded to the allegations about the possible military use of U.S.-made HPCs by stating that "the Chinese side has bought through normal trade channels some large computers from the U.S. for use in meteorological forecasting, earthquake disaster prevention, and in other scientific and research areas...this is completely normal business activity, [and] the Chinese side has not violated the agreements reached concerning the aspects of export controls."⁹⁹ Even if the Chinese description of their usage of U.S.-made HPCs is accurate, the reports reveal worrisome gaps in U.S. export controls. Apparently these controls can neither easily verify end use in China, nor ensure that exports below the licensing threshold cannot be easily upgraded to performance levels above the threshold limit. These problems were highlighted in a report released by the House National Security Committee in October 1997. The report challenged the findings of the earlier Stanford report that shaped the 1995 liberalizations of HPC controls, concluding that HPC systems well below the 7,000 MTOPS threshold were relevant to U.S. se-

curity interests. The greatest concern for the panel was ensuring that HPC systems with capabilities of 7,000 MTOPS licensed to civilian end users are not transferred, once in the recipient country, to military end users.¹⁰⁰

The impact of the controversy surrounding the export of HPC technology to Russian and Chinese nuclear weapons facilities has revitalized advocates of nonproliferation. Despite objections from the computer industry and the Clinton administration, Congress included language in the 1998 Defense Authorization Act (Public Law 105-85), which tightened HPC export controls. In particular, the new law shifts end-use determination back onto the government. The new legislation is based on an amendment sponsored by the Chairman of the House National Security Committee, Representative Floyd Spence (Republican-South Carolina), and Representative Ronald Dellums (Democrat-California), the ranking minority member of the committee. The legislation applies only to HPC exports to "tier 3" countries (including Russia and China). It provides that any export of an HPC faster than 2,000 MTOPS to these countries must be submitted for a 10-day review by the Secretaries of Commerce, Defense, State, and Energy and the Director of the Arms Control and Disarmament Agency. If any of these officials raise objections during the review period, an individual license must be obtained for the export. Other provisions of the legislation mandate that the president must give Congress 180-days notice before changing the 2,000 MTOPS threshold for "tier 3" countries, and 120-days notice before changing the list of countries that fall

under “tier 3” restrictions. Finally, the legislation also requires that the Department of Commerce conduct post-shipment verification of end use on all HPCs faster than 2,000 MTOPS exported to “tier 3” countries, although it allows exceptions if the Secretary of Commerce provides a detailed explanation of why such an inspection was not conducted.¹⁰¹

In the debate over the bill, computer industry officials objected to the new restrictions, which a trade publication later referred to as a “rollback of the administration’s 1995 relaxation of export controls.”¹⁰² The Clinton administration also protested, with Deputy Assistant Secretary of Defense Mitchell B. Wallerstein warning that “these changes would significantly impair the President’s flexibility—and that of DOD—to ensure that export control policies and procedures are implemented in a manner that protects our national security interests without damaging the continued economic viability of the U.S. computer industry.”¹⁰³ Clinton’s National Security Advisor, Samuel Berger, even termed the Spence-Dellums language an “unacceptable limit to the President’s authority to conduct foreign policy,” and threatened to veto the Defense Authorization bill if it were included. However, a White House spokesman later changed this position, saying that although “we strongly object” to the tightened export controls, they would not trigger a veto.¹⁰⁴ The Senate initially resisted language similar to that proposed by Spence and Dellums in its version of the bill, but the conference report on the issue preserved it. President Clinton subsequently signed the bill into law on

November 18, 1997, giving the nonproliferation advocates their first victory in this area in several years.¹⁰⁵

It may be premature to conclude that the tide has fully turned in favor of the nonproliferation advocates, however. In January 1998, the Commerce Department released draft regulations covering end-use verification for HPCs exported to “tier 3” countries. The proposed regulations would reportedly allow the purchasers of U.S.-made HPCs to fill out end-use reports on their own and submit them to the U.S. government. Apparently, the proposed regulations do not impose any penalties on those purchasers who fail to submit such post-shipment end-use reports, and the one-time end-use report would not be followed up if the HPC was subsequently moved to another site or re-exported.¹⁰⁶

The proposed regulations drew fire immediately from both computer industry executives and nonproliferation experts. Computer industry officials said the regulations were “extraterritorial” and “unenforceable,” since they attempt to impose reporting requirements on foreign companies operating outside the United States. “This is wacko,” commented one computer executive, suggesting that the industry opposes even cursory post-shipment end-use verification.¹⁰⁷ Nonproliferation advocates, by contrast, ridiculed the proposed regulations as absurdly lax, with Dr. Gary Milhollin of the Wisconsin Project on Nuclear Arms Control saying that the Commerce Department was “treating supercomputers like blenders and fishing rods. Just fill out a little card and send it in.” Milhollin predicted

that nonproliferation advocates in Congress would object to the proposed regulations, viewing them as inconsistent with the end-use verification provisions of the 1998 Defense Authorization Act.¹⁰⁸ Thus the stage is now set for a the latest phase of the struggle between trade promoters and nonproliferation advocates over HPC export controls.

CONCLUSION

Throughout the first five years of his administration, President Clinton has largely stood behind computer exporters and taken several actions to liberalize HPC export controls. It is possible, however, that his stance will now change in the wake of the Russia and China cases and the subsequent resurgence of nonproliferation advocates in the Congress. The Clinton administration’s acquiescence in the provisions of the 1998 Defense Authorization Act suggests that the nonproliferation advocates have strengthened their position, although it remains too early to say if this trend will continue. The key factor is the ongoing philosophical debate over the priority that should be given to trade promotion and nonproliferation initiatives in the formulation of export control policy. This disagreement continues to find expression in both executive actions by the Clinton administration—like the proposed regulations on end-user verification—as well as in Congressional debate over the still-pending revised Export Administration Act.

A review of the debate between the two perspectives in the scholarly literature and in Congressional debates shows strong arguments on each side. Given the intensity of the case for both trade promotion and nonproliferation, it would appear

that the best system of export controls is one that allows for flexibility and the handling of export licenses on a case-by-case basis.¹⁰⁹ By reducing the number of days allowed for the processing of a license request, but preserving the right of agencies to appeal Bureau of Export Administration decisions to the president, the proposed Export Administration Act ensures that the most contentious cases will be resolved at the highest level.¹¹⁰ The 10-day review period mandated by the 1998 Defense Authorization Act also seems a reasonable compromise, as it at least allows some time for a review without imposing crippling delays on industry.

However, the effort to reestablish a statutory basis for export control policy through the passage of a revised Export Administration Act has been frustrated by the difficulty of defining the precise conditions and time frames under which agencies may appeal to the president. Disagreements over reforming the licensing process reflect the extent to which small details have enormous political implications in the export control licensing process. While the business community is relatively satisfied with the status quo and fears that new legislation—like the 1998 Defense Authorization Act—will tighten controls, the proliferation community fears looser controls. The result is deadlock, blocking the passage of the proposed Export Administration Act. Backers of the proposed legislation have sought to resolve these problems before bringing the Export Administration Act to a floor vote, but Congressional staffers believe that such behind the scenes lobbying requires pressure from the outside community, which

has until now largely been satisfied with the status quo.¹¹¹ William Reinsch, Under Secretary of Commerce for Export Administration, takes a different tact, arguing that “a statutory foundation” for licensing reforms “would send an important message to U.S. exporters that these reforms will not be rolled back.”¹¹²

The reconciliation of these opposing viewpoints is necessary for the passage of a revised Export Administration Act and the codification of the HPC export control process. Until the trade promoters or the non-proliferation advocates compromise or one of them attains the level of consensus for their agenda that was reached by the containment doctrine during the Cold War, the current standoff will likely continue. The tightening of controls imposed by the 1998 Defense Authorization Act could foster the emergence of a compromise, however, as computer industry executives are now less satisfied with the status quo, and may view a revised Export Administration Act as a way to prevent non-proliferation advocates from enacting piecemeal restrictions in the future.

Although the streamlining measures in the proposed 1996 Export Administration Act failed to pass in the 104th Congress, a new Export Administration Act awaits the 105th Congress. Other Clinton administration decisions, including general license exemption reforms and the failure (thus far) to punish unlicensed exporters of HPCs to China and Russia aggressively, indicate that the trade promoters continue to remain a potent political force in Washington, despite the setback dealt them by the restrictions imposed by the 1998 Defense Autho-

rization Act. Whether this latest legislation signals a new trend toward tighter controls on HPC exports may ultimately depend on the “transition states”: should a former Cold War adversary test a nuclear device that can be linked to the export of a U.S. HPC or transfer HPC capabilities to a rogue regime, it would likely galvanize support for stronger export controls. However, in the absence of such a dramatic event, the impact of the recent Russian and Chinese cases could easily fade over time. In that case, it may well be that the trade promoters will continue to have the upper hand in the design of U.S. export controls on HPC.

¹ For a discussion of the issues involved in balancing trade and strategic interests in the formulation of HPC export control policy, see John Arquilla, “Between a Rock and a Hard-Drive: Export Controls on Supercomputers,” *The Nonproliferation Review* 3 (Winter 1996), pp. 55-61.

² *Public Law* 105-85, Sections 1211-1215. The full text of the law is available on the World Wide Web through the Library of Congress at <http://thomas.loc.gov>.

³ Michael S. Lelyveld, “Computer-Use Certification Program Hit,” *The Journal of Commerce*, January 13, 1998, pp. 1, 3.

⁴ Marie Anchoroguy, “Japanese-American Trade Conflict and Supercomputers,” *Political Science Quarterly* 109 (Spring 1994), p. 40.

⁵ Jack Worlton, *Some Myths About High Performance Computers and Their Role in the Manufacture of Nuclear Weapons* (Los Angeles: Worlton and Associates, Technical Report #32, June 22, 1990).

⁶ Jack Worlton argues that the term supercomputer term is now outdated because “a word that is used to mean everything means nothing.” (See Worlton, *Some Myths About High-Performance Computers*, p. 21). However, the term “high-performance computer” is also somewhat ambiguous. This anomaly is possibly explained by the desire of the computer industry and its representatives to de-emphasize the power and capabilities of these machines by removing the word “super”.

⁷ Seymour Goodman *et al.*, *Building on the Basics: An Examination of High-Performance Com-*

puting Export Control Policy in the 1990s (Palo Alto, CA: Center for International Security and Arms Control, November 1995).

⁸ Nancy Dunne and Louise Kehoe, "US Relaxes Controls on High-Tech Exports," *Financial Times*, September 30, 1993, p. 1.

⁹ Pat Cooper and Theresa Hitchens, "New U.S. Computer Export Controls Spark Optimism, Arms Control Fear," *Defense News*, October 16-22, 1995, p. 26.

¹⁰ Pat Cooper and Theresa Hitchens, "U.S. Reviews Computer Export Decontrols: Will Rethink Technology Evaluation Process for Value to Weapons Makers," *Defense News*, December 18-25, 1995, p. 6.

¹¹ For further reading on the technological aspects of the development of high performance computers in the 1990s relative to the capabilities of other computers, see Worlton, *Some Myths About High Performance Computers*, as well as Goodman *et al.*, *Building on the Basics*. See also the testimony of Dr. Anita K. Jones, Director, Defense Research and Engineering, Department of Defense, before the House Committee on Science Sub-Committee on Basic Research on the Federal High Performance Computing and Communications (HPCC) Program, Federal News Service, October 31, 1995, pp. 12-20.

¹² Anchoroguy, "Japanese-American Trade Conflict," pp. 35-80.

¹³ *Ibid.*, p. 39.

¹⁴ U.S. Congress, House, Committee on Science, Subcommittee on Basic Research, *Hearing on Accelerated Strategic Computing Initiative: Statement of Dr. Anita K. Jones*, 104th Congress, 1st session, October 31, 1995, p. 16

¹⁵ William Perry, *Annual Report to the President and the Congress* (Washington, D.C.: U.S. Government Printing Office, February 1995), p. 161.

¹⁶ Gary Milhollin, "Fire Sale," *The New York Times*, September 18, 1996, p. A19.

¹⁷ "Information warfare is designed to achieve information superiority in support of national military strategy by affecting adversary information systems while leveraging and protecting the Department's information and information systems." In Perry, *Annual Report to the President and Congress*, p. 263.

¹⁸ For further reading on the emerging significance of IW, see Martin Libicki, "The Emerging Primacy of Information," *Orbis* 40 (Spring 1996), pp. 261-274; John Arquilla, "The Strategic Implications of Information Dominance," *Strategic Review* (Summer 1994), pp. 24-30; and Joseph A. Nye and William Owens, "America's Information Edge," *Foreign Affairs* 75 (March-April 1996), pp. 20-36.

¹⁹ See Perry, *Annual Report to the President and Congress*, pp. 71-74 and Trade Promotion Coordinating Committee, *National Export Strategy* (Washington, D.C.: Trade Promotion Coordinating Committee, October 1993), p. 32.

²⁰ For a discussion of the COCOM regime, see John Heinz, *U.S. Strategic Trade: An Export Control System for the 1990s* (Boulder, CO: Westview Press, 1990); Philip J. Funigiello, *American-Soviet Trade During the Cold War*

(Chapel Hill, NC: University of North Carolina Press, 1988); Stuart MacDonald, *Technology and the Tyranny of Export Controls* (New York: St. Martin's Press, 1990); and Michael Mastanduno, "The United States Defiant: Export Controls in the Postwar Era," *Daedalus* 120 (Fall 1991), pp. 91-112.

²¹ Mastanduno, "The United States Defiant," pp. 99-100.

²² *Ibid.*, pp. 102-103.

²³ See George Kozmetsky, "Supercomputers and National Policy: Maintaining U.S. Preeminence in an Emerging Industry," in J.R. Kirkland and J.H. Poole, eds., *Supercomputers* (New York: Praeger, 1987), pp. 9-42.

²⁴ Goodman *et al.*, *Building on the Basics*, pp. 2-3.

²⁵ National Academy of Sciences, Panel on the Future Design and Implementation of U.S. National Security Export Controls, *Finding Common Ground: U.S. Export Controls in a Changed Global Environment* (Washington, D.C.: National Academy Press, 1991), p. 251.

²⁶ Goodman *et al.*, *Building on the Basics*, p. 2.

²⁷ Heinz, *U.S. Strategic Trade*, pp. 34-35.

²⁸ Mastanduno, "The United States Defiant," p. 107.

²⁹ Ambassador Alan Wendt, Senior Representative for Strategic Technology Policy, "US Export Controls in a Changing Global Environment" Address before a National Academy of Sciences symposium, Irvine, California, June 11, 1991, in *U.S. Department of State Dispatch* 2 (July 1, 1991), p. 480.

³⁰ John Glenn, "Supercomputers and Superbombs," *Congressional Record*, October 31, 1989 S14382.

³¹ Wendt, "U.S. Export Controls," p. 481.

³² Gary K. Bertsch and Steven Elliot-Gower, "US Export Controls in Transition: Implications of the New Security Environment," in David Kemme, ed., *Technology Markets and Export Controls in the 1990s* (New York: New York University Press, 1991), pp. 105-128.

³³ See Gary K. Bertsch and Richard T. Cupitt, "Nonproliferation in the 1990s: Enhancing International Cooperation on Export Controls," *The Washington Quarterly* 16 (Autumn 1993), pp. 53-70.

³⁴ Seymour E. Goodman *et al.*, "High Performance Computing: Controllability and Cooperation," in *Dual-Use Technologies and Export Controls in the Post-Cold War Era: Documents from a Joint Program of the National Academy of Sciences and the Russian Academy of Sciences* (Washington, D.C.: National Research Council, 1991), p. 38.

³⁵ See also, Christine Westbrook and Alan B. Sherr, "U.S.-Soviet Joint Ventures and Export Control Policy," in Gary K. Bertsch and Steven Elliot-Gower, eds., *Export Controls in Transition: Perspectives, Problems, and Prospects* (Durham, NC: Duke University Press, 1992), pp. 169-202.

³⁶ Goodman *et al.*, "High Performance Computing," pp. 51-53.

³⁷ *Ibid.*, p. 2.

³⁸ *Ibid.*, pp. 2-3.

³⁹ Nancy Dunne and Louise Kehoe, "US Relaxes Controls on High Technology," *Financial Times*, September 30, 1993, p. 1.

⁴⁰ "Administration Delays Tackling Defense Export Issues," *Aerospace Daily*, October 1, 1993, p. 2.

⁴¹ Jack Robertson, "Export Curbs Blasted; Policy Change Urged; Controls on Technology Exports," *Electronic News*, June 14, 1993, p. 1.

⁴² U.S. Congress, House, Committee on Foreign Relations, *U.S. Proliferation Policy Toward Rogue Regimes: Testimony of Stephen Bryen*, 103rd Congress, 1st session, September 14, 1993.

⁴³ Bernard Levine, "Industry Seeks More Export Slack; Computer Industry Wants Liberalized Rules for Components And Telecommunications," *Electronic News*, October 4, 1993, p. 1.

⁴⁴ Trade Promotion Coordinating Committee, *National Export Strategy*, p. 32.

⁴⁵ Norman Mineta, "Toward a National Export Strategy," *Congressional Record* 139 (130), September 29, 1993, p. E2312.

⁴⁶ Barney Frank, "Freeing the U.S. Computer Industry," *Congressional Record* 139 (144), October 22, 1993, p. E2515.

⁴⁷ U.S. Congress, House, Committee on Science, Subcommittee on Technology, Environment, and Aviation, *Hearing on Export Controls and High Technology: Statement by James L. Novakoff, Manager, International Trade Affairs, Cray Research, Inc.* 103rd Congress, 2nd session, May 24, 1994, pp. 72-73.

⁴⁸ Stuart Auerbach, "Cray Deal A Casualty of Atomic Weapons Fears," *The Washington Post*, March 19, 1993, p. C1.

⁴⁹ David Durenberger, "Export Controls—The Need For A Sensible U.S. Policy," *Congressional Record* 139 (37), March 23, 1993, p. S3542.

⁵⁰ U.S. Government official (name withheld by request), interview with author, Washington, D.C., April 1996.

⁵¹ Levine, "Industry Seeks More Export Slack," p. 1.

⁵² Council on Competitiveness, *Economic Security: The Dollar\$ and Sense of U.S. Foreign Policy* (Washington, D.C.: Council on Competitiveness, 1994), p. 66.

⁵³ U.S. Congress, House, Committee on International Relations, Subcommittee on International Economic Policy and Trade, *Hearing on Impact of Export Controls on U.S. Industry: Statement of Howard Lewis III, Vice President for Trade and Technology Policy, National Association of Manufacturers*, 104th Congress, 1st session, January 25, 1995, p. 18.

⁵⁴ U.S. Congress, Senate, Committee on Banking, Subcommittee on Freedenberg, Testimony before the Senate Committee on Banking, Housing, and Urban Affairs Subcommittee on International Financial and Monetary Policy, *Hearing on the Export Administration Act*, 103rd Congress, 2nd session, February 3, 1994, p. 73.

⁵⁵ U.S. Congress, House, Committee on Science, Space, and Technology, Subcommittee on Technology, Environment, and Aviation, *Hearing on the Export Administration Act: Testimony of Luke Alexander*, 103rd Congress, 2nd session, May 24,

1994, pp. 52, 57.

⁵⁶ For the exact wording of the regulations governing HPC export controls, see *15 Code of Federal Regulations*, Chapter VII, Subchapter C, Paragraph 740.7 and 742.12. For Clinton's statement announcing the 1995 liberalization see William Jefferson Clinton, "Statement on Reform of Computer Export Controls," *Weekly Compilation of Presidential Documents* 31 (40), October 9, 1995, pp. 1783-1784.

⁵⁷ Cooper and Hitchens, "New U.S. Export Rules Spark Optimism," p. 26.

⁵⁸ U.S. Congress, Senate Governmental Affairs Subcommittee on International Security, Proliferation, and Federal Services, hearing on *Proliferation and U.S. Export Controls*, 105th Congress, 1st Session, 11 June 1997, p. 17.

⁵⁹ Theresa Hitchens and Barbara Opall, "U.S. Revises Plan to Ease Computer Export Rules," *Defense News*, February 14-20, 1994, p. 1.

⁶⁰ Goodman *et al.*, *Building on the Basics*, p. vii.

⁶¹ "Spence Blasts Clinton For Easing Overseas Supercomputer Sales," *C4I News*, October 12, 1995, p. 1.

⁶² General Accounting Office, *Export Licensing Procedures for Dual-Use Items Need to Be Strengthened: Report to Senator John Glenn, Chairman of the Committee on Government Affairs* (Washington, D.C.: General Accounting Office, April 1994).

⁶³ *Ibid.*, p. 30.

⁶⁴ *Ibid.*, p. 4.

⁶⁵ U.S. government official (name withheld by request), interview with author, Washington, D.C., March 1996.

⁶⁶ General Accounting Office, *Export Licensing Procedures*, pp. 50-52.

⁶⁷ This summary of the export licensing process is taken from: Offices of Inspector General at the U.S. Departments of Commerce, Defense, Energy, and State, *The Federal Government's Export Licensing Processes for Munitions and Dual-Use Commodities* (Washington, D.C.: U.S. Government Printing Office, September 1993), p. 8. For a summary flowchart of the dual-use export licensing process, see p. 23.

⁶⁸ See H.R. 361 "Omnibus Export Administration Act of 1996," section 109, for a detailed account of the proposed timeline for license review.

⁶⁹ See U.S. Congress, House, International Relations Committee, *Comments by Representative Sam Gejdenson (D-CT), at H.R. 361 Mark-up*, 104th Congress, 1st session, March 29, 1996.

⁷⁰ U.S. government official (name withheld by request), interview with author, Washington, D.C., April 1996.

⁷¹ U.S. Congress, House, Committee on Foreign Relations, Subcommittee on Economic Policy, Trade, and the Environment, *Hearing on the Export Administration Act: Statement of Richard Lehman, Director of Public Affairs, the IBM Corporation*, 103rd Congress, 1st session, November 18, 1993, p. 41.

⁷² See the following for further reading on post-Cold War multilateral export control regimes: Mastanduno, "The United States Defiant;" Aaron Karp, "Controlling Weapons Proliferation: The

Role of Export Controls" *The Journal of Strategic Studies* 16 (March 1993), pp. 18-45; Bertsch and Cupitt, "Non-Proliferation in the 1990s," pp. 53-70.

⁷³ For a review of U.S. multilateral arms control agreements, see Zachary Davis *et al.*, *Proliferation Control Regimes: Background and Status* (Washington, D.C.: Congressional Research Service, April 27, 1995) and Arms Control and Disarmament Agency, *Threat Control through Arms Control* (Washington, D.C.: U.S. Government Printing Office, 1995).

⁷⁴ Six key reports that support, with varying degrees of enthusiasm, trade promotion include National Research Council, *Dual-Use Technologies and Export Control in the Post-Cold War Era* (Washington, D.C.: National Academy of Sciences, 1994); Trade Promotion Coordinating Committee, *National Export Strategy: Meeting Foreign Competition* (Washington, D.C.: Trade Promotion Coordinating Committee, October 1995); J. David Richardson, *Sizing Up U.S. Export Disincentives* (Washington, D.C.: Institute for International Economics, 1994); Jack Worlton, *Some Myths About High-Performance Computers*; Goodman *et al.*, *Building on the Basics*; Council on Competitiveness, *Economic Security: The Dollar\$ and Sense of U.S. Foreign Policy*.

⁷⁵ U.S. government official (name withheld by request), interview with author, Washington, D.C., March 1996.

⁷⁶ Treaty on the Non-Proliferation of Nuclear Weapons, Article I (New York: United Nations, 1968).

⁷⁷ U.S. government official (name withheld by request), interview with author, Washington, D.C., March 1996.

⁷⁸ Zachary Davis *et al.*, *Proliferation Control Regimes*, p. 8. For a more skeptical treatment of the IAEA safeguards process, see Paul Leventhal, "Plugging the Leaks in Nuclear Export Controls: Why Bother?" *Orbis* 36 (Spring 1992), pp. 167-180.

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