DISCUSSION PAPER

• *ABSTRACT*

Science and technology can be used and developed to support nonviolent struggle as well as military struggle. By examining what science and technology is likely to be useful for nonviolent action, a set of priorities for disciplinary fields, research projects and methods of research is obtained that is quite different from those associated with military priorities. This case study illustrates the value of studying not just the science and technology that exists but also the science and technology that might exist in different social structures.

Science, Technology and Nonviolent Action: The Case for a Utopian Dimension in the Social Analysis of Science and Technology

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Military interests have long exerted a strong influence on the development of science and technology, especially since World War II.[1] Military funding is the immediate stimulus for studying certain fields, such as cryptography and nuclear physics. It is also the reason why particular technological artefacts, such as tanks and nuclear weapons, have been constructed. The military exerts influence on science and technology not only through direct funding but also indirectly through influence on what areas scientists think worth researching, and what problems they think important. The relationship between scientists and the military is not one-way: many scientists are eager to devote their skills to military ends.[2]

In spite of the enormous scale of military research and development and its obvious impacts on science and technology, there has been relatively little social analysis of this process compared to studies of what scientists call 'pure science'. Furthermore, even

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within the relatively small literature on sociology of defence[3] science and technology, almost all the attention has been on what exists rather than on what might exist. In other words, alternatives to the military have been ignored.

In this paper, I describe one such alternative: 'social defence' — which can be defined as nonviolent community resistance to aggression — and some of its implications for science and technology. Studying the ways that science and technology might aid social defence provides a range of insights that are unobtainable by studying military science and technology. Firstly, and most obviously, such a study gives some practical suggestions for improving social defence. Secondly, it provides insight into the ways that the military has shaped science and technology, by offering an alternative scenario for their shaping.[4] Thirdly, it provides an example of a different approach to the social analysis of science and technology. Instead of studying only what is, this approach is based on studying also what *isn't* and what *could be*: in other words, it offers a *utopian* dimension.

The next section provides a brief overview of social studies of military science and technology and their limitations. Then I describe 'social defence', and give some illustrative findings concerning the kinds of science and technology that would serve a system of social defence. The final section deals with implications.

Social Analysis of Military Science and Technology

The world's militaries support something like one quarter to one half of all scientists and engineers.[5] In a number of fields, from weather research to computing, the military has long provided a substantial fraction of research funding. Military-inspired investigations are found in obvious areas, such as ballistics and nuclear weapons, and quite a few less obvious areas, such as gravitational anomalies and the psychology of groups.

To what extent has science and technology been shaped, influenced, oriented, hindered or accelerated by military funding and priorities? There are at least two ways to address this question. The first is to look at the paths by which generic areas in science and technology, such as particle physics or microelectronics, have been influenced by military funding and priorities. In all but a few cases it is difficult to trace a direct military influence, partly because of

the inherent difficulties in establishing such causal connections, and partly because academic and commercial influences are usually much stronger.

A second way to approach the question is to look at specific, detailed deployment of knowledge and hardware. Consider, for example, a tank. It is the result of military planning, funding, testing and so forth. If militaries did not exist, it seems unlikely that tanks would exist. So, in this sense, the military has an overwhelming influence on this technology.[6] Similarly, certain specific inscriptions of scientific knowledge — such as the computer programs used to calculate trajectories for precision-guided munitions — are directly attributable to military planning, funding and testing, all in the context of an overall military operation. When it comes to the details of actual artefacts and knowledges-in-use that are part of military operations, it is easy to see the influence of the military on science and technology.

Scholars interested in social shaping mostly use the first approach, tackling the intellectually challenging task of seeking to see military influences on generic areas of science and technology, usually with a focus on 'basic' science. This is a reasonable enterprise, but it should not obscure the all-too-obvious shaping of artefacts and knowledges which is, perhaps, seen as so obvious as not to be worth investigating. It should be noted that to refer to 'basic' science is to prejudge the assessment, since 'basic' science is normally assumed to exclude those areas of science which are close to applications and in which the influence of groups such as the military is obvious and direct.[7]

Social analysts have given relatively little attention to the military role in science and technology, at least compared to the importance of the military in their funding. It is not the aim of this paper to give a comprehensive overview of social science research on science, technology and the military.[8] For my purposes here, it is sufficient to comment on a few characteristic works and make some general points.

The book *Military Enterprise and Technological Change*, edited by Merritt Roe Smith, primarily deals with the history of science and technology as they have been linked to the military.[9] For example, there are chapters entitled 'Technological Innovation and Organizational Change: The Navy's Adoption of the Radio, 1899–1919', and 'Ford Eagle Boats and Mass Production during World War I'. One chapter departs from this historical approach:

David Noble's critique of command systems of production in military enterprises and their bias against the working class.[10] Noble is the only author to put his values clearly on the line.

In the Autumn 1990 issue of *Science, Technology, & Human Values*, there is a special section with five articles on 'Technology and the Arms Race'.[11] The approach here is that of political science, with examinations of international politics, national security bureaucracies and arms manufacturers. Most of the authors appear to oppose the arms race and to favour reforms to control it. For example, Sanford Lakoff and W. Erik Bruvold, in the lead article, argue that '[g]iven political will, even the qualitative arms race is amenable to control'.[12]

In his book *Inventing Accuracy*, Donald MacKenzie provides a sophisticated account of the development of the missile guidance technology, and of debates over missile accuracy.[13] His analysis is constructivist: he takes pains to show the complex interaction of social and technical factors that led to the stabilization of particular knowledges and artefacts. MacKenzie hopes that his analysis will contribute to thinking of a world with no nuclear weapons.

These three selections of scholarship represent some of the approaches to military science and technology, generally following the disciplinary fields of history, politics and social construction of technology. In every case the researchers aim to provide insight into the social dynamics of military science and technology, whether it is the process of military innovation, public controversy over particular weapons, the macropolitics of weapons systems funding and deployment, or the micropolitics of creating or refining a theory or artefact.

How are these and other contributions in this area to be judged? The usual approach would be to rely on scholarly criteria, looking at the accuracy of information, the cogency of arguments, the soundness of theoretical frameworks, and the fruitfulness of the treatments for further research. But for my purposes here, it is appropriate to take a step back and ask: what is the *point* of doing this research? Is there any insight in these studies that would aid practical action in the world relating to military science and technology? For example, social analyses might be able to help improve the effectiveness of the military, by improving military technology (which has, of course, social dimensions), military organization or the legitimation of the military. Military establishments do draw on

the work of social scientists, and in turn have had an impact on certain social science agendas and theories.[14]

Alternatively, social analyses might be able to help counter the effectiveness of the military, or to develop alternatives to it. My assessment is that little of the scholarly literature in this field has practical value to those seeking alternatives to military methods. One reason for this is that the research is written for other scholars and, in terms of style and content, is neither easily accessible nor oriented to practitioners. Peace movements — for example, as judged by movement publications — take little note of academic research, including research published in scholarly peace studies journals.[15]

To ask about the practical use of studies of military science and technology is to adopt a criterion for evaluation different from the usual scholarly ones. Nicholas Maxwell has argued that most scientific and scholarly work is based on the 'philosophy of knowledge', which assumes that knowledge is of value in itself. Maxwell argues that the philosophy of knowledge should be replaced by a 'philosophy of wisdom', in which science (including social science) is directly geared to solve major problems facing humanity, such as poverty, repression and war.[16] Maxwell's framework provides an effective way to analyze the social studies of military science and technology. Most of these studies are founded on the philosophy of knowledge: they seek greater insight into the dynamics of science, technology and the military, without building their analysis around an explicit social goal. The authors may hope, as MacKenzie and some of the others clearly do, that after gaining greater knowledge, it can then be used for the benefit of society. But because the frameworks for building knowledge are not engaged with the actual projects for social benefit, these hopes are usually futile.[17] David Noble's essay, built on a clear commitment, is an exception to this pattern, and would fit into Maxwell's 'philosophy of wisdom'. But to talk about a philosophy of wisdom is inherently contentious, because there are obvious disagreements about paths to a better world. Advocates of military strength argue that deadly weapons are essential to defend free societies from aggression. This is the usual rationale for doing military R&D: the responsibility for using the results is left to political leaders who are assumed to serve the national (and indeed the human) interest.

Contrary to this position, the stance taken in this paper is that 'wisdom' in present-day society lies in the search for alternatives to

war and the military. Military systems are responsible for the deaths of hundreds of millions of people, continue to be involved in numerous wars today, and are the major agents of political repression around the world. There are various alternatives to war and the military, and various paths to these alternatives, including conflict resolution, education and social justice.[18] Each of these alternatives can be aided by suitable science and technology and by social analyses of science and technology, as well as by social analysis directly. To pursue the argument, one particular alternative is discussed here: social defence.

Social Defence

'Social defence' can be defined as nonviolent community resistance to aggression as an alternative to military defence. It relies on methods such as strikes, boycotts, refusals to obey, rallies, sit-ins and setting up alternative institutions. It is also known as 'nonviolent defence', 'civilian defence' and 'civilian-based defence'.[19] This section gives a brief overview of nonviolent action and social defence, before discussing the relevance of science and technology to them.

Nonviolent action has been used for centuries as a method of struggle against repression and aggression. The key figure who forged nonviolent action into a conscious method of social struggle was Mahatma Gandhi, whose campaigns and writings stimulated a number of thinkers and activists to explore nonviolence as a systematic alternative to violence.[20] But it was only in the 1950s that nonviolent action was proposed as a pragmatic, full-scale alternative to military defence, most prominently by Stephen King-Hall, a writer and former British naval officer.[21] Since then, the idea of social defence has been taken up by a number of peace researchers,[22] and has played a significant role in peace movements, especially in western Europe.

There are a number of historical case studies often raised to illustrate the potential of nonviolent action. In August 1968, Warsaw Pact forces invaded Czechoslovakia to put a stop to an easing of repressive rule — to what was called 'socialism with a human face'. The Czechoslovak military did nothing, realizing that armed resistance was futile; Western military forces also did nothing. But

there was a spontaneous nonviolent resistance by the Czechoslovak people. They rallied in the streets and tried to win over the invading soldiers, often with success. The radio system broadcast resistance messages, called a Czechoslovak Communist Party Congress, and counselled nonviolence. Although the most active phase of resistance lasted only a week, it took eight months before a puppet government could be installed. Furthermore, the nonviolence of the resistance highlighted the justice of its cause, and severely undermined the commitment of western communist parties to the Soviet Union.[23] There are also a variety of other examples, including the collapse of the Kapp Putsch in Germany in 1920,[24] nonviolent insurrections that toppled dictatorships in Guatemala and El Salvador in 1944,[25] the ending of the Marcos dictatorships in the Philippines in 1986 through 'people power', and the collapse of eastern European regimes in 1989.[26] Such examples cannot prove the effectiveness of nonviolent action, but they do indicate its potential. Social defence cannot be guaranteed to succeed, but neither can military defence.

At first, nonviolent action may seem counterintuitive. How can nonviolence be as effective as violence? The key is to look at the degree of commitment of various individuals and groups.[27] Violence tends to polarize a conflict, and each side's violence provides a justification for the other's. Nonviolent action, by contrast, is more likely to win supporters, especially when violence is used against nonviolent protesters. Furthermore, third parties are more likely to support a cause whose supporters are willing to suffer without violent retaliation. This is why aggressors try to paint those they attack as violent, as in the case of police use of *agents provocateur*, Hitler's propaganda about the Reichstag fire, and US President Lyndon Johnson's use of the Tonkin Bay incident to justify increasing US military involvement in Vietnam.

Although there have been many historical uses of nonviolent action and there is a large literature on nonviolent action, no society has yet organized itself systematically for social defence. A few political parties, such as the German Greens, have put social defence on their platforms, a few European governments have sponsored studies into social defence,[28] and a few activist groups have carried out investigations.[29] Mostly, though, social defence has remained an idea.

What exactly are the threats against which social defence is

needed? To begin with, at any given time since World War II there have been some two dozen wars being waged in the world, most but not all in the Third World. These wars are supported by a vigorous trade in weapons and organized training in military techniques, mostly provided by governments and corporations from the leading industrial powers, especially the United States. Nonviolent methods of deterring or resisting the aggression in these wars are of immediate interest to the people involved. As well, people from other countries can help by providing ideas and material support for nonviolent struggle, as already occurs on a limited scale.

Few of the major industrial powers have come under attack themselves since 1945, but this is not an impossibility. There was no European-wide war for nearly a century after 1815, but this did not mean the danger had disappeared. A nuclear war, intentional or accidental, remains a possibility so long as nuclear arsenals exist. Furthermore, many conventional weapons, such as fuel-air explosives (used against Iraq in 1991), are nearly as destructive as small nuclear devices.

Another major threat is military dictatorship. A considerable fraction of the world's governments is directly or indirectly in military hands. Armies are far more likely to be used against a country's own people than against enemy troops. Military rule is bolstered by technologies for torture and social control — the so-called 'technologies of repression' — which are mainly researched, designed and manufactured in countries such as the United States, Russia, Britain, France and Italy, and exported to Third World governments.[30] In many industrialized countries, a military takeover may be unlikely, but the possibility cannot be rejected entirely. Military coups have occurred in countries such as Poland and Greece, as well as in numerous countries in Latin America, Africa and Asia. Martial law is a significant possibility in the aftermath of a major nuclear crisis.[31]

Social defence is relevant to all these threats. The conventional justification for military forces is to defend against foreign military threats. If military defence is to be eliminated, then some method of defence will be required; a large component of the literature on social defence addresses conventional threats.[32] A deeper analysis of the role of military forces is that their major function is to maintain the power of dominant political and economic interests.[33] Even when there is no external threat, militaries are 'needed' to

thwart popular challenges to current ruling groups. In the case of military dictatorships, the military *is* the ruling group. Social defence is an appropriate means of resisting military impositions. Needless to say, military forces, however useful for defence against foreign enemies, are the cause rather than the solution to the possibility of a military coup.

Nonviolent action has received increasing attention in the past several decades. One major factor has been the dramatic expansion in the planned use of methods of nonviolent action, especially in environmental campaigns, spread through workshops by members of Movement for a New Society and others.[34] A number of instances of nonviolent resistance, such as the toppling of the dictatorship in the Philippines in 1986, the Palestinian intifada of 1987–93 and the collapse of communist regimes in Europe in 1989, have received enormous attention. In addition, a number of Third World liberation groups, having seen the failure and counterproductive results of armed struggle, have begun exploring nonviolent options.[35] While it remains true that the average reader of the mass media may have little feeling for the use or potential of nonviolent action, in activist circles interest is as great as it has ever been. The collapse of the communist bloc has aided this process considerably, since many Marxist groups in both the First and Third Worlds have long been advocates of armed struggle, and often intensely hostile to proponents of nonviolence.

Although the amount of organized nonviolent action has increased considerably, it is still mainly carried out by small groups. Most society-wide uses of nonviolent action — the sort needed for a social defence system — have been largely spontaneous, as in Czechoslovakia in 1968. In such cases there has been no planning, mobilization, training or preparation of infrastructure. By contrast, military forces have the advantage of substantial funding, considerable staffing, legal sanction, training and cooperation from many sectors of the economy. If social defence were supported in such a style, it seems plausible that its effectiveness would be greatly increased.

One aspect of this is science and technology. Decades of military-oriented R&D have produced an awesome array of weapons, as well as knowledge and methods for other aspects of the military mission. If an equivalent R&D commitment to social defence was made, no doubt its mission could be equally well supported. Or could it?

Science and Technology for Nonviolent Struggle

Mary Cawte and I carried out an investigation of how science and technology might support a system of social defence.[36] A survey of the literature on social defence reveals that this topic has been virtually untouched: the primary exception is a set of suggestions by peace researcher Johan Galtung.[37] Similarly, the scientific and technological literatures make no mention of social defence. It is only in the social sciences, especially in political science and social psychology, where an occasional analysis of nonviolent action may be found.[38]

Since, in principle, every field of study could contribute to social defence, we established priority areas for investigation by setting out key areas important to a social defence system. These can be classified as follows:

Positive factors

Psychological and organizational factors

- morale, unity, will
- knowledge, education, understanding, analysis, strategy, tactics, evaluation
- coordination, decision-making, organization, leadership

Physical infrastructure

- communication
- survival: food, clothing, shelter, energy, transport, health
- industry, production, economics

Other factors

- skills (including direct disarmament)
- self-reliance
- allies
- constructive programme

Negative factors

- anti-nuclear weapons (countering the threat and effects of nuclear weapons)

- anti-biological weapons
- anti-chemical weapons
- anti-conventional weapons

This list was compiled with advice from a few nonviolence scholars. It is impossible to give weights to these factors in terms of their importance, since there is no theoretical framework available for this purpose. Nevertheless, a general ranking is possible by looking at studies of nonviolent struggles. Undoubtedly the greatest attention is given to psychological and organizational factors. Anders Boserup and Andrew Mack, in one of the key books in the field, conclude that unity of the nonviolent resistance is its centre of gravity.[39] Gene Keyes disagrees, finding that the morale of the resistance is the key.[40] Robert Burrowes concludes that the centre of gravity of both the oppressor and the resistance is the will of the key social groups that support the respective strategies.[41] But despite disagreements, these and most other authors agree that the key to effective nonviolent resistance to aggression lies in psychological and organizational factors.

As for physical infrastructure, communication technology is probably the most important factor, and this is because of its close link to psychological and organizational factors. Survival of the population is not often threatened in a nonviolent resistance (one case is the Palestinian intifada), and industry seems only occasionally to have played an important role. The capacity to understand, resist, and dismantle weapons of the aggressor is a topic seldom discussed in the nonviolence literature.

This list of key factors provides a preliminary way to assess the importance of scientific fields to nonviolent struggle. For example, consider biology. It can offer some help in the task of survival — for example, via understanding of ecology, such as knowledge of species not requiring pesticides or fertilizers (which might be unavailable during a blockade), or fruit-bearing species. Biologists could also provide some insight into the capability of biological weapons, and how to counter them.

An examination of other fields of science and engineering soon shows that a number of them can contribute to survival (earth sciences, medicine, agricultural science, most branches of engineering), and many to communication (computer science, electrical engineering, mathematics). But aside from a few other areas (chemistry can contribute to anti-chemical warfare; engineering has a

crucial role in designing industry for a social defence system),[42] the bulk of science and engineering has little to offer to nonviolent struggle.[43] This conclusion needs an immediate qualification. Aside from contributions to survival and communication, the bulk of *present-day* science and engineering seems to offer little to nonviolent struggle. It is quite possible that these fields could be more relevant if they were redirected — for example through a change in funding patterns — from military to nonviolent goals. In terms of present systems of knowledge, skills and hardware, the social sciences have a much more important role to play in supporting social defence than do the natural sciences and engineering.[44]

Having surveyed the contours of science and technology for social defence, it is useful to pick an area for a more specific illustration. Communication technology is suitable because it is vital in both military and social defence and because it involves several technical disciplines.

Military communication puts a priority on messages sent along the chain of command and on secrecy and reliability, especially during war. Gathering information is an important element, especially information about enemy military capacities and intentions. Thus there are dedicated military telecommunications, spy satellites, interception of enemy signals, and systems for C^3I (command, control, communication and intelligence). But social defence is based on popular participation, and is usually assumed not to be centrally directed. It stresses communicating with both supporters and opponents, including soldiers and members of the population from any aggressor country. Secrecy is usually used as little as possible. An open, honest and steadfast population is more likely to remain united and committed and to win converts than is a secretive and devious one.

Generally speaking, interactive communication systems are most suitable for social defence. This includes word of mouth, the post, telephone, CB radio, short-wave radio and computer networks. By contrast, the technologies of the mass media — large newspapers, television, commercial radio — are ideally suited for authoritarian rule. This is the reason why military takeovers so commonly begin with occupation of television and radio stations. A social defence system would rely as little as possible on mass media, and would develop interactive communication.[45] This simple conclusion alone provides a strong implication for technological development if priorities were changed from military to social defence. Instead of

developing secure, hardened, specialist, command systems, the priority would be on developing resilient, redundant, cheap and easy-to-use interactive systems. Instead of developing the capacities of spy satellites, the priority would be on developing ham radio satellites, to which anyone can send messages using a portable computer and transmitter.

Having established general priorities in communication technology for social defence, some specific problems can be investigated. Computer networks, for example, are ideal for social defence,[46] but contain a few vulnerabilities. Typically in any computer network there is a system administrator, who has access to the passwords and hence potentially the communication of all other users. An aggressor might coerce or bribe the system administrator to cooperate. This contingency could be avoided in a number of ways. One is to design the system so that, in an emergency, the capacity of the system administrator (or anyone else) to monitor communication is eliminated. This might be designed to occur when a certain fraction of users sends a certain signal. Alternatively, systems without a single system administrator could be designed. A lot of research and testing is required to develop the most effective systems.

Confidentiality of telecommunications is an area where military and nonmilitary priorities are transparent. The US National Security Agency has promoted a technology (the 'Clipper chip') that would allow it to read all encrypted communication, whereas many commercial and public interest groups favour totally secure encryption algorithms.[47] Obviously, a social defence system is far better served by the latter direction.[48]

The case of telecommunications and encryption is an example of how the research projects for social defence would differ from those for military purposes. Military researchers have put an enormous amount of effort into surveillance of other people's communications. For social defence, the priority would be developing and using secure interactive communication systems.

In summary, a comparison of research priorities for military and nonviolent ends shows some dramatic differences at a number of levels. Research into improving nonviolent struggle would lead to a much greater emphasis on social science than does military-related research. A priority on nonviolent struggle would mean greater attention to particular fields, such as short-wave and packet radio. Finally, within particular fields, a nonviolence-oriented research agenda would lead to emphasis on different puzzles, such as on

secure rather than government-readable encryption in telecommunications.

Implications for Science and Technology

For researchers into the social shaping of science and technology, it is no surprise that different funding, applications and goals lead to emphasis on different disciplines and projects. The insight to be gained from an investigation of science and technology for social defence is more specific. It suggests the particular disciplines and projects which would differ if military goals were replaced by nonviolent ones. Specifically, a science and technology policy based on promoting social defence would be dramatically different from one based on promoting military strength. The following changes would be among the most significant:[49]

(1) There would much greater emphasis given to social sciences compared to natural sciences and engineering;

(2) The effort given to different research fields would be shifted considerably. For example, particle physics would be a much lower priority, whereas interactive telecommunications and social psychology would be much higher priorities;

(3) Different particular projects in any field would be emphasized. For example, more attention in encryption research would be given to cheap, convenient and totally secure algorithms, and little if any to algorithms designed to be broken by a central authority; and

(4) Research would be more responsive to a wide range of community interests, rather than mainly to interests of the military and state bureaucracies.

Of these four points, the second and third are the most obvious. They are examples of the familiar way in which interests shape the development of science and technology. The first point is perhaps more significant. The implication is that the present situation, in which natural science and engineering receive the bulk of research monies is, to a considerable degree, a product of military priorities operating this century, and that quite a different balance between the 'soft' and 'hard' sciences might result if social defence were given the same investments and priority now given to the military.

Complaints by scholars in the humanities and social sciences that they are shortchanged in the struggle for research money typically stress the intellectual worthiness or the importance of culture. The analysis here provides quite a different argument: that social science — or, more precisely, particular branches of social science — are central to the development of the capacity of a society to defend itself using nonviolent methods. (It should be noted that present-day social science has been shaped to a certain extent by military priorities,[50] and that a social science shaped by social defence priorities might look quite different.)

The fourth point above requires some elaboration. All science and technology involves some social interaction in its development and use. The question is: which groups do most of the interacting? In the case of military-oriented science and technology, the primary groups are in the military itself, as well as in relevant government bureaucracies and corporations. For example, in the case of combat rifles, there are designers, testers, funding agencies, manufacturers and soldiers in the field. Actually, in the case of rifles, some civilians have an indirect input, since they use the weapons, or related ones, for nonmilitary purposes such as hunting. In most cases, such as long-range bombers, no 'members of the public' are involved, except perhaps as casualties. The conclusion here is straightforward: the principal groups that are involved in developing and using military science and technology are ones closely linked to the military R&D process itself.

Social defence, by contrast to armies, is a participatory form of struggle. Whereas most combat soldiers are young, fit men, anyone who wants to, regardless of age, sex or abilities, can participate in some form of nonviolent action.[51] This means that testing a method of nonviolent action usually involves a field test with a large cross-section of the population. This might be planting fruit and nut-bearing trees to make communities more self-sufficient in food, or designing factories so that they can be safely and easily shut down if taken over by an aggressor. The implication is that R&D for social defence, to be effective, would require close liaison with numerous community groups, from local gardeners to factory workers. The equivalent of soldiers testing out a new rifle would be a community testing out a new communication procedure. Military and social defence R&D are alike inasmuch as science and technology are never developed solely in the minds of intellectuals or in remote labs: there is always a process of social interaction. Where

these alternatives differ, in this regard, is in the social groups of greatest significance to the R&D process.

So far, I have assumed that R&D for social defence would be carried out by separate specialist groups, as in the case of almost all military R&D. But since social defence is inherently more participatory, there would be advantages in pulling science out of the lab and making research itself a more participatory activity. Social defence R&D might become more of a process managed as well as shaped by the communities that would be relying on the results. Social defence R&D might well follow the route of 'science shops', 'appropriate technology', and workers' initiatives for socially useful technology — namely, a route that puts decisions about the nature and products of research in the hands of a broader cross-section of the population.[52] Needless to say, not all these initiatives have been successful. After all, they challenge the dominant trend over the past century for specialists and bureaucracies to take more control over R&D. It is not the aim of this paper to provide a blueprint for conversion to social defence, but rather to raise some of the implications of this alternative for understanding current priorities for science and technology.

This raises a more general issue: if social defence is introduced, what does that imply for the organization of society more generally, such as the state and the economy? Social defence thinkers differ in their answers. Gene Sharp, the world's most prominent nonviolence scholar, believes that the way to introduce civilian-based defence is by convincing government and military leaders of its greater effectiveness. He does not believe that major changes in the structure of society should be linked to the conversion from military to civilian-based defence.[53] Quite a number of activists, on the other hand, see the promotion of social defence as part of a broader process of social change, including the use of nonviolent action by feminists, workers, environmentalists and others. In this picture, there might be considerable changes in the role of the state and large corporations that would accompany any move towards social defence.[54]

Implications for Science and Technology Studies

The usual approach to the social shaping of science and technology is to observe the apparent connection between the existence of a social interest and developments in science or technology that seem

to respond to or serve that social interest. This is a reasonable way to proceed, but one assumption, usually unstated, should be questioned: that there is some baseline of what science or technology would be if the social interest did not exist or was not directly affecting R&D. This assumption is reminiscent of the model of scientific development in which an 'internal logic' dictates the trajectory of science, sometimes perturbed by external influences. A problem with this assumption is that there is no neutral position with which to compare the 'perturbed' science. The reason is quite simple: science is never done in the abstract, but always occurs in a social context. This is more obvious in the case of technology, which would not exist but for (and apart from) human decisions to create it.

This is a problem with the 'perturbation model' for evaluating external influences, but there is no need to reject it entirely, and instead study the 'co-evolution' of 'science-society' without trying to determine the effect of specific social structures and groups. The alternative is quite simple: instead of comparing the effect of military (or other) influences on science and technology with the case of no effect, a military-affected science can be compared with a social-defence-affected science. This eliminates the assumption of a 'neutral trajectory', while retaining the insight gained from making a comparison of effects.

Looking at the general theme of security or defence, conventional military defence and social defence are only two possibilities. Others include 'defensive military defence' (ruling out obviously offensive weapons, such as long-range bombers, while retaining weapons mainly useful for defence, such as short-range jet fighters), guerrilla or partisan warfare, and nonresistance (no formal defence system at all). Any one of these could be used as a baseline for examining the shaping of science and technology by other systems.

This method of comparing the actual development of science and technology in society with the likely development that would occur with a different set of policies or social organization can be called a 'utopian' analysis of science and technology. An alternative, hypothetical social structure, and the science and technology likely to accompany or grow out of it, are used to gain insight into the present system. This insight is also relevant to evaluating methods for moving to the alternative system, especially when elements of the alternative already exist. This method could also be carried out

in 'dystopian' mode, by imagining undesirable futures — such as a world fascist state — and the likely science and technology that would accompany it. In either case, an evaluation of the alternative is difficult to avoid, especially when drawing policy implications.

As indicated earlier, most approaches to the study of science and technology only examine what exists, not what might exist in a different sort of society. This applies both to technological determinist studies and to social constructivist studies of technology.[55] From the point of view of utopian analysis, all such studies have a conservative orientation, in that they affirm that which exists and offer no analytical means for focussing attention on what might exist in a different society. Technological determinist studies often examine future developments under the assumption that they are the 'logical' outgrowth of present technologies. Constructivist analyses typically examine technological possibilities that were foreclosed in the past, but always within the context of the actually existing society; seldom do constructivist analysts investigate what might happen in the future.[56] In both approaches, little insight is given into future technological possibilities under different social conditions.

Ironically, while scholars of science and technology have avoided utopian analysis, many practitioners have used it for decades. The 'alternative technology' movement was built on examination of a belief that some technologies are more suitable to a participatory, just and nonrepressive society than others, and that promoting such technologies can be part of the process of moving towards such a society.[57] The movements against nuclear weapons and nuclear power have been based, to a considerable extent, on opposition to the likely sort of social arrangements in a 'nuclear society', such as a permanent state of nuclear terror and a surveillance state to guard against nuclear terrorists.[58] Today there are large numbers of technology enthusiasts promoting computer networks and other forms of participatory media.[59] These and other such movements can be criticized, to be sure, for näive assumptions about the relation between technology and society, for example. But there is no doubting that they have a vision of a society differing from the existing or likely one, and of the role of technology in that vision.

Perhaps one reason why technology studies scholars have avoided utopian analyses is that they prefer not to be openly 'political' — that is, not to be open about their values. Although carrying out a utopian analysis does not necesarily mean that the analyst endorses the utopia, many others might make this assump-

tion. By contrast, it is much easier to hide one's values when carrying out analyses of existing technologies or, alternatively, to proclaim one's values when they involve an endorsement or only a mild criticism of dominant institutions.

The development of science and technology for nonviolent action potentially involves most major fields of research, from architecture to zoology, but there is a special role for researchers in science and technology studies. They are in an excellent position to provide a link between technical specialists and the social dimensions which are of central importance in nonviolent action. It should not be imagined that this sort of 'utopian' study is necessarily uncritical: alternative science and technology are in special need of critical assessment because, among other reasons, there are so many more possibilities to consider!

• NOTES

Helpful comments were received from Robert Burrowes, Mary Cawte, Jim McCartney, Stewart Russell and several anonymous referees. This work was supported by a grant from the Australian Research Council.

1. Useful general treatments are given by Robin Clarke, *The Science of War and Peace* (London: Jonathan Cape, 1971), and Martin van Creveld, *Technology and War: From 2000 BC to the Present* (New York: Free Press, 1989). See also John Desmond Bernal, *Science in History: Volume 3: The Natural Sciences in Our Time* (London: Watts, 1969), 831–48; Richard Coopey, Matthew R.H. Uttley and Graham Spinardi (eds), *Defence Science and Technology: Adjusting to Change* (Chur, Switzerland: Harwood, 1993); David Dickson, *The New Politics of Science* (New York: Pantheon, 1984), Chapter 3; James William Gibson, *The Perfect War: Technowar in Vietnam* (Boston, MA: Atlantic Monthly Press, 1986); Stuart W. Leslie, *The Cold War and American Science: The Military-Industrial-Academic Complex at MIT and Stanford* (New York: Columbia University Press, 1993); Les Levidow and Kevin Robins (eds), *Cyborg Worlds: The Military Information Society* (London: Free Association Books, 1989); Everett Mendelsohn, Merritt Roe Smith and Peter Weingart (eds), *Science, Technology and the Military* (Dordrecht: Kluwer, 1988); Jean-Jacques Salomon (ed.), *Science, War and Peace* (Paris: Economica, 1990); 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); Merritt Roe Smith (ed.), *Military Enterprise and Technological Change: Perspectives on the American Experience* (Cambridge, MA: MIT Press, 1985); and John Tirman (ed.), *The Militarization of High Technology* (Cambridge, MA: Ballinger, 1984). There are also analyses of specific research fields or weapons, such as David H. DeVorkin, *Science with a Vengeance: How the*

Military Created the US Space Sciences after World War II (New York: Springer-Verlag, 1992); John Ellis, *The Social History of the Machine Gun* (London: Croom Helm, 1975); James Fallows, 'The American Army and the M-16 Rifle', in Donald MacKenzie and Judy Wajcman (eds), *The Social Shaping of Technology* (Milton Keynes, Bucks.: Open University Press, 1985), 239–51; Paul Forman, 'Behind Quantum Electronics: National Security as Basis for Physical Research in the United States, 1940–1960', *Historical Studies in the Physical Sciences*, Vol. 18 (1987), 149–229; 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 (1991), 179–201; and John H. Perkins, 'Reshaping Technology in Wartime: The Effect of Military Goals on Entomological Research and Insect-Control Practices', *Technology and Culture*, Vol. 19 (1978), 169–86.

2. Bruno Vitale, 'Scientists as Military Hustlers', in *Issues in Radical Science* (London: Free Association Books, 1985), 73–87.

3. Contrary to common usage, in this paper the word 'defence' is not assumed to mean 'military defence', but can include as well nonviolent defence, civil defence, psychological defence and other means of resisting or surviving aggression.

4. Throughout this paper, the language of 'the social shaping of science and technology' will be used for convenience, rather than as an endorsement of this particular theoretical framework. The analysis here is compatible with a range of models of the interaction of science and society, and perhaps even of the seamlessness of science-society. Among other models, this includes: the dichotomy of internal and external factors in the development of science; the idea of interests and their impact or association with the creation and validation of knowledge and artefacts; and social shaping (see MacKenzie & Wajcman [eds], op. cit. note 1). Some comments on the implications of this study for social analysis of science and technology are given in the final section.

5. Marek Thee, 'The Race in Military Technology', in Joseph Rotblat (ed.), *Scientists, the Arms Race and Disarmament* (London: Taylor & Francis, 1982), 49–56, at 51.

6. To be sure, there are other influences on tanks besides purely military ones, such as costs.

7. There is a parallel here with the idealization commonly used by scientists to deny any but an internal logic of scientific advance: by discussing only broad fields of research, such as molecular biology or organic chemistry, it becomes far more difficult to perceive 'social shaping' than by looking at particular topics or labs. Another parallel is with studies of disease. The effect of a particular disease-causing agent can be hidden if too large a population of unaffected people is included, as epidemiologists well recognize. If a chemical used at a particular factory is dangerous, then the workers are the relevant population, not the entire city. To reiterate: to look for the most obvious military influences on technology, look at military technologies!

8. For useful reviews, see Philip Gummett, 'Issues for STS Raised by Defence Science and Technology Policy', *Social Studies of Science*, Vol. 20 (1990), 541–58; Donald MacKenzie, 'Science and Technology Studies and the Question of the Military', *Social Studies of Science*, Vol. 16 (1986), 361–71; Alex Roland, 'Technology and War: A Bibliographic Essay', in Smith (ed.), op. cit. note 1, 347–79; Harvey M. Sapolsky, 'Science, Technology and Military Policy', in Ina Spiegel-

R(94)sing and Derek de Solla Price (eds), *Science, Technology and Society: A Cross-Disciplinary Perspective* (London & Beverly Hills, CA: Sage, 1977), 443–71; Wim A. Smit, 'Science, Technology, and the Military: Relations in Transition', in Sheila Jasanoff, Gerald E. Markle, James C. Petersen and Trevor Pinch (eds), *Handbook of Science and Technology Studies* (Thousand Oaks, CA, London & New Delhi: Sage, 1995), 598–626.

9. Smith (ed.), op. cit. note 1.

10. David F. Noble, 'Command Performance: A Perspective on the Social and Economic Consequences of Military Enterprise', in Smith (ed.), op. cit. note 1, 329–46.

11. Patrick W. Hamlett (ed.), 'Special Section: Technology and the Arms Race', *Science, Technology, & Human Values*, Vol. 15 (1990), 379–473.

12. Sanford Lakoff and W. Erik Bruvold, 'Controlling the Qualitative Arms Race: The Primacy of Politics', *Science, Technology, & Human Values*, Vol. 15 (1990), 382–411, quote at 382.

13. Donald MacKenzie, *Inventing Accuracy: A Historical Sociology of Nuclear Missile Guidance* (Cambridge, MA: MIT Press, 1990).

14. See, for example, Peter Buck, 'Adjusting to Military Life: The Social Sciences Go to War, 1941–1950', in Smith (ed.), op. cit. note 1, 203–52; Irving Louis Horowitz (ed.), *The Rise and Fall of Project Camelot: Studies in the Relationship between Social Science and Practical Politics* (Cambridge, MA: MIT Press, 1967); Douglas D. Noble, *The Classroom Arsenal: Military Research, Information Technology, and Public Education (London: Falmer Press, 1991); Christopher Simpson, Science of Coercion: Communication Research and Psychological Warfare 1945–1960* (New York: Oxford University Press, 1994); Peter Watson, *War on the Mind: The Military Uses and Abuses of Psychology* (Harmondsworth, Middx: Penguin, 1980).

15. This conclusion is based on years of reading movement journals such as *Peace News*. Academic work may have a more indirect effect via scholars who participate in peace actions, through their students, or via second-hand, more popular accounts of their research. Even taking these indirect channels into account, it is difficult to perceive any significant influence of scholarly writings about war and peace on peace action. One possible conclusion to be drawn from this observation, of course, is that the peace movement is the main loser from this neglect.

16. Nicholas Maxwell, *From Knowledge to Wisdom: A Revolution in the Aims and Methods of Science* (Oxford: Basil Blackwell, 1984); Maxwell, 'What Kind of Inquiry Can Best Help Us Create a Good World?', *Science, Technology, & Human Values*, Vol. 17 (1992), 205–27; Maxwell, 'A New Enlightenment', *Science & Public Affairs* (London, Spring 1997), 50–56.

17. For MacKenzie's position, see: Donald MacKenzie and Graham Spinardi, 'Tacit Knowledge, Weapons Design, and the Uninvention of Nuclear Weapons', *American Journal of Sociology*, Vol. 101, No. 1 (July 1995), 44–99; MacKenzie, 'Moving Toward Disinvention', *Bulletin of the Atomic Scientists*, Vol. 52, No. 5 (September/October 1996), 4; and MacKenzie, 'Wasting Assets', *London Review of Books* (23 January 1997), 24–25. See also D. MacKenzie, *Knowing Machines: Essays on Technical Change* (Cambridge, MA: MIT Press, 1996). MacKenzie's comments are a supplement to his analysis, rather than being central to it. My comments here on the work of MacKenzie and others should be tempered by the

observation that they, more than most other scholars, are grappling with crucial social issues, in several cases with a clear commitment to moving towards a world without war. This is all the more reason to examine the limitations of their approaches.

18. See, for example, Birgit Brock-Utne, *Educating for Peace: A Feminist Perspective* (New York: Pergamon, 1985); Dietrich Fischer, *Preventing War in the Nuclear Age* (Totowa, NJ: Rowman & Allanheld, 1984); Harry B. Hollins, Averill L. Powers and Mark Sommer, *The Conquest of War: Alternative Strategies for Global Security* (Boulder, CO: Westview Press, 1989); Robert A. Irwin, *Building a Peace System* (Washington, DC: Expro Press, 1989).

19. See: Anders Boserup and Andrew Mack, *War Without Weapons: Non-violence in National Defence* (London: Frances Pinter, 1974); the journal *Civilian-Based Defense*; Johan Galtung, *Peace, War and Defense: Essays in Peace Research, Volume Two* (Copenhagen: Christian Ejlers, 1976); Gustaaf Geeraerts (ed.), *Possibilities of Civilian Defence in Western Europe* (Amsterdam: Swets & Zeitlinger, 1977); Steven Duncan Huxley, *Constitutionalist Insurgency in Finland: Finnish 'Passive Resistance' against Russification as a Case of Nonmilitary Struggle in the European Resistance Tradition* (Helsinki: Finnish Historical Society, 1990); Stephen King-Hall, *Defence in the Nuclear Age* (London: Victor Gollancz, 1958); Brian Martin, *Social Defence, Social Change* (London: Freedom Press, 1993); Johan Niezing, *Sociale Verdediging als Logisch Alternatief: Van Utopie naar Optie* (Assen, Netherlands: Van Gorcum, 1987); Michael Randle, *Civil Resistance* (London: Fontana, 1994); Adam Roberts (ed.), *The Strategy of Civilian Defence: Non-violent Resistance to Aggression* (London: Faber & Faber, 1967); Gene Sharp, *Making Europe Unconquerable: The Potential of Civilian-based Deterrence and Defense* (Cambridge, MA: Ballinger, 1985); and Gene Sharp, with the assistance of Bruce Jenkins, *Civilian-Based Defense: A Post-Military Weapons System* (Princeton, NJ: Princeton University Press, 1990).

20. Richard B. Gregg, *The Power of Nonviolence* (New York: Schocken Books, [1935] 1966); Krishnalal Shridharani, *War Without Violence: A Study of Gandhi's Method and its Accomplishments* (London: Victor Gollancz, 1939).

21. King-Hall, op. cit. note 19. See also Bradford Lyttle, *National Defense Thru Nonviolent Resistance* (Chicago, IL: Shahn-ti Sena Publications, 1958).

22. Notably Theodor Ebert, Johan Galtung, Adam Roberts and Gene Sharp: see the work cited in note 19.

23. Philip Windsor and Adam Roberts, *Czechoslovakia 1968: Reform, Repression and Resistance* (London: Chatto & Windus, 1969).

24. D.J. Goodspeed, *The Conspirators: A Study of the Coup d'État* (London: Macmillan, 1962).

25. Patricia Parkman, *Nonviolent Insurrection in El Salvador: The Fall of Maximiliano Hernández Martínez* (Tucson, AZ: University of Arizona Press, 1988).

26. Michael Randall, *People Power: The Building of a New European Home* (Stroud, Glos.: Hawthorn Press, 1991).

27. The key reference is Gene Sharp, *The Politics of Nonviolent Action* (Boston, MA: Porter Sargent, 1973). For critiques, see Brian Martin, 'Gene Sharp's Theory of Power', *Journal of Peace Research*, Vol. 26 (1989), 213–22; and Kate McGuinness, 'Gene Sharp's Theory of Power: A Feminist Critique of Consent', *Journal of Peace Research*, Vol. 30 (1993), 101–15.

28. One such study is Alex P. Schmid, in collaboration with Ellen Berends and Luuk Zonneveld, *Social Defence and Soviet Military Power: An Inquiry into the Relevance of an Alternative Defence Concept* (Leiden: Center for the Study of Social Conflict, State University of Leiden, 1985).

29. Jacki Quilty et al., *Capital Defence* (Canberra: Canberra Peacemakers, 1986).

30. Steve Wright, 'The New Technologies of Political Repression: A New Case for Arms Control?', *Philosophy and Social Action*, Vol. 17 (July-December 1991), 31–62.

31. Brian Martin, 'Politics after a Nuclear Crisis', *Journal of Libertarian Studies*, Vol. 9, No. 2 (Fall 1990), 69–78.

32. See especially Sharp, op. cit. note 19.

33. Charles Tilly, 'War Making and State Making as Organized Crime', in Peter B. Evans, Dietrich Rueschemeyer and Theda Skocpol (eds), *Bringing the State Back In* (Cambridge: Cambridge University Press, 1985), 169–91.

34. The classic manual is Virginia Coover, Ellen Deacon, Charles Esser and Christopher Moore, *Resource Manual for a Living Revolution* (Philadelphia, PA: New Society Publishers, 1981).

35. Stephen Zunes, 'Unarmed Insurrections against Authoritarian Governments in the Third World: A New Kind of Revolution', *Third World Quarterly*, Vol. 15 (1994), 403–26. Given the enormously powerful weapons available to states, including information technologies used for surveillance, it can be argued that armed liberation is increasingly unlikely to succeed and ever more likely to lead to massive death and suffering. As well, effective use of violence requires secrecy and centralized command, so that the revolutionaries tend to replicate the undemocratic system they are trying to supplant. See also Martin Oppenheimer, *The Urban Guerilla* (Chicago, IL: Quadrangle Books, 1969).

36. The framework for the study is given in Brian Martin, 'Science for Nonviolent Struggle', *Science and Public Policy*, Vol. 19 (1992), 55–58.

37. Galtung, op. cit. note 19. Relevant in a more general sense is the prophetic work by Aldous Huxley, *Science, Liberty and Peace* (New York: Harper & Row, 1946).

38. For example, A. Paul Hare and Herbert H. Blumberg (eds), *Nonviolent Direct Action: American Cases: Social-psychological Analyses* (Washington, DC: Corpus Books, 1968); V.K. Kool (ed.), *Nonviolence: Social and Psychological Issues* (Lanham, MD: University Press of America, 1993); Leroy H. Pelton, *The Psychology of Nonviolence* (New York: Pergamon Press, 1974).

39. Boserup & Mack, op. cit. note 19.

40. Gene Keyes, 'Strategic Non-violent Defense: The Construct of an Option', *Journal of Strategic Studies*, Vol. 4 (1981), 125–51.

41. Robert J. Burrowes, *The Strategy of Nonviolent Defense: A Gandhian Approach* (Albany, NY: State University of New York Press, 1996).

42. Even though industry only occasionally plays an important role in a nonviolent struggle, sometimes it does; engineering can play a crucial role in preparing it for these latter cases.

43. It is necessary to spell out the converse, namely that some (present-day) science and engineering is useful for nonviolent struggle, such as the examples mentioned. One referee wrote: 'the examples of how (a different?) science could contribute to social defence are self-defeating because some of them are now

actually carried out within the present military R&D that is so much detested by the author'. Contrary to this referee, my argument is built on the assumption that some current R&D (including military R&D) is relevant to nonviolent struggle.

44. One referee claimed that this statement seems to be in conflict with the earlier statement that social science agendas and theories have been influenced by military funding and priorities. But even military-shaped social science can potentially be useful for social defence, and there is plenty of social science research that has responded to other agendas. 'Social shaping of technology' does not necessarily result in technology that cannot be used for purposes for which it was not shaped.

45. Schweik Action Wollongong, 'Telecommunications for Nonviolent Struggle', *Civilian-based Defense: News & Opinion*, Vol. 7, No. 6 (August 1992), 7–10.

46. It has often been noted that the Internet had its origins in Arpanet, a US military computer network. While designing a computer communication network to survive nuclear attack was floated as an idea at the time, the immediate purpose of Arpanet was to link together research laboratories. See, for example, Jeffrey A. Hart, Robert R. Reed and François Bar, 'The Building of the Internet: Implications for the Future of Broadband Networks', *Telecommunications Policy*, Vol. 16, No. 8 (1992), 666–89. The military origins of the Internet by no means preclude an assessment that it is highly useful for social defence (see note 44). Generally speaking, open and interactive media, such as computer bulletin boards, are selectively useful to popular movements, but can be useful to the military if usage is tightly controlled. Similarly, mass media such as radio and television are easy to control centrally, but can be effective tools for popular nonviolent resistance if controlled by members of a fully united population. On this latter point see Brian Martin, 'Communication Technology and Nonviolent Action', *Media Development*, Vol. 43, No. 2 (1996), 3–9.

47. Peter Cassidy, 'Silent Coup in Cyberspace', *CovertAction Quarterly*, No. 52 (Spring 1995), 54–60; Lance J. Hoffman (ed.), *Building in Big Brother: The Cryptographic Policy Debate* (New York: Springer-Verlag, 1995).

48. Although, as stated earlier, social defence is based on a large degree of openness, this does not mean that vulnerability to surveillance is irrelevant. Openness is relevant when it comes to plans for major nonviolent actions such as rallies, boycotts, public meetings and sit-ins. In addition, much of the planning for such actions is open to a wide range of participants. (This is in contrast to the secrecy involved in planning military strikes.) On the other hand, there is also a need for reliable and secure communication (for example, to alert individuals who are about to be arrested), as well as the confidentiality of a conversation between two people. Openness, the boundaries of which must be constructed by the relevant community, can be considered an issue of political principle. It involves a commitment to dialogue with all relevant parties; some believe that dialogue is the foundation of nonviolent action. Surveillance, by contrast, is at best a one-directional communication channel, and certainly involves no dialogue. Developing communication channels free from surveillance thus is a valid part of developing the capacity for nonviolent struggle.

49. Another area where there are potential differences between science and technology policies for these two methods of struggle is the balance between 'pure' and 'applied' research. Setting aside debates about the utility of this distinction, it is unlikely that there would be great differences: in both cases there are immediate

(applied) uses of science and technology, and in both cases pure research may be stimulated by applications, and/or lead to them.

50. See the work cited in note 14.

51. Obviously, not everyone is able to participate in *every* form of nonviolent action. For example, using a short-wave radio to send messages requires certain skills and technology. But virtually everyone can participate in petitions, rallies, boycotts, strikes and other forms of noncooperation.

52. On science shops, see Rolf Zaal and Loet Leydesdorff, 'Amsterdam Science Shop and its Influence on University Research: The Effects of Ten Years of Dealing with Non-academic Questions', *Science and Public Policy*, Vol. 14 (1987), 310–16. On appropriate technology, see Godfrey Boyle, Peter Harper and the editors of *Undercurrents* (eds), *Radical Technology* (London: Wildwood House, 1976); Ken Darrow and Mike Saxenian (eds), *Appropriate Technology Sourcebook: A Guide to Practical Books for Village and Small Community Technology* (Stanford, CA: Volunteers in Asia, 1986). On workers' initiatives see Hilary Wainwright and Dave Elliott, *The Lucas Plan: A New Trade Unionism in the Making?* (London: Allison & Busby, 1982).

53. Sharp, op. cit. note 19.

54. See Martin (1993), op. cit. note 19: Chapters 13 and 14 deal respectively with political and economic systems most compatible with social defence.

55. See, for example, Wiebe E. Bijker, Thomas P. Hughes and Trevor J. Pinch (eds), *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology* (Cambridge, MA: MIT Press, 1987).

56. For a critique of constructivism, see Langdon Winner, 'Upon Opening the Black Box and Finding It Empty: Social Constructivism and the Philosophy of Technology', *Science, Technology, & Human Values*, Vol. 18 (1993), 362–78.

57. Boyle, Harper et al. (eds), op. cit. note 52.

58. Robert Jungk, *The New Tyranny: How Nuclear Power Enslaves Us* (New York: Grosset & Dunlap, 1979); Joel Kovel, *Against the State of Nuclear Terror* (London: Pan Books, 1983).

59. See, for example, many contributions in the journal *Whole Earth Review*.

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