The Pentagon, The Major Vertex of the Iron Triangle

Military Influence on Technological Change in the United States

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Technology has three aspects, “artifacts, knowledge, and social relations.”[1] Technological change is the development and implementation of new forms, or transformation of existing forms of either artifacts, knowledge, or social relations. There has been a great amount of technological change in the United States since World War II, affecting virtually all facets of society. World War II itself, served as a major stimulus for technological development because “In American (and world) history, war and the preparations for it have had an extraordinary influence on technological change, industrialization, and economic development.”[2] In contrast to previous wars, however, “the United States did not completely demobilize with the defeat of the Axis powers in 1945. The close relationship that the federal government had forged with industry and academia during the war extended into the Cold War,”[3] and with it the influence of the military in technological development became long lasting. “Eisenhower famously named this new form the ‘military-industrial complex,’ but the nexus of institutions is better captured by the concept of the ‘iron triangle’ of self-perpetuating academic, industrial, and military collaboration.”[4] The military has influenced technological change to a large degree in all three aspects of technology. As David Noble has said, “The influence [of the military] spills over in the specific shape of the technologies themselves and in the way they are put together and used, with far-reaching economic and social consequences.”[5] It can be claimed that the military has been the dominant influence on technological change, not just having the plurality, but in fact having the clear-cut majority of influence among the various social groups. While users, entrepreneurs, and workers have influenced technological change in the course of post-World War II America, the military has clearly had the greatest effect, acting on its own, through other governmental agencies, and through control or influence of industry and academia.

Numerous technologies were developed and instituted by the iron triangle during World War II. The list of technologies developed to create an advantage in the arsenal of the United States was immense, including:

> radar, nuclear energy, electronics, computers, high-performance aircraft, and control and communication systems. All of these technologies, and the list is endless, were created to serve purposes peculiar to the military: proximity fuses for bombs, submarine and aircraft detection, combat communications, rocketry and missile warfare, gunfire control, ballistics calculations, command and control defense networks, high-speed, versatile-flight aircraft, and nuclear weapons.[6]

The science of Cybernetics, developed by Norbert Wiener, used for radar-controlled anti-aircraft fire, was also developed in this time.[7] To preserve the system that allowed the United States to enhance its arsenal so greatly, and to remain at the fore with the onset of the Cold War apparent, government needed to react. "In his… *Science: The Endless Frontier*, composed at President Roosevelt's request as a blueprint for postwar science and technology policy, Vannevar Bush called for a civilian-controlled National Research Foundation to preserve the government-industry-university relationship created during the war."[8] As a result of Bush's urging, the National Defense Research Committee, which gave research and development contracts to industry, academia, and military laboratories to develop new weapons, was founded.[9] In addition, the Office of Naval Research (ONR), and the National Science Foundation, also founded after WWII, gave similar contracts. The ONR, in particular, was instrumental in not only promoting military technology development, but basic scientific research as well. In fact, "By 1948 the ONR was funding 40 percent of *all* basic research in the United States."[10]

Electrical & electronics technologies, and electrical sciences, were major areas in which rapid technological change occurred in the United States. For much of the postwar period, the United States has been the worldwide leader in electrical technologies, and the military is the major reason. The transistor forms the basis for all modern digital technologies. It was internally funded and developed in 1947 by Bell Labs for long distance telephony. The type of transistor first developed was a point contact transistor.[11] Despite the fact that development of the early transistor was independent, the success of this technology, and its universal replacement of vacuum tubes was the result of the military. Much work was needed to make the transistor reliable and cost effective, and the military provided funding. As a result, the small, cheap, and reliable field effect transistor and junction transistor were developed.[12] The military was the major buyer of transistor technologies well into the 1960s, using them for space applications, aircraft, communications, and missiles.[13] Since the military bought so many transistors, companies had a capital base from which to expand into industrial and consumer products like computers, microprocessors, and transistor radios. The military was also the dominant player in future semiconductor research. "Almost half of the cost of semiconductor R&D between the late 1950s and the early 1970s was paid by military sources. Defense users were first to put into service integrated circuits (ICs, the next major hardware advance after transistors)."[14] These advances in semiconductors, and electronics in general, followed the course set by the "military ideal of miniaturization of electronics,"[15] not necessarily the business ideal of profit maximization in sales to non-military customers. Direct support for research in these areas was channeled through the Pentagon's Advanced Research Projects Agency (ARPA). "ARPA-supported work has included… advanced microprocessor research (including work on gallium arsenide semiconductors and very-large-scale integrated circuits)."[16]

Computer science, design, and technology, which grew out of electrical and electronics engineering, have also seen major technological changes as a result of military sponsorship. In fact, "The Pentagon's Defense Advanced Research Projects Agency (DARPA) is more than any other single agency in the world, responsible for the shape of advanced computer science today—and for many technologies now in widespread commercial use."[17] "ONR money [also] proved especially significant for the burgeoning field of computer design."[18] Almost all of the major advances in the computer fields can be traced directly to the military. "DARPA… virtually creat[ed] the science of artificial intelligence. The first supercomputer… was a DARPA project. Computer time sharing, a fundamental advance, came out of work sponsored by DARPA; so did packet-switching networks, the workhorses of today's telecommunications data networks. And computer graphics——now used on desktop computers and video-arcade screens as well as in F-10 cockpits——is a DARPA-sponsored invention."[19] ARPA, the previous name of DARPA, also created "the ARPANET computer network, which eventually spawned… the modern worldwide network of networks known as the Internet."[20] Other advances in computer science and technology, as well as social relations associated with computers can be traced to non-military sources, especially from the 1970s onward. In this period, "personal computers went from being hobbyist kits, to mass-market machines, to nodes on a fledgling Internet."[21] Small start-up companies such as Microsoft and Apple, as well as large companies like IBM, started producing computers and software for the personal and business markets, and so tailored their products to meet these needs. The trajectory of development was shifted slightly by the popularity of the personal computer, but military influence remained stronger. "Even after mature commercial computer markets emerged in the early 1960s, U.S. military agencies continued to invest heavily in advanced computer research, equipment, and software."[22] "As Frank Rose has written, 'the computerization of society… has essentially been a side effect of the computerization of war."[23]

Insecticides were another focus area of the military technological development machine. "A specific goal drove development of insecticides by the U.S. government in World War II: military victory."[24] The military wanted to reduce the number of deaths caused by disease. Insects such as mosquitoes and lice were vectors for deadly diseases such as malaria and typhus. To eliminate this threat to the health of soldiers, insecticides were needed. "Just as supplies of insecticides became critical, a savior appeared in the form of a simple molecule called dichlorodiphenyltrichloroethane, or DDT."[25] DDT was used extensively by the military throughout the war. "Geigy Company of Switzerland discovered DDT's insecticidal properties in 1939."[26] That is to say, a private, foreign company, independent of military funding discovered the artifact of DDT before the war. Despite this fact, the military was, to a large degree, responsible for the prevalence of this chemical in the postwar period. Part of the military's role in the establishment of DDT as the insecticide of choice lies in the large purchases that it made, much like transistors. Geigy Company was a very small company, which had very little marketing for its product, and only advertised it for the Colorado potato beetle. By the end of the war, DDT was seen as a miracle chemical that could be used for all insects, and the proof lay in the military's use of it. Since it was seen as the savior of the United States military, there was a euphoria associated with it. DDT was used extensively in agriculture and general pest control in the postwar period as a result of military influence.

Technologies in the home in the 1950s saw a growth in automation. "washing machines, furnaces, toasters, coffee makers, thermostats and hot water heaters"[27] were among the household technologies that incorporated automatic components and processes. This automation grew out of the feedback and control systems that were developed for military uses during WWII. Despite the fact that the feedback mechanisms and control systems were developed for military technologies, they did not automatically arise in household technologies. Much adaptation was required to implement the concepts and ideas to other technologies. These adaptations were carried out unsupported by military money. In this area, military influence was minimal, though some artifacts that come out of ARPA/DARPA and NASA research found applications in the home. "DARPA almost single-handedly created the discipline of materials science, paving the way for high-strength, lightweight composites that are… [used] in tennis rackets."[28] While the influence of the military on household technologies was less than on computing, electronics, or insecticides, it was significant nonetheless.

Throughout the course of human history, military action has been a stimulus for technological development and change. When war is raging, there is only one measure of success, military victory. To stay ahead, a nation must adapt and rise to the challenge. Often, this requires bettering the arsenal of weapons a nation has at its disposal. In the United States, the iron triangle of military-industry-academia was the invention that won World War II. In the postwar era, the iron triangle not only remained but expanded, so that a large proportion of all technological development was directed by the military. Electronics, computers, and communications; automatic toasters, lightweight tennis rackets, and DDT, are all to a great degree the result of the military's influence. The military has been the dominant influence on technological change in the United States since World War II.

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[1] Ronald Kline, lecture, September 28, 2001

[2] Merritt Roe Smith and Gregory Clancey, eds., *Major Problems in the History of American Technology*, Boston, p. 427.

[3] Merritt Roe Smith and Gregory Clancey, eds., *Major Problems in the History of American Technology*, Boston, p. 427.

[4] Paul N. Edwards, "*Why Build Computers?*," in Merritt Roe Smith and Gregory Clancey, eds., *Major Problems in the History of American Technology*, Boston, p. 455.

[5] David Noble, "*Command Performance*," in Merritt Roe Smith and Gregory Clancey, eds., *Major Problems in the History of American Technology*, Boston, p. 463.

[6] David Noble, "*Command Performance*," in Merritt Roe Smith and Gregory Clancey, eds., *Major Problems in the History of American Technology*, Boston, p. 462.

[7] Ronald Kline, lecture, November 16, 2001

[8] Paul N. Edwards, "*Why Build Computers?*," in Merritt Roe Smith and Gregory Clancey, eds., *Major Problems in the History of American Technology*, Boston, p. 456.

[9] Ronald Kline, lecture, November 16, 2001

[10] Paul N. Edwards, "*Why Build Computers?*," in Merritt Roe Smith and Gregory Clancey, eds., *Major Problems in the History of American Technology*, Boston, p. 457.
[11] Ronald Kline, lecture, December 5, 2001
[12] Ronald Kline, lecture, December 5, 2001
[13] Ronald Kline, lecture, December 5, 2001
[14] Paul N. Edwards, "*Why Build Computers?*," in Merritt Roe Smith and Gregory Clancey, eds., *Major Problems in the History of American Technology*, Boston, p. 458.
[15] Ronald Kline, lecture, December 5, 2001
[16] Paul N. Edwards, "*Why Build Computers?*," in Merritt Roe Smith and Gregory Clancey, eds., *Major Problems in the History of American Technology*, Boston, p. 459.
[17] William D. Marbach, "*The Race to Build a Supercomputer*," in Merritt Roe Smith and Gregory Clancey, eds., *Major Problems in the History of American Technology*, Boston, p. 445.
[18] Paul N. Edwards, "*Why Build Computers?*," in Merritt Roe Smith and Gregory Clancey, eds., *Major Problems in the History of American Technology*, Boston, p. 457.
[19] William D. Marbach, "*The Race to Build a Supercomputer*," in Merritt Roe Smith and Gregory Clancey, eds., *Major Problems in the History of American Technology*, Boston, p. 445.
[20] Paul N. Edwards, "*Why Build Computers?*," in Merritt Roe Smith and Gregory Clancey, eds., *Major Problems in the History of American Technology*, Boston, p. 459.
[21] Merritt Roe Smith and Gregory Clancey, eds., *Major Problems in the History of American Technology*, Boston, p. 471.
[22] Paul N. Edwards, "*Why Build Computers?*," in Merritt Roe Smith and Gregory Clancey, eds., *Major Problems in the History of American Technology*, Boston, p. 458.
[23] Paul N. Edwards, "*Why Build Computers?*," in Merritt Roe Smith and Gregory Clancey, eds., *Major Problems in the History of American Technology*, Boston, p. 459.
[24] Edmund P. Russell III, "*Testing Insecticides and Repellents in World War II*," in Merritt Roe Smith and Gregory Clancey, eds., *Major Problems in the History of American Technology*, Boston, p. 399.
[25] Edmund P. Russell III, "*Testing Insecticides and Repellents in World War II*," in Merritt Roe Smith and Gregory Clancey, eds., *Major Problems in the History of American Technology*, Boston, p. 402.
[26] Edmund P. Russell III, "*Testing Insecticides and Repellents in World War II*," in Merritt Roe Smith and Gregory Clancey, eds., *Major Problems in the History of American Technology*, Boston, p. 402.
[27] Ronald Kline, lecture, November 28, 2001
[28] Jeff Bingaman and Bobby R. Inman, "*'Dual-Use' Technology, 1991*," in Merritt Roe Smith and Gregory Clancey, eds., *Major Problems in the History of American Technology*, Boston, p. 446.