Proliferation and Cooperation

"One 486 chip has more computing power than U.S. scientists had when they developed the first atomic bomb."

—Philip Heerman, computer scientist, Sandia National Labs,
Quoted in *Wired* Magazine, April 2001

The assumption that because computers and microprocessors are the engines of economic growth they must also be the engines for military force is wrong.

Critics of control threshold increases believe that high performance computers are sensitive "enabling" technologies for nuclear weapons, missiles, submarines, and other military applications. It seems reasonable to assume that if computers and microprocessors are the engines of economic growth, they are also engines of military strength. Such a premise, although certainly true in the 1970s and probably true in the 1980s, is no longer valid today. The dramatic increase in computing power over the past 10 years and the transformation of computers from highly specialized research tools in the 1980s into a mass-market infrastructure in the late 1990s breaks the connection between high performance computing and weapons proliferation.

Military applications and WMD programs do not require much computing power.

Fundamentally, military applications do not require much computing power. This is especially true for design and manufacturing. The United States designed and built its weapons and military equipment with computers of 500 to 1000 MTOPS.[1] At the time, these were large, sophisticated supercomputers, and high performance computers as they are known today did not exist. The same computing power or more is now available from a good desktop computer or workstation now commonly found in offices and classrooms.

For example, the F-22, the most advanced U.S. fighter, was designed with a 958 MTOPS Cray supercomputer, roughly one-quarter the power now found in mass-produced Pentium chips.[2] High performance computers are not necessary for foreign military or nuclear weapons programs and foreign weapons do not depend on access to computing power. Computing power is considerably less important than the ability to integrate materials, manufacturing equipment, and skills into a modern weapon. This ability to integrate disparate technologies requires years of experience in design, operation, and manufacturing.[3] Faster computers can cut program run times, but the output is the same, and saving a few hours in programs whose lengths are measured in years does not provide an advantage.

Despite frequent charges that computers make a substantial contribution to foreign weapons of mass destruction (WMD) programs, these programs also do not require high performance computers for their design and construction. The most

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telling example of this is that after more than a decade of review, none of the multilateral WMD nonproliferation regimes control computers—the Nuclear Suppliers Group, the Missile Technology Regime, and the Australia Group. These regimes, led by the United States, have concluded that computers are not especially significant for proliferation, given the very low levels of computing power needed for design and manufacturing.

This is particularly true for nuclear weapons. The U.S., Soviet, British, French, and Chinese nuclear arsenals were designed without high performance computers. First generation weapons were designed and produced entirely without benefit of computers. One proliferation expert notes:

Without reliable data and design codes, computer technology has little use for countries developing weapons systems.

> At one time computers, useful for numerical simulation in weapon design, were considered a restricted technology that limited the ability of other nations to develop weapons. However, this capability is most important for thermonuclear weapon design, not fission weapons. The computational effort required for the neutronic and hydrodynamic computations used in fission weapons is actually quite modest, easily within the capability of any commercial PC available today. Even with thermonuclear weapon design, computational requirements are not that extreme. The design efforts for most weapons in the US arsenal were completed well before the microprocessor revolution of the 1990s. A high-end workstation is comparable or superior to the best computers available when most current US warheads were developed. Even the lowest performance office computers now on the market are orders of magnitude faster than the computers used to design the first hydrogen bombs. [4]

Computer power for mobile battlefield applications is less critical than the ability to integrate computers, sensors and platforms into effective systems.

Numerous studies have reached this conclusion. Studies by Etter, Goodman, and others note that computing power is less important than access to test data and specialized software. Sophisticated simulation capabilities can permit nuclear weapon states to reduce or even eliminate the need for weapons tests to develop or prove a design. However, computational power is of little benefit unless the computer is running sophisticated codes based on extensive experience and data—in particular, data derived from actual nuclear weapons explosions. A country without extensive experience in weapons design is at a significant disadvantage, and the lack of reliable data and proven codes will substantially constrain the usefulness of computer technology.[5]

First or second generation nuclear weapons of the kind proliferators are attempting to manufacture need very little computing power for their design or manufacture. Designing the next generation of nuclear weapons needs immense computing power—power of a kind that now can be obtained only from machines capable of

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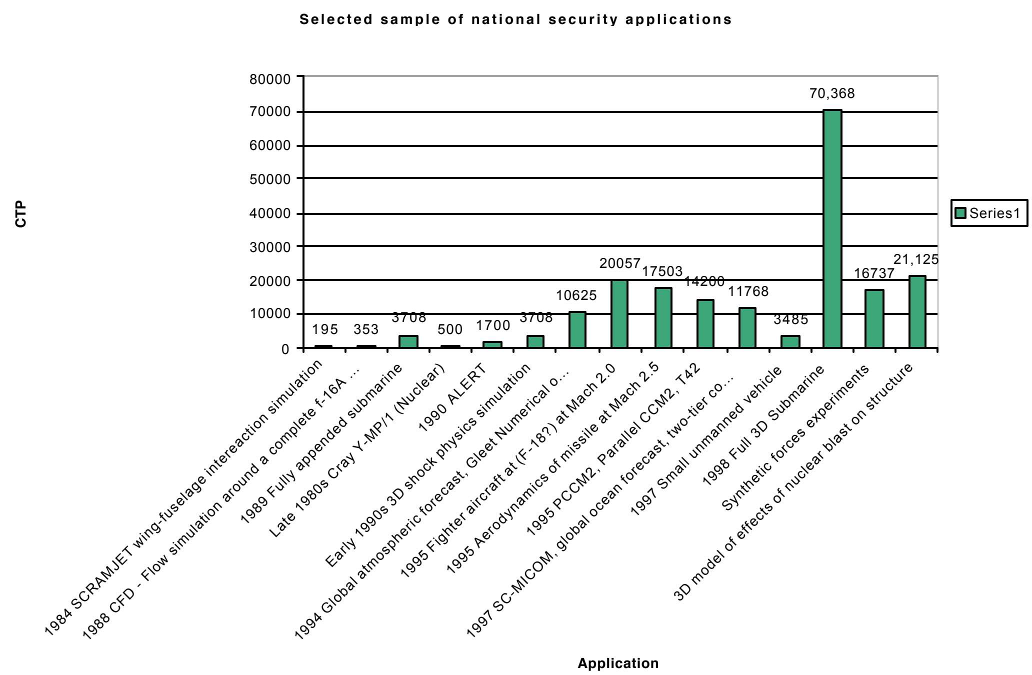
millions of MTOPS. Only a few U.S. laboratories and agencies have these large, expensive, specially designed machines.

Although many conventional military applications may require high-powered computing, battle management applications require very little computing power.

Computers can contribute to military capabilities in ways other than the design and manufacture of weapons. Examples of such applications are shown in figure 2.1. A key objective of the Cold War export control system was to prevent the Soviet Union from obtaining Western microprocessors and computers for use as components in weapons systems or in military applications such as antisubmarine warfare, air defense, battle management, and weather prediction. This objective lives on in our export controls despite the radical change in the international security and economic environment.

Figure 2.1

Many applications essential to national security require very small amounts of computing power.



Work by Goodman, Wolcott, and Homer provides a range of MTOPS used in military applications. Many of these applications can be run using clusters of commodity computers.[6] Cluster computing provides very high performance for most military applications, but it is not suitable for mobile battlefield applications. However, the need for high performance computers in battle management applications is overstated. Many military applications use mass-market desktop computers, workstations, and servers. In many cases, high performance computing is used to develop the necessary software codes for battle management, not to run them. Data collected by platforms such as aircraft or submarines are taken back for analysis and processing. Clustered computers can be used in this processing phase to analyze the collected data and produce software applications and codes to be sent back to aircraft and ships for battle management and combat purposes. These codes can then be run on less powerful machines.

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JSTARS: 650 MTOPS

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EP-3E: 240 MTOPS

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Apple Laptop: 2018 MTOPS

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The United States itself used elderly 650 MTOPS VAX computers until recently in the J-STARS battlefield surveillance aircraft. Although computers of this level are now widely available, the VAX is no longer produced. The computers used on the EP-3E Aries II (the aircraft involved in the recent incident with China) uses 1997 workstations capable of 240 MTOPS.[7] Both the JSTARS and the EP-3E used computers that are at least a generation or two behind what is available on the retail market. In addition, few countries can afford to attempt to mirror U.S. battle management systems—they are more interested in finding where these systems are vulnerable.

Computing power is important in performing these functions, but less critical than the ability to integrate computers, sensors, and platforms into effective systems that can operate on the battlefield. The crucial element for many of these applications is the sensor. For the foreseeable future, the United States faces no likely competitors in fielding advanced space-based and aircraft sensors. This limits the utility of access to computer power for any potential opponent to that information that can be obtained from commercially available imagery and from traditional sensors, such as ground-based radars and aerial photoreconnaissance.

One national security function—cryptanalysis—deserves separate discussion. Specially modified computers with very high performance remain useful for cryptanalysis, but clustered low-level computers can provide this level of performance. The National Security Agency (NSA) also uses very powerful, specially designed microprocessors and computers for cryptanalytic purposes, but these are not general-purpose items sold on the commercial market. They would be controlled as munitions for export purposes. NSA became indifferent to export controls for commercial high performance computers several years ago.

Technological improvements have eroded the proliferation and security rationale for controlling commercially available hardware.

An energetic political debate has exaggerated the role of computers in military applications. Assembling conventional weapons or weapons of mass destruction, requires a package of skills, equipment, and technologies. The ability to integrate these various elements into a modern weapon requires deep experience in design, operation, and manufacturing. It may require specialized databases and, in many cases, test data assembled over a period of years.[8] These elements are more important than the speed at which the data are processed. Computers are only a small part of the skills and equipment needed to build weapons.[9] More important, high performance computers can be replaced in a weapons program by an average desktop or workstation and a strong national software capability.

Conclusion

The popular image of computers suggests that they are essential to arms production

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and proliferation. This notion is intuitively appealing—given the role computers play in the economy, in research, and in U.S. weapons development programs—but misleading. Information technology is crucial to military applications, but computer speed is not. Performance increases in basic microprocessors and desktop computer sold in the millions, combined with software and applications developments, mean that today's low-level systems provide all the computing power needed for military and proliferation-related applications. Technological improvements have eroded the proliferation and security rationale for the control of commercially available hardware. Military advantage results from specialized software and applications more than the power of the computers available. One result of these changes has been a marked reduction in support among U.S. allies for continued controls on information technology.

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Notes

[1] See Seymour E. Goodman, Peter Wolcott, and Patrick Homer, *High performance Computing, National Security Applications and Export Control Policy at the Close of the 20th Century* (Washington, D.C.: Bureau of Export Administration, 1998).
[2] Ibid., 15.
[3] See Jeffrey Cooper, "Military Working Group Paper," prepared for the CSIS Information Technology Export Control Project, December 29, 2000, 8–12.
[4] Carey Sublette, "Nuclear Weapons—Frequently Asked Questions" (February 1999), Federation of American Scientists, http://www.fas.org/nuke/hew/Nwfaq/Nfaq0.html, accessed April 15, 2001.
[5] See Goodman et al., *High Performance Computing*; Sublette, "Nuclear Weapons"; and Etter et al., "Export Control of High Performance Computing."
[6] See Department of Defense Modernization Group, http://www.ncsa.uiuc.edu/Edu/DodHome.html, accessed April 15, 2001.
[7] "Navy Training System Plan for the EP-3E Airborne Reconnaissance Integrated Electronics Suite II Sensor System Improvement Program Aircraft," N88-NTSP-A-50-8605D/P, January 2001.
[8] Cooper, "Military Working Group Paper."
[9] The Rock Island Arsenal, working as a test bed for DARPA in advanced military productions, found it could run the most sophisticated software "agents" for modernized production methods with a handful of Pentium desktop computers. The project reports, "It is substantially less expensive from a hardware perspective to use a large number of inexpensive processors than a single processor having equivalent total processing capabilities. See Autonomous Agents at Rock Island Arsenal, http://www.aaria.uc.edu/menu.html, accessed April 15, 2001.

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