Brian Martin, *Technology for nonviolent struggle*
(London: War Resisters' International, 2001)

Chapter 2

Militarised technology

In order to understand the potential role of technology for nonviolent struggle, it is useful to understand the actual role of technology for military purposes. What is technology?[1] A simple and narrow definition is that technology is any physical object created or shaped by humans (or other animals). Technologies include paper, toothbrushes, clothes, violins, hammers, buildings, cars, factories, and genetically modified organisms. These objects can be called artefacts. A broader definition of technology includes both artefacts and their social context, such as the processes, methods and organisations to produce and use them. This includes things such as the manufacturing division of labour, just-in-time production systems, town planning and methods used in scientific laboratories. This broader definition is useful for emphasising that artefacts only have meaning within the context of their creation and use. In this book, the word "technology" refers to both artefacts and their social context.

Similarly, "science" can be defined as both knowledge of the world and the social processes used to achieve it, including discussions in laboratories, science education, scientific journals and funding. The distinction between science and technology, once commonly made, is increasingly blurred. The scientific enterprise is deeply technological, relying heavily on instruments and associated activities. Just as importantly, the production of artefacts requires, in many cases, sophisticated scientific understanding. This is nowhere better illustrated than in contemporary military science and technology. For example, the development of nuclear weapons depended on a deep understanding of nuclear processes, and in turn nuclear technologies provided means for developing nuclear science. For convenience, I often refer just to "technology" rather than "science and technology," with the understanding that they are closely interlinked and that each can stand in for the other.

In this chapter, I examine military influences on technology. Some influences are immediate and obvious, such as military contracts to produce bazookas and cruise missiles; others are deep and structural, such as military links with capitalism and patriarchy. My approach is to start with the immediate influences and later discuss the deep ones. The first section deals with military funding and applications, training and employment, belief systems and suppression of challenges. The second section deals with "countervailing influences," namely factors that resist military influence on technology: civilian applications, bureaucratic interests and popular resistance. The final section discusses connections between the military and social structures of the state, capitalism, bureaucracy and patriarchy, and how they can affect technology.

Military shaping of technology

Military priorities play a major role in the development of many technologies.[2] Figures 1 and 2 illustrate how this process, which can be called the military shaping of technology, can occur. Factors such as funding and employment are pictured as influences from the top ("military influence/context"). Military applications are shown in the middle and civilian applications at the bottom. Figure 1 shows the case of science and technology that are very specifically oriented for military purposes, such as the computer software in a cruise missile; there are only occasionally a few civilian spinoffs. Figure 2 shows a more general perspective, looking at entire fields of science and technology. In this case, civilian applications are a significant competing influence.

With figure 1, the military-specific orientation is blatant. With figure 2, it is clear that both military and civilian purposes may be served by the same general fields. I now look in more detail at the specific areas of military funding and applications, training and employment, belief systems and suppression of challenges.

Military funding and applications

When money and other resources are provided to develop certain technologies, obviously this is an enormously strong influence on what technologies are actually developed. Military budgets for research and development (R&D) around the world are huge. They have resulted in an amazing array of powerful and sophisti

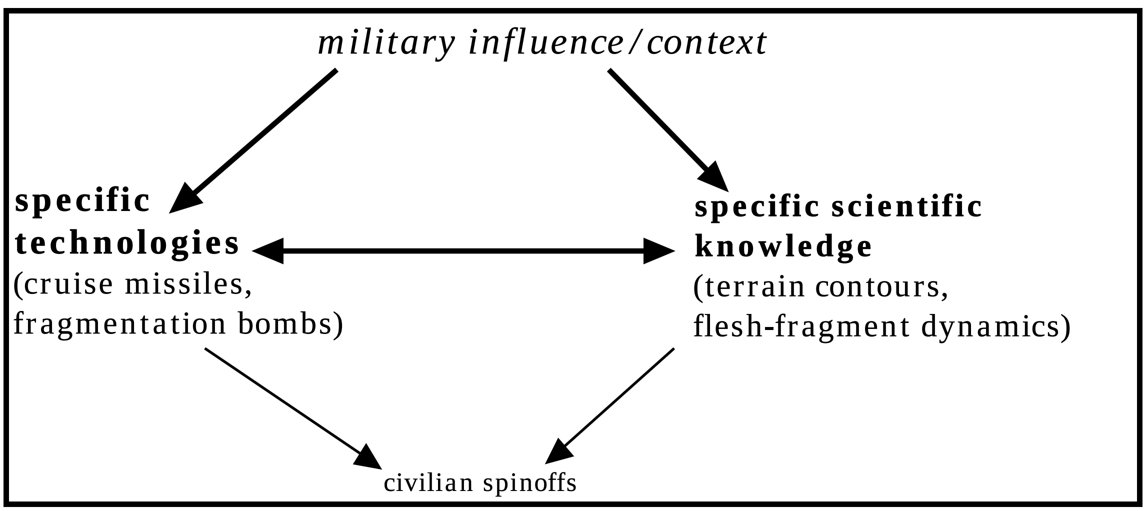

Figure 1. *A model of military shaping emphasising military-specific science and technology.*

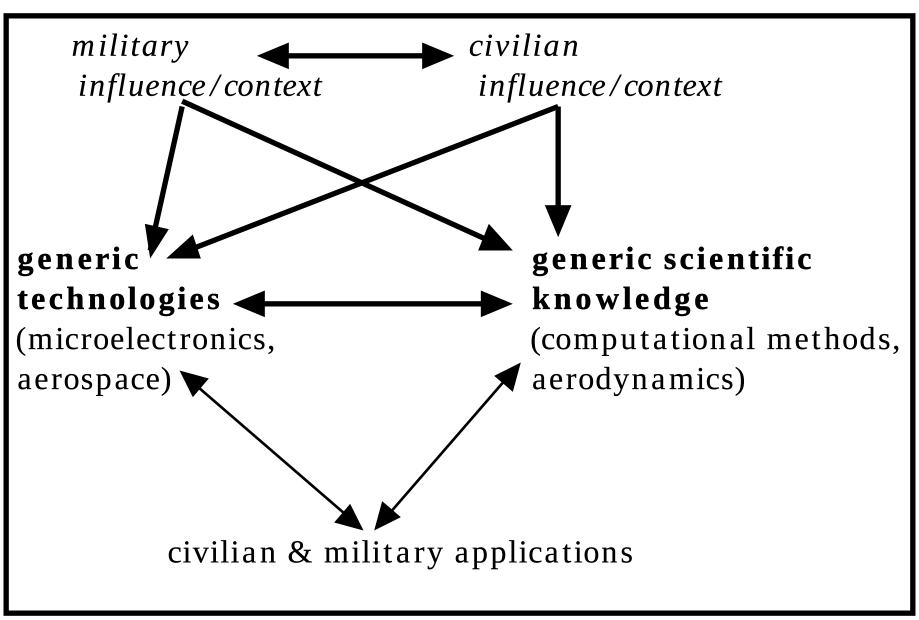

Figure 2. *A model of military shaping emphasising generic science and technology.*

cated weapons, from land mines to aircraft carriers.

Occasionally military funding leads to ideas, methods or products that are useful for civilian purposes. For example, the computer network called Internet grew out of a network set up by the US Defense Advanced Research Projects Agency (DARPA). However, examples like this are quite compatible with the idea that military funding is a powerful way of shaping technologies. The influence of funding simply makes it more likely—not inevitable—that the resulting technologies will be mainly useful for military purposes.

"Funding" is a shorthand for a more complex process which can be called "military technological innovation."[3] There are studies of how military and political elites steer the process of deciding upon, developing and deploying military technologies. This research provides insight into the specific features of military technological innovation in different countries and situations; it is fully compatible with the basic idea that military funding promotes and shapes technology to serve military purposes.

The military is always on the lookout for anything that can be used for its advantage. There is money to develop techniques and products. The possibility of applications has an influence on R&D, by encouraging at least some researchers to pursue areas where applications are more likely. For example, some researchers in pure mathematics are more likely to work in areas where there are possible applications. These applications might be computational methods, theoretical chemistry, energy conservation or ballistics.

Sometimes entire fields are shaped by military priorities. An obvious example is nuclear physics, which has received heavy military funding and provided jobs for many researchers. Furthermore, in several countries governments pursued nuclear power programmes as a means of keeping open the option of acquiring nuclear weapons or (in the US "Atoms for Peace" programme) to reposition nuclear technology as "peaceful." The priority on nuclear weapons and nuclear power has meant that non-military nuclear physics, carried out in universities, has had a higher priority than otherwise would have been the case. Military researchers have been ready to take advantage of any advance from university research. Without the military and commercial interest in nuclear technology, it is likely that other branches of physics such as solar physics would have received greater attention.

Microelectronics and computing are other fields that were, for many years, driven by military applications.[4] For example, the development of sophisticated nuclear weapons makes heavy demands on computer power. In the early decades of nuclear weapons, the US nuclear weapons design laboratories—Lawrence Livermore National Laboratory and Los Alamos National Laboratory—worked closely with computer manufacturers to develop machines serving their particular requirements for high-speed numerical computation, and in some cases purchased a large proportion of the resulting production runs. Some of the choices in the architecture of supercomputers consequently reflect military influences.[5]

Since the development of computers, the field of numerical analysis—which, in part, deals with ways to solve problems using computers—has dramatically expanded, and there are areas of pure mathematics that take up esoteric questions related to numerical analysis. Thus, the development of computers has influenced the research priorities of some mathematicians; in turn, pure mathematics research relating to numerical analysis occasionally leads to results that have practical value.

In this way, possible applications influence the direction of research. Military applications are one such application. Thus, although most pure mathematicians do not have military applications directly in mind, their work may be oriented in directions making it more likely to serve military purposes.

The large amount of US military funding for electronics in the years after World War II actually led to few transfers for civilian uses.[6] In recent years, commercial uses have played a larger role in microelectronics research. Commercialisation is even a goal for some military-funded research.[7]

In the case of the insecticide DDT during World War II, military applications served to accelerate research in one particular direction. As a result of the emphasis on short-term control of insect pests by chemicals to support the war effort, research into biological control of pests declined rapidly, institutionalising a pattern that has persisted long after commercial interests became the primary influence on pesticide research.[8]

The social science field of communication studies in the United States was shaped by massive military funding and military agendas, especially in the early years 1945-1960. The military's interest in the field derived from interest in psychological warfare which—in military terms—included not just propaganda but also techniques such as deception, "dirty tricks," assassination, and terrorism. This context was omitted from the academic face of communication studies. Leading researchers and research centres received massive military grants. Major military studies were often later published in academic forums, usually without acknowledgement of their link to the military. Communication research was oriented to the goals of domination and manipulation of mass audiences. The development and use of now-standard survey techniques also reflected military priorities.[9]

Similarly, research in educational technology in the US has been heavily funded by the military, with military priorities of developing man-machine systems. Douglas Noble argues that computers in classrooms and computer-related procedures are not neutral tools, but rather reflect military goals. For example, when educational institutions operate in terms of "instructional delivery systems," this can be said to reflect a military interest in command and control.[10]

It is worth emphasising that military shaping of science and technology can occur even when researchers themselves do not realise that military funding or applications are influencing their work. It is always possible to debate the true purpose of any research. For example, in military research on biological agents, military scientists and administrators may perceive or portray the research as "defensive"—designed to counter biological weapons of opponents—whereas outsiders may believe the research is a prelude to (offensive) biological warfare.[11] This "ambiguity of research" is always present to some degree, since any technology can be used for a variety of purposes, though more easily for some purposes than others.

In the following example, "pure" research is taken up by the military.

> I did my PhD on the theory of dense plasma—the hot, ionised gas found at the centre of the sun and red giant stars. The work involved the calculation of the spatial correlations between the electrons and atomic nuclei making up this plasma. The calculations could be done mathematically rather than on a computer, but the work was esoteric, painstaking and even a little tedious.
>
> En route to take up a postdoctoral position in London, I stopped over at the University of California in Berkeley to visit one of my thesis examiners. He congratulated me on the thesis, and then remarked, 'My colleagues at Livermore are finding it very useful for their calculations of what happens at the centre of a hydrogen bomb explosion.'
>
> Aware that Livermore is a design laboratory for nuclear weapons, I replied: 'Surely not! I thought of that possibility, but discarded it. My calculations are only valid for equilibrium systems. A hydrogen bomb explosion is not in equilibrium.'
>
> 'Aha!' he said. 'Of course the Livermore group use enormous computer programs to do their non-equilibrium calculations. But they need to check these highly complex programs by means of mathematical solu-

> tions in special cases. Your calculations are playing that role.'
>
> A feature of this example from my youthful innocence was that the nuclear weapons scientists were already using my calculations before they had been published. But the main scientific application of my thesis which I wished to see utilised, the correction of an error in existing models of the solar interior, was only adopted three or four years later.[12]

Such personal concern to avoid military uses for one's research is not that common. Much more typical is a concern to do good science and not worry about applications. Seldom, though, is it expressed as bluntly as by a graduate student at the Massachusetts Institute of Technology: "What I'm designing may one day be used to kill millions of people … I don't care. That's not my responsibility. I'm given an interesting technological problem and I get enjoyment out of solving it."[13]

Militaries need to ensure that weapons systems work as desired. Therefore, they set up systems to ensure compliance to military specifications, or simply order certain products or services that fit such specifications. These specifications sometimes have an impact on "civilian" science and technology. In order to ensure that weapons systems work, the US Department of Defense enforces regulations covering certain required standards. Checks are made of standards for the volt and ohm (units for measuring electrical potential and resistance) either by auditors or, more recently, by insisting on documentation of procedures. These standards may then be used in science.[14]

The influence of military R&D on technological specifications is a more subtle influence than the direct influence on choice of technologies to produce. It is possible to delve into the intricate issues of how standards or the form of civilian technologies have been shaped by military influences. But whether such influences exist is less important than the obvious existence of weapons: technologies designed to kill or destroy. The choice to produce weapons is the key issue. Investigating subsequent influences on the form or application of related civilian technologies is an intriguing intellectual puzzle but is not central to the problem of technology in war.

Training and employment

Prior to World War II, most scientific research was carried out by individuals or small groups, with small budgets. The war and the massive military funding that accompanied and followed it led to science carried out on an industrial scale, with big funding, enormously expensive pieces of apparatus, large teams of workers, managerial systems and centralised control, with an associated dependence on wealthy patrons, usually the government. This system of "big science" is ideally designed to allow control over scientific agendas by state managers, among whom the military features prominently.[15]

Today, most scientists and technologists are full-time professionals working for government, industry or universities. To get to these positions, they first have to undergo a long period of study and apprenticeship. To obtain a research post with some degree of authority and influence in a field, the researcher must proceed successfully through high school, university, PhD studies and often postdoctoral employment. The employment situation and the training to get there have a big impact on the sort of work the researchers do.

Most scientific training promotes conformity to standard scientific ideas and methods. In school and university, students are seldom encouraged to question conventional ideas such as cell structure, quantum theory or bridge design. Most science teachers simply teach "the facts," including a set of methods for solving standard problems. They might want in principle to foster a more questioning approach, but in practice the syllabus is usually so filled with facts and skills that there is little time to do so. Students who are good at solving complex problems of the standard type—whether this is calculus or chemical analysis—are given the greatest encouragement through the system of assignments, examinations and grades. Those who develop their own methods, or who question the point of the exercises, are seldom favoured, unless they are also extremely good at the standard approaches.

By the time students are ready to begin their research apprenticeship, they have imbibed the current scientific world view. Research then involves a certain breaking down of the textbook picture of science, exploring areas where answers are less predictable and encouraging limited challenges to orthodoxy.

Although scientific training promotes conventional orientations to science, a few individuals come through their education with unorthodox perspectives. However, it is most difficult to develop a career at variance with standard views, because there are few jobs that allow this. Most jobs in government and industry are for applied research and development, or in pure research very obviously related to applied areas. Researchers in government agriculture departments might study transport of chemicals in soils. Chemical companies are likely to employ researchers to develop more effective pesticides. University researchers typically have more freedom, but they often rely on industry or government for grants to obtain equipment and technical support. Setting off in a research direction divergent from the standard one is not an easy road.

The military influence comes in at this level. The military provides jobs for a vast number of scientists and engineers, perhaps one quarter or even one half worldwide. Although a few military-funded scientists are able to do "pure research," it is in areas of potential interest to the military, such as theoretical nuclear physics rather than sustainable agriculture.

The social location of most scientists and engineers who are *not* employed directly by the military is still quite convenient for military purposes. Most university and industry scientists and engineers are highly specialised in their training and work: they cannot readily switch from mechanical engineering to microbiology or vice versa. They are generally well-paid, see themselves as professionals and work among peers. As a group of workers who are mainly highly specialised, professionally oriented employees, most scientists and engineers are receptive to doing work where there is ample funding. They are trained and employed as technicians, namely to solve technical puzzles, and not to explore in depth who benefits and loses from their work. The funded research has to be in their field, so that their specialised skills can be brought to bear; it has to be sufficiently well funded, in keeping with their professional status; and it has to be recognised as acceptable by their peers.

The military can take advantage of this situation. Much military R&D requires highly specialised skills. The military has plenty of money to pay for research. Finally, military funding is acceptable to a good proportion of scientists and engineers. Most corporations are happy to have military funding, and so are most universities.[16] Most scientists and engineers are happy to accept whatever funding is available. There are also some who actively solicit military support, proposing projects that will appeal to military funders.[17]

Occasionally, though, there is opposition by scientists to military research. The most prominent case concerned the Strategic Defense Initiative (SDI), otherwise known as "star wars," promoted by the US government. SDI was announced in 1983 during a massive mobilisation of the peace movement, and was clearly an attempt to undermine opposition to US government and military agendas. Thousands of scientists, seeing SDI as a continuation of the arms race, refused to seek or accept funding for SDI projects.[18]

However, this was an exceptional case, and even so there were plenty of scientists who were quite willing to take money for SDI, often with the rationalisation that they would use the money for their own research purposes. Critics saw SDI as both technically infeasible and militarily provocative. Many of those who signed the pledge against receiving SDI funding were not opposed to military funding for research in areas not related to SDI; indeed, many were seeking or in receipt of military funding.

As noted, SDI was an exception, linked to the strong antinuclear popular sentiment at the time. In most cases, there is no attempt at a boycott, and only a minority of scientists refuse military largesse on an individual level. For example, the cream of western physicists joined the Manhattan Project during World War II to produce the first nuclear weapons—of course with the honourable motivation of defeating an evil enemy—and there has been no shortage of scientists to produce hydrogen bombs, antipersonnel weapons and instruments of torture. When the Nazis took power in Germany in the 1930s, there was very little political resistance from the German physics community even though top scientists were dismissed and pressured to emigrate.[19]

Groups that might challenge military priorities in a fundamental fashion, such as peace movements, some churches, some trade unions and some political movements, seldom have the resources to fund scientific research, much less large-scale technological development. The technically trained labour force is mainly available to those groups that can afford to pay for it. The military is in an excellent position to do so. Even when scientists and engineers are working for industry and universities, or are unemployed, they provide a reserve labour force of experts of potential value for military purposes.[20]

Belief systems

Technology is shaped in various ways by systems of belief, or ideology to use another expression. At a basic level, it is necessary for a considerable number of people to believe in their society's superiority in order to justify killing members of other societies, either in defending against attack or in launching one. Underlying the existence of the military is the assumption that it is legitimate to use technology to defend a society by force, including these days mass killing of enemy soldiers and civilians. Technology is a means to achieve a widely shared aim.

Belief systems do not arise out of thin air. Education systems, cultural traditions, enforcement of ideological orthodoxy and a host of other mechanisms are involved. How beliefs influence technological development, and vice versa, is often hard to figure out. This topic is far too big to deal with fully here, so a few examples will have to suffice.

In the 1920s, most aeroplanes were made of wood but fully metal construction was heavily researched. The switch to metal aeroplanes occurred before there was much evidence of their superiority, arguably because of beliefs about science and progress. Metal symbolised both science and progress, hence far more effort was expended developing and justifying metal aeroplanes than improving wooden ones.[21]

During the Vietnam war, US planners conceptualised the war in terms of science, technology, bureaucracy and management. These were all areas in which the US was superior, hence defeat was unthinkable. The conceptualisation of the war as technological led to the deployment of sophisticated weapons, contributed to the enormous human and environmental impact of the war (two million Vietnamese deaths), and helped obscure the real reasons for US defeat.[22]

In the case of the Strategic Defense Initiative, there were massive military funding influences on scientific research, but just as important were ideological factors. The massive funding boom for star wars helped to draw corporations into service to the US military and to weaken opposition to US military policy, especially by promoting the idea that this was a "defence" system. Thus, although star wars never came close to achieving its technological ambitions, it "worked" in both economic and political senses.[23] On a wider scale, it can be argued that the US Cold War vision of global power on the basis of automated, centralised control both shaped the development of computers and was sustained by both the technology and symbolism of computers.[24]

Suppression of challenges

Military funding, military applications and the training and employment of scientists and engineers are all influences that shape science and technology to be selectively useful for military purposes. Another influence operates in a different way, by negative rather than positive reinforcement: when a development occurs that challenges military priorities, it may be subject to attack. This process is not always straightforward, so it is worth looking at a few examples. In each of these cases, military influence is one among a number of influences on science and technology.

Lucas Aerospace is a large corporation based in the UK. Much of its work is for military contracts, specifically for aircraft. In the 1970s, workers at Lucas, concerned about loss of employment from declining military orders, developed an alternative corporate plan.[25] The alternative plan included a number of products that could be produced with the facilities and skills available at Lucas, but which were designed to serve "human needs" such as mass transit or mobility of disabled people. Note that the workers distinguished "human needs" from military contracts.

The management of Lucas consistently refused to accept any of the workers' proposals, insisting on managerial prerogatives, and rejecting even those alternatives that were projected to make a profit. This stance by Lucas management was not taken at the behest of the military, but it certainly served military ends (as well as maintaining managerial control). If initiatives such as those by the Lucas workers had been successful and imitated widely, they might have been a threat to the usual acquiescent role taken by industry in fulfilling military orders, and also a threat to the achievement of military priorities for technological development.

In the 1980s, the US National Security Agency (NSA) attempted to put controls on mathematical research in cryptography, the study of codes. Before publication, cryptography research was expected to be cleared through the NSA.[26] In the 1990s, the NSA developed a cryptography system—including a computer chip, the "Clipper chip," and an encryption algorithm, "Skipjack"—that would allow government agencies to read messages under certain conditions. Most computer network users strongly preferred encryption systems—of which a number were available—that could not be easily cracked by anyone. The US government banned export of encryption systems while promoting the Clipper chip. The primary stated justification for the Clipper chip was monitoring of criminals, but the role of the NSA showed the importance of military priorities. In this case, the alternative, a market of encryption systems useful for commercial or private purposes, was opposed by military interests.[27]

Another example is nuclear technology, in which military and civilian applications have long overlapped. Nuclear power, inasmuch as it is perceived to be a civilian technology, helps to legitimate nuclear technology generally, including nuclear weapons. There are many cases of critics of nuclear power—especially scientists and engineers—who have been reprimanded, transferred, harassed, slandered and dismissed.[28] Another dimension to this issue is the attack on alternatives to nuclear power, such as cutbacks on funding for solar energy.[29]

There are not so many examples of attacks on critics within nuclear weapons programmes, probably because few weapons scientists are in a position to dissent openly and still have any chance of retaining their jobs. Andre Sakharov in the Soviet Union was a prominent critic who was sent into internal exile as a result. In the United States, Hugh DeWitt, a theoretical physicist at Lawrence Livermore National Laboratory where nuclear weapons are designed, has spoken out against government weapons policies and come under attack within the lab several times as a result. The importance of such cases is not so much their effect on the individual dissidents, but the example provided to others who might otherwise have considered speaking out themselves. Even a few cases of this sort send a strong message that it is much safer to work on the job as it is defined from above.[30] In this way, conformity to military priorities is maintained.

Countervailing influences

Military shaping of technology is not all-powerful, otherwise every technology would be oriented to military purposes and we would all be wearing combat boots and living in fallout shelters. It is worth outlining the main influences that resist or challenge military priorities for science and technology, namely civilian applications, bureaucratic interests and popular resistance.

Civilian applications

This is undoubtedly the greatest influence, covering as it does influences from a host of other factors from basic needs such as food and housing to commerce and culture (including art). Civilian interest groups, including corporations, governments and consumers, usually want technologies to serve their immediate purposes. In capitalist societies, cost in the market is a key consideration. This explains, for example, why most industries are not designed to withstand a military attack. (Only in a few countries, such as Iraq, Sweden and Switzerland, are some factories built underground or otherwise designed with military threats in mind.) In most countries, there are few stockpiles of food, goods or strategic minerals beyond what is dictated by the search for profits. Most road and rail systems are designed primarily for civilian purposes.

Military influences do have some influences on all these areas, but civilian influences are usually much greater. Military influence on technology is greatest in areas where there is little civilian interest, such as missiles.

Bureaucratic interests

Within the military and within military industries, officers, soldiers, managers and workers have jobs, status, authority, routines, standard ways of thinking, and emotional commitments. In other words, the current way of doing things is a way of life. Changes in technology also introduce the prospect of social changes. These social changes are likely to be welcomed by some and opposed by others, in ways that don't necessarily correlate with military efficiency. In other words, vested interests within various bureaucracies constitute one influence on technological development.

Sometimes the main vested interest can be called conservatism, since it manifests itself as resistance to new technologies. For example, around 1900, when the new method of continuous-aim firing from ships was proposed, bureaucrats within the US Navy at first ignored and then did everything possible to discredit the method and delay its introduction, in spite of the fact that it was vastly superior to the existing method. The reason for the resistance was that the new method entailed changes in the organisation of tasks on board: it changed the arrangements in naval society.[31]

The introduction of the machine gun provides another example of military conservatism. It was vastly more effective than rifles and, because of this, threatened to make obsolete the traditional training and tactics based on beliefs in the importance of courage and quality of troops. Plentiful evidence was available of the superiority of the machine gun in various colonial wars, but these victories were attributed to white superiority over native peoples rather than to technological superiority. As a result, the implications of the machine gun for warfare were not grasped and integrated into military organisations and planning until well into World War I, when the suicidal implications of infantry attacks on positions defended by machine guns eventually became clear. Even in this situation, hundreds of thousands of soldiers were killed before commanders were willing to recognise the failure of standard methods.[32]

Another example is the US-produced M-16 rifle, which was the result of prolonged bureaucratic manipulation. Another rifle had been developed, the AR-15, which attained a high reputation among soldiers. However, Eugene Stoner, the designer of the AR-15, worked outside the Army's arsenal system, and thus this rifle was a threat to the bureaucratic status quo. The AR-15 was subject to numerous design changes imposed by rigid specifications, many of which were irrelevant to practical conditions, such as performing in freezing temperatures. The design changes led to the M-16, which was much heavier, inconvenient and failure-prone, and led to more deaths in action. Soldiers who were aware of the problems with the M-16 wrote to their parents who in turn put pressure on Congress. As a result, the sabotage of the AR-15 was exposed in hearings of Congress.[33]

These examples are distinctive because strong bureaucratic interests favoured a clearly inferior technology for the purposes of warfare. However, bureaucratic interests are present at all times, and on many occasions they favour superior technology. This means that the adoption of a technology, whether technically superior or inferior, may have occurred in part because of bureaucratic considerations.

More generally, it is a reasonable assumption that military leaders will not voluntarily adopt any technology that undermines the need or rationale for their existence. As will be discussed later, even when nonviolent methods of struggle are superior in terms of reducing the threat from an enemy, militaries favour military methods. Military strength creates its own necessity, by posing a threat to other societies and stimulating military races.

Without actual war, military technologies would not need to be efficient for warfare, but could serve other functions, such as maintaining current bureaucratic systems, creating profits for industry and providing symbols of power and masculinity. During the Cold War, it has been argued, western military weaponry became more and more "baroque," namely excessively expensive and complicated and hence not likely to be particularly effective.[34] The Cold War confrontation provided the justification for massive military expenditures, but there was no practical testing of weapons designed for war between major industrial powers.

Popular resistance

Another key factor in technological development for the military is the unwillingness of people to support certain methods of fighting. "People" here includes civilians, politicians, soldiers, military commanders and engineers.

The role of civilians has been considerable. Peace movements have campaigned against various sorts of weapons and, in some cases, against any form of organised violence. There have been campaigns against nuclear, biological, chemical and antipersonnel weapons, among others. In many cases these campaigns are supported by government leaders. The results can be seen in the limited use of biological, chemical and nuclear weapons in warfare and in treaties against these weapons. The popular revulsion against certain types of weapons and warfare is a powerful factor. But this popular revulsion is subject to change. Before World War II, aerial bombing was thought to be totally outrageous; the 1937 bombing of Guernica by the German-supported fascists in Spain generated intense anguish. Yet aerial bombing was adopted by both sides in World War II. Through a gradual process of expansion from military to civilian targets, aerial bombing became a much more "acceptable" method of warfare. In the future, it is quite possible that biological, chemical or nuclear warfare may become seen as standard procedure, most likely as a result of all-out war. Many people have worked and continue to work to ensure that this does not occur, through publicity, international law, and destruction of stocks of weapons.

Soldiers and officers also have ideas about what is acceptable in warfare, and these ideas have an important impact on technological development. In previous centuries, armies faced each other in set-piece confrontations, in ways that, by present-day standards, seem incredibly restrained. Then, relatively few civilians were killed; technologies were designed mainly for killing soldiers. Today, many more civilians are killed in wars than soldiers; weapons of mass destruction are designed for this purpose.

Most people are highly reluctant to hurt others. Soldiers have to be trained to kill, especially when the enemy is confronted face-to-face. There is evidence that most front-line soldiers in World War II and other wars did not fire their rifles, and that many of those who did fire intended to miss. In many countries, armies cannot be filled by volunteers; conscription is needed. Technological development has made it easier to kill at a distance, without recognising the enemy as a person. Engineers who design bombers and pilots who fly them can maintain a psychological distance from the people who are being attacked. It is possible to see much of modern weapons development as a response to a pressure to use fewer people in fighting and to reduce the need for face-to-face combat. In this way, the repulsion most people feel towards killing is sidestepped. Another way to overcome this repulsion is to train soldiers using highly realistic simulations so that responses become automatic. This has been done increasingly in the US military since World War II, with correspondingly greater psychological impacts on those soldiers who engage in "intimate" killing, such as in the Vietnam war.[35]

With modern poisons and other small weapons, it is now possible for one individual behind enemy lines—especially an agent who has joined the other side's armed forces—to be more potent than a whole battalion of front-line soldiers. By planting poisons in water supplies or in the food of individuals or by just slitting throats, one agent could kill hundreds of soldiers and cause a crisis in morale. Technological developments could aid such an approach to warfare. But this has not been a major R&D focus compared to conventional weapons. One reason is that it would be difficult to recruit soldiers to undertake this sort of killing. Also, if adopted by both sides, it would be a threat to the military command, since agents would target officers who, in conventional warfare, are least likely to be killed.

Taking into account these various countervailing influences, it is possible to present a more complicated picture of military shaping of science and technology. Figure 3 shows some of the influences and some of the connections.

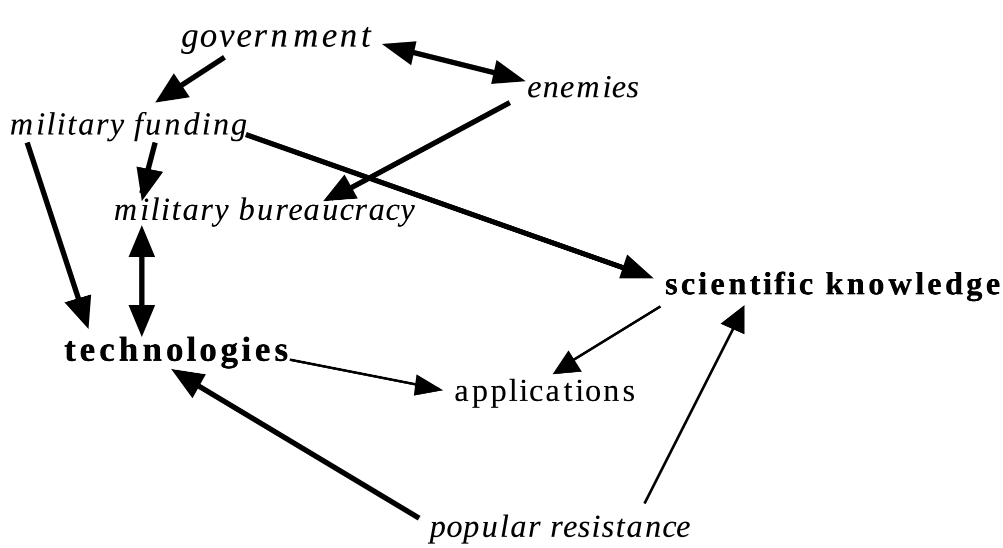

Figure 3. *A model of military shaping showing a variety of specific influences on science and technology.*

Deeper links

So far in this discussion of military influences on the development and use of technologies, it has been assumed that the purpose of the military is simply to defend societies against aggression. This is the usual picture drawn by militaries and governments and widely believed by members of the public. But there is another viewpoint: that the military is tied in fundamental ways to social structures, especially the state, capitalism, bureaucracy and patriarchy. In this picture, the military both supports and is supported by these structures. This has implications for understanding military-related technology.

Only occasionally are contemporary military forces used to engage in combat against military forces of another country. It is actually much more common for a country's military to be used against the people of the country itself, most obviously in military dictatorships. This suggests that militaries have as much to do with social control—in the interests of certain groups in a society—as with defence against foreign threats. At the global level, military forces and alliances such as NATO serve to protect dominant groups from challenge. For example, NATO troops help to sustain global economic inequality.

The state, in a sociological sense, can be defined as a community based on a monopoly over organised violence within a territory, this violence being considered "legitimate" by the state itself.[36] In modern societies, organised violence is only considered legitimate when exercised by the police or the military. The state is more commonly thought of as being composed of the government (including national and local officials), government bureaucracies, the legal system, the military, and government-run operations such as schools. The state maintains itself financially mainly through taxes, administers services and regulations through government bureaucracies, and maintains order through the police and the legal system. In any major challenge to the system—such as refusal to pay taxes—the police and, if necessary, the military are available to maintain state power. War is a primary impetus behind the rise of the state. Indeed, war-making and state-making are mutually reinforcing.[37]

The state must defend against external threats, to be sure, but internal threats are more frequent and more complex. Most contemporary states administer unequal societies, with wealth, status and privilege distributed very unevenly, usually accompanied by systematic methods to maintain this inequality, such as class structure and sexual and ethnic discrimination. The pervasive injustice of societies stimulates challenges to the status quo. In societies with representative governments, the usual methods of social control are schooling, manipulation of perception through the mass media, systems of legitimacy such as parliaments and courts, and the economic system. But when these systems are not sufficient to protect the interests of dominant groups, the police and the military may be deployed, for example to arrest demonstrators or break strikes.

During the cold war, the superpowers could justify their massive arsenals by pointing to the threat posed by the enemy. The cold war is over but military spending, though somewhat cut back, continues at a very high rate. It has been widely remarked by commentators that the US Department of Defense and spy agencies have been desperately searching for new legitimations for their existence—favourite rationales are "rogue states," terrorism and the drug trade. The lack of an overt justification for a continuing military megamachine provides added weight to explanations referring to the military's role in maintaining systems of inequality.

The links between the military and the state also have implications for technology. A large proportion of funding for R&D comes from the state. This includes many nominally civilian areas, such as transport systems, communications, sewerage, energy and industry. Planners within the state are likely to prefer technological systems that ensure continuation of state power.

For example, central provision of energy, through oil and natural gas supplies and through electricity produced at large power stations, is ideally suited for allowing state control or regulation. Taxes can easily be imposed on such energy operations, since consumers must obtain their energy from a few large suppliers. Contrast this with a community in which building design eliminates the need for most energy for heating, town planning allows most people to walk or ride bicycles, and small local enterprises provide for energy from the sun, wind and biofuels. With such a community, there is much less need for strong state intervention. The energy system is low risk: there is no hazard from nuclear reactor accidents, large oil spills, or sabotage of electricity generating plants. There is less dependence on external supplies, and hence resource control—and struggles over this control—is not so vital an issue. There is no great need for heavy investment in automobile manufacture or freeway construction, and hence less need for central regulation or funding in these sorts of areas. Because the community is largely self-sufficient in energy, there is less justification for taxing the energy sector.[38]

As will be discussed in chapter 6, the conventional high-energy-use system, with its high risks, high vulnerability to disruption and large economic investments, also makes it a target for military attack. Thus, military forces are needed to defend such a system. By contrast, the low-energy self-reliant system has much less need for military defence.[39] This example shows the mutually consistent and reinforcing roles of the state and the military. The energy system that provides a convenient vehicle for state intervention and extraction of resources (taxes) for the state is also one that requires and justifies the military. Part of the state's extraction of resources is to provide energy supplies for the military itself. Centralised provision of energy is convenient for this purpose. By contrast, a system built around energy efficiency, solar heaters and town planning to reduce transport doesn't provide much scope for supporting an energy-hungry military.

From the point of view of the state, the traditional dichotomies between "peace" and "war" and between "civil" and "military" are increasingly irrelevant. The military capacity of a state depends on systems of education and training, R&D and industry, all ostensibly "civil" arenas. Especially since World War II, the states of industrial societies have pursued policies concerning knowledge and production that lay the basis for technological warfare.[40]

Monopoly capitalism—built around large corporations with active intervention by the state in support of these corporations—favours technologies that also tend to be useful for the military. The automobile industry is an example. A transport system based on large production plants is relatively easy to adapt for military purposes. This is partly because the plants can be converted to produce military goods, but more because the plants are controlled by a few people through large corporate bureaucracies. This organisational structure is easily influenced to serve military ends, either through military contracts or through direct administration in wartime.[41] By contrast, a production system based on smaller enterprises producing more bicycles and fewer heavy vehicles, with a great deal of worker control, is less subject to central control either by capitalists or military administrators.

The economic system commonly called communism—but better described as state socialism, bureaucratic socialism or state capitalism—serves military imperatives even more directly and easily than monopoly capitalism.[42] In the case of both capitalism and state socialism, the large scale of production, the role of the state in regulation and the system of bureaucratic management of enterprises all favour technological systems that are compatible with military purposes.

Similar considerations apply to the role of bureaucracy, which can be defined as a way of organising work built around the principle that workers are replaceable cogs.[43] Bureaucracies are hierarchical, based on a division of labour and operate using standardised procedures. Most government bodies are organised as bureaucracies, but so are large corporations, political parties, churches, trade unions and many other organisations. The military is perhaps the ultimate in bureaucracies, with its rigid hierarchy (the ranks) and system of command. Bureaucracy is the basic organising principle of the state, monopoly capitalism and the military. The technological systems favoured by bureaucratic elites are ones that ensure them a continuing role and position of power. They tend to favour large systems requiring centralised control, such as centralised welfare systems and large hospitals. The previous examples of transport and energy illustrate the interests of bureaucratic elites.

Yet another important social structure linked to the military is patriarchy, the organised social domination of men over women. Patriarchy is a pervasive set of relationships, including male violence against women, control over reproductive choice, discrimination in employment, devaluation of child rearing, different social expectations for men and women, and many other dimensions. It is possible to argue that any system of unequal power, such as systems of central government and corporate management, are patriarchal in themselves; in any case, they are highly compatible with patriarchy, since men control most of the elite positions and regularly use their positions to maintain male privilege.

Militaries are notoriously patriarchal.[44] Most soldiers and almost all top commanders are men, and most military forces strongly denigrate human characteristics that are considered feminine. On the other hand, militaries are designed for fighting against other men. Women are victims, to be sure, both as civilian casualties and through being raped in wartime and within the military itself. But, it may be argued, the function of patriarchy is to allow some men to dominate other men (as well as women). If men are mobilised to defend male privilege and male identity against women, it becomes easier to maintain the role of elites (who are mostly men).

The overt influence of patriarchy on science and technology can be found in a number of areas, such as reproductive technologies and theories of brain lateralisation. In terms of military technology, though, perhaps the greatest—if rather diffuse—influence is the built-in preference for violence and technology, which goes to the core of the military role in society. Violence is commonly associated with masculinity, whereas nonviolence is seen as stereotypically feminine. (This helps explain the common but quite false presumption that nonviolence means being passive.) Also, it is a characteristically masculine trait to be unemotional and aloof. Technology that allows killing at a distance thus meshes with a common conception of masculinity.

In recent decades, traditional forms of male domination in the military have come under threat as women seek equality within the armed services in some countries. Furthermore, some military women—seeing themselves as feminists—argue that they bring a different sensibility to the military role, with their greater ability to relate to local people, especially women, in UN intervention missions. This suggests that the conventional picture of militaries as composed of men exhibiting a traditional masculinity may no longer be adequate.[45] Women can adopt masculine values and men can adopt feminine values, and both types of values can be expressed in either positive or damaging ways. Thus, women can enter the military with the aim of making it less oppressive, but at the risk of themselves becoming acculturated to the military ethos of competitiveness, hierarchy, domination and violence. This struggle between military and feminist values will also be played out in struggles over choices and uses of military technology.

This discussion of deep links between the military and the state, capitalism, bureaucracy and patriarchy, and implications for science and technology, has only introduced a few ideas from a topic with many dimensions.[46] The issues are complex and seldom addressed. Nevertheless, a few key points are worth stating again. The military and military-inspired technology are not designed just for defence against foreign enemies, but are more centrally involved in maintaining social control. This control is at the service of the state, of economic elites (in today's societies, most commonly capitalists), of elite bureaucrats, and of the system of male domination. Understanding the shaping of science and technology for military purposes thus is not a simple undertaking, since it ultimately involves analysis of all social institutions. A possible picture is given in figure 4. Although this figure encompasses more of the processes involved, its vagueness reduces its usefulness. For many purposes figure 1, for example, is more helpful. Models should be chosen because of their value in providing insight, and sometimes simple—and hence inaccurate or incomplete—models are more helpful.[47]

In this chapter I have focussed on military influences on and uses of technology. Another perspective is that technology is shaped more generally by the structures of the state, capitalism, patriarchy, etc., with which the military is largely compatible. So even without a direct military influence, technology might still be "militarised"—oriented to military purposes—to a considerable extent. This model is compatible with figure 4. I'm not sure whether it is a better way to understand what's going on.

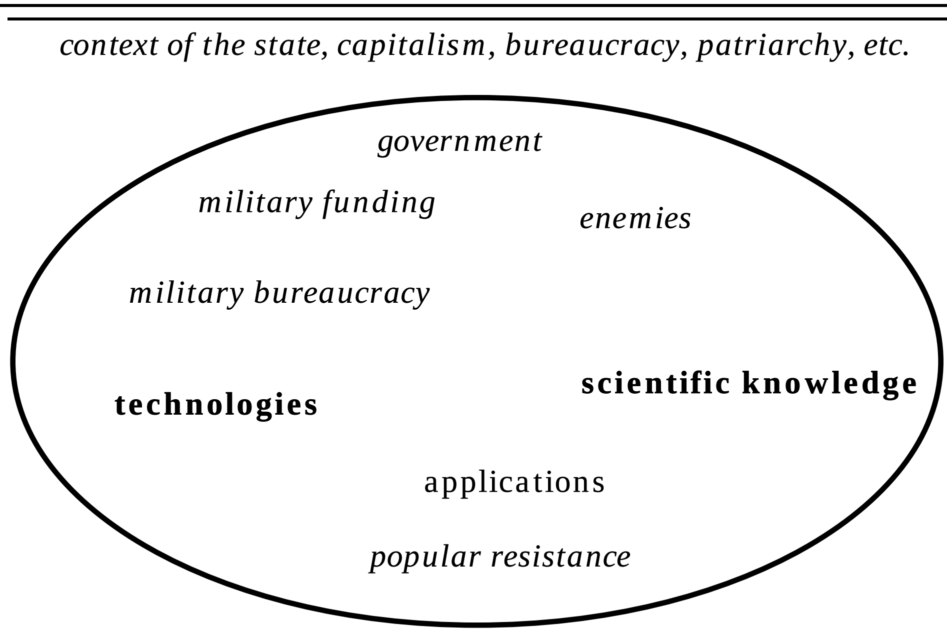

Figure 4. *A model of military shaping showing a variety of specific influences on science and technology in the context of social structures. There are no arrows because the various items are mixed together in a "soup" of mutual interactions.*

Notes

1. Theories of technology are discussed in the appendix. The general model adopted here is that military and other social factors influence but do not determine technology, and that any specific technology is easier to use for some purposes than others.

2. General treatments of the influence of the military on science and technology include J. D. Bernal, *The Social Function of Science* (London: George Routledge & Sons, 1939), chapter VII; Robin Clarke, *The Science of War and Peace* (London: Jonathan Cape, 1971); Paul Dickson, *The Electronic Battlefield* (Bloomington: Indiana University Press, 1976); Everett Mendelsohn, "Science, technology and the military: patterns of interaction," in Jean-Jacques Salomon (ed.), *Science War and Peace* (Paris: Economica, 1990), pp. 49-70; Everett H. Mendelsohn, Merritt Roe Smith and Peter Weingart (eds.), *Science, Technology and the Military* (Dordrecht: Kluwer, 1988); Robert K. Merton, *Science, Technology and Society in Seventeenth Century England* (New York: Howard Fertig, 1970 [1938]); John U. Nef, *War and Human Progress: An Essay on the Rise of Industrial Civilization* (London: Routledge & Kegan Paul, 1950); Merritt Roe Smith (ed.), *Military Enterprise and Technological Change: Perspectives on the American Experience* (Cambridge, MA: MIT Press, 1985). References to specific areas are given later. On arms production and trade, see William W. Keller, *Arm in Arm: The Political Economy of the Global Arms Trade* (New York: HarperCollins, 1995); Keith Krause, *Arms and the State: Patterns of Military Production and Trade* (Cambridge: Cambridge University Press, 1992).

3. See for example Matthew Evangelista, *Innovation and the Arms Race: How the United States and the Soviet Union Develop New Military Technologies* (Ithaca, NY: Cornell University Press, 1988); Wim A. Smit, John Grin and Lev Voronkov (eds.), *Military Technological Innovation and Stability in a Changing World: Politically Assessing and Influencing Weapon Innovation and Military Research and Development* (Amsterdam: VU University Press, 1992).

4. Janet Abbate, *Inventing the Internet* (Cambridge, MA: MIT Press, 1999); Paul N. Edwards, *The Closed World: Computers and the Politics of Discourse in Cold War America* (Cambridge, MA: MIT Press, 1996); Paul Forman, "Behind quantum electronics: national security as basis for physical research in the United States, 1940-1960," *Historical Studies in the Physical and Biological Sciences*, Vol. 18, No. 1, 1987, pp. 149-229; Brian Martin, "Computing and war," *Peace and Change*, Vol. 14, No. 2, April 1989, pp. 203-222.

5. Donald MacKenzie, "The influence of the Los Alamos and Livermore National Laboratories on the development of supercomputing," *Annals of the History of Computing*, Vol. 13, No. 2, 1991, pp. 179-201.

6. Robert DeGrasse, "The military and semiconductors," in John Tirman (ed.), *The Militarization of High Technology* (Cambridge, MA: Ballinger, 1984), pp. 77-104.

7. Donald MacKenzie and Graham Spinardi, "The technological impact of a defence research establishment," in Richard Coopey, Matthew R. H. Uttley and Graham Spinardi (eds.), *Defence Science and Technology: Adjusting to Change* (Chur, Switzerland: Harwood Academic Publishers, 1993), pp. 85-124.

8. John H. Perkins, "Reshaping technology in wartime: the effect of military goals on entomological research and insect-control practices," *Technology and Culture*, Vol. 19, No. 2, April 1978, pp. 169-186.

9. Christopher Simpson, *Science of Coercion: Communication Research and Psychological Warfare 1945-1960* (New York: Oxford University Press, 1994). I thank Mary Cawte for drawing this book to my attention.

10. Douglas D. Noble, *The Classroom Arsenal: Military Research, Information Technology, and Public Education* (London: Falmer Press, 1991).

11. Susan Wright and Stuart Ketcham, "The problem of interpreting the U.S. biological defense research program," in Susan Wright (ed.), *Preventing a Biological Arms Race* (Cambridge, MA: MIT Press, 1990), pp. 169-196.

12. Mark Diesendorf, "On being a dissident scientist," *Ockham's Razor 2* (Sydney: Australian Broadcasting Corporation, 1988), pp. 9-14, at p. 10.

13. Quoted in Stuart W. Leslie, *The Cold War and American Science: The Military-Industrial-Academic Complex at MIT and Stanford* (New York: Columbia University Press, 1993), p. 238.

14. Joseph O'Connell, "Metrology: the creation of universality by the circulation of

particulars," *Social Studies of Science*, Vol. 23, No. 1, February 1993, pp. 129-173. Andreas Speck gives the additional example that standards for German roads and airport runways—such as the width and the strength of the base—are set by military criteria.

15. Daniel S. Greenberg, *The Politics of Pure Science* (New York: New American Library, 1971); Gregory McLauchlan, "The advent of nuclear weapons and the formation of the scientific-military-industrial complex in World War II," in Gregg B. Walker, David A. Bella and Steven J. Sprecher (eds.), *The Military-Industrial Complex: Eisenhower's Warning Three Decades Later* (New York: Peter Lang, 1992), pp. 101-127.

16. On university-military links, see *Annals of the American Academy of Political and Social Sciences*, Vol. 502, March 1989; David Dickson, *The New Politics of Science* (New York: Pantheon, 1984), chapter 3; Jonathan Feldman, *Universities in the Business of Repression: The Academic-Military-Industrial Complex and Central America* (Boston: South End Press, 1989); Daniel S. Greenberg, *The Politics of Pure Science* (New York: New American Library, 1971); Stuart W. Leslie, *The Cold War and American Science: The Military-Industrial-Academic Complex at MIT and Stanford* (New York: Columbia University Press, 1993); Christopher Simpson (ed.), *Universities and Empire: Money and Politics in the Social Sciences During the Cold War* (New York: New Press, 1998); Clark Thomborson, "Role of military funding in academic computer science," in David Bellin and Gary Chapman (eds.), *Computers in Battle—Will They Work?* (Boston: Harcourt Brace Jovanovich, 1987), pp. 283-296.

17. Bruno Vitale, "Scientists as military hustlers," in *Issues in Radical Science* (London: Free Association Books, 1985), pp. 73-87.

18. David Cortright, *Peace Works: The Citizen's Role in Ending the Cold War* (Boulder: Westview Press, 1993), pp. 179-186; Steve Nadis, "After the boycott: how scientists are stopping SDI," *Science for the People*, No. 20, January-February 1988, pp. 21-26.

19. Alan D. Beyerchen, *Scientists under Hitler: Politics and the Physics Community in the Third Reich* (New Haven, CT: Yale University Press, 1977). I thank Mary Cawte for mentioning this reference.

20. On scientists as a reserve labour force see Chandra Mukerji, *A Fragile Power: Scientists and the State* (Princeton, NJ: Princeton University Press, 1989).

21. Eric Schatzberg, "Ideology and technical choice: the decline of the wooden airplane in the United States, 1920-1945," *Technology and Culture*, Vol. 35, No. 1, January 1994, p. 34-69.

22. James William Gibson, *The Perfect War: Technowar in Vietnam* (Boston: Atlantic Monthly Press, 1986).

23. Vincent Mosco, "The military information society and 'star wars'," in *The Pay-Per Society: Computers and Communication in the Information Age* (Toronto: Garamond, 1989), pp. 131-172, also published in revised form as "Strategic offence: star wars as military hegemony," in Les Levidow and Kevin Robins (eds.), *Cyborg Worlds: The Military Information Society* (London: Free Association Books, 1989), pp. 87-112.

24. Paul N. Edwards, *The Closed World: Computers and the Politics of Discourse in Cold War America* (Cambridge, MA: MIT Press, 1996).

25. Hilary Wainwright and Dave Elliott, *The Lucas Plan: A New Trade Unionism in the Making?* (London: Allison and Busby, 1982).

26. David Dickson, *The New Politics of Science* (New York: Pantheon, 1984), pp. 141-145.

27. Lance J. Hoffman (ed.), *Building in Big Brother: The Cryptographic Policy Debate* (New York: Springer-Verlag, 1995).

28. Leslie J. Freeman, *Nuclear Witnesses* (New York: Norton, 1981); Brian Martin, "Nuclear suppression," *Science and Public Policy*, Vol. 13, No. 6, December 1986, pp. 312-320.

29. Daniel M. Berman and John T. O'Connor, *Who Owns the Sun? People, Politics, and the Struggle for a Solar Economy* (White River Junction, Vermont: Chelsea Green, 1996); Ray Reece, *The Sun Betrayed: A Report on the Corporate Seizure of U.S. Solar Energy Development* (Boston: South End Press, 1979).

30. Brian Martin, "Suppression of dissent in science," *Research in Social Problems and Public Policy*, Vol. 7, 1999, pp. 105-135.

31. Elting E. Morison, *Men, Machines, and Modern Times* (Cambridge, MA: MIT Press, 1966), chapter 2.

32. John Ellis, *The Social History of the Machine Gun* (London: Croom Helm, 1975).

33. James Fallows, "The American Army and the M-16 rifle," in Donald MacKenzie and Judy Wajcman (eds.), *The Social Shaping of Technology*

(Milton Keynes: Open University Press, 1985), pp. 239-251.

34. Mary Kaldor, *The Baroque Arsenal* (London: Andre Deutsch, 1982).

35. Dave Grossman, *On Killing: The Psychological Cost of Learning to Kill in War and Society* (Boston: Little, Brown, 1995).

36. There is a large amount of writing about various forces that have weakened the power of the state, including transnational corporations, international organisations and social movements. Undoubtedly the state is no longer hegemonic, if it ever was. When it comes to examining the military, the state remains the dominant influence, but there is an increasing role being played by mercenaries, militias and international "peacekeeping" forces. Mary Kaldor, *New and Old Wars: Organized Violence in a Global Era* (Cambridge: Polity Press, 1999) provides an insightful analysis of the recent transformation of war from state-based invasion-and-defence mode to a postmodern form with state, paramilitary, criminal and international actors involved in a mixture of war, organised crime and mass human rights violations.

37. On the state and the military, see Ekkehart Krippendorff, *Staat und Krieg: Die Historische Logik Politischer Unvernunft* (Frankfurt: Suhrkamp, 1985), as reviewed by Johan Galtung, "The state, the military and war," *Journal of Peace Research*, Vol. 26, No. 1, 1989, pp. 101-105 (I thank Mary Cawte for this reference); Bruce D. Porter, *War and the Rise of the State: The Military Foundations of Modern Politics* (New York: Free Press, 1994); Charles Tilly, *Coercion, Capital, and European States, AD 990-1992* (Cambridge MA: Blackwell, 1992). For the case of the US, see Gregory Hooks, *Forging the Military-Industrial Complex: World War II's Battle of the Potomac* (Urbana: University of Illinois Press, 1991).

38. Andreas Speck notes that an alternative interpretation is that centralised energy systems are more a result of capitalist interests, with big companies using their control to keep competitors small and dependent.

39. A self-reliant system is much more useful in an actual war, since it cannot be destroyed as easily. The point here is that centralised systems, through their very vulnerability, provide a stronger *justification* for military defence.

40. Maurice Pearton, *The Knowledgeable State: Diplomacy, War and Technology since 1830* (London: Burnett Books, 1982).

41. For a nice treatment of different relationships between the state and war industry in the United States, see Gregory Hooks and Gregory McLauchlan, "The institutional foundations of warmaking: three eras of U.S. warmaking, 1939-1989," *Theory and Society*, Vol. 21, 1992, pp. 757-788.

42. See for example Carl Gustav Jacobsen, "Arms Build-ups under Socialism: The USSR and China," in N. P. Gleditsch and O. Njølstad, (eds.), *Arms Races: Technological and Political Dynamics* (London: Sage, 1990), pp. 285-294.

43. Fred Emery (personal communication) provided this convenient encapsulation of bureaucracy.

44. Cynthia Enloe, *Does Khaki Become You? The Militarisation of Women's Lives* (London: Pluto, 1983); Cynthia Enloe, *The Morning After: Sexual Politics at the End of the Cold War* (Berkeley: University of California Press, 1993); Betty Reardon, *Sexism and the War System* (New York: Teachers College Press, 1985); Jeanne Vickers, *Women and War* (London: Zed Books, 1993). On challenging this situation, see Birgit Brock-Utne, *Educating for Peace: A Feminist Perspective* (New York: Pergamon, 1985).

45. I thank Ellen Elster for suggesting these points.

46. Brian Martin, *Uprooting War* (London: Freedom Press, 1984). It is possible to go further and argue that science and technology have always been linked with warfare and that this connection is integral in western societies. See, for example, Jacques Grinevald, "The greening of Europe," *Bulletin of Peace Proposals*, Vol. 22, No. 1, 1991, pp. 41-47. I thank Mary Cawte for finding this reference.

47. Models are always simplifications of the object or situation modelled, and hence inaccurate and incomplete to a greater or lesser degree. Simple models usually are easier to understand and work with. The question is, which simplications should be made? See Brian Martin, *Information Liberation* (London: Freedom Press, 1998), chapter 8.