HUMAN VALUES AND THE TECHNOLOGY OF WEAPONS

by Bernard T. Feld

Within my own lifetime, I have witnessed a profound revolution in the pace of technological innovation not only in the realm of weaponry but in almost all aspects of the application of science to societal problems. Not only the intensity of wars but the consumption of electrical power for the production of civilian goods, the number of automobiles in use, the spread of worldwide communication via radio and television, the production of synthetic materials in clothing, the use of disposable bottles for soft and hard drinks—all these amenities of contemporary civilization, and many others, have been growing inexorably at a constant rate. In fact, the majority of the attributes of modern civilization—at least those so regarded by the inhabitants of the so-called developed world—from lethal weapons to TV dinners, have been doubling themselves every ten years or so. (This rate of growth, though it sounds impressive, corresponds to only about a 7 percent annual growth rate, which is certainly not all that far from what has been happening in most industrialized countries since the end of World War I except for a short interruption, of some five to eight years, during the "depression" of the twenties.)

Dangers of Exponential Growth

Now a 6-7 percent annual increase, in this age accustomed to inflation, does not sound particularly ominous—although the equivalent ten to twelve year doubling time perhaps sounds slightly more so—but such is the nature of compound interest (mathematicians and other scientist types call it an "exponential" increase) that over my own lifetime, of some fifty years, the effect has been to multiply almost every product of our technological society some thirtyfold.

To understand the amazing properties of the exponential, I pro-

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pose that we play the following childish game: I will give you each $1,000 now, if you will each give me one penny today, two tomorrow, four on the third day, doubling it each day for only one month. (Try it out on the back of an envelope, and the result will astound you. Would you believe that, on the thirtieth day, each of you would be obligated to give me ten million dollars?)

Consider the simplest measure of the intensity of war—the amount of high explosives (TNT or its equivalent) used against the "enemy," a term that, these days, encompasses the entire civilian population of the antagonist, as well as his army. Over the entire period of World War I (1914–18) the total amount of high explosives used, mostly in artillery, was some five to ten thousand tons of TNT, or approximately two thousand tons per year. In World War II, some twenty-five years later, this amount had risen to some thirty-five to fifty thousand tons of TNT per year, mostly used in the strategic bombing raids over Germany and Japan. Leaving aside for the moment the qualitative (stepwise) jump in available explosive power brought about by the development of the atomic, and later the hydrogen bombs, which have fortunately not been used since their early ill-conceived and tragic use, the steady increase of ordinary high explosives in military conflicts has continued at more or less the earlier rate since the end of World War II. Thus, in 1971, the U.S. Air Force dropped high explosives over South and North Vietnam, Cambodia, and Laos at the rate of around one hundred thousand tons per month, or approximately one million tons during the year. (I note, parenthetically, that one million tons of TNT is the equivalent of approximately fifty Hiroshima-sized atomic bombs, or one Hiroshima per week!)

A look at the figures quoted above, for the use of ordinary high explosives in World War I, World War II, and Vietnam, shows that the increase follows a simple exponential (compound interest) curve, with a 10 percent increase per year, or a six-year doubling time. So wartime destruction falls in the same category as population increase (steady at about 2–3 percent per year worldwide over the last century or so), increase of nitrous oxide in the atmosphere, consumption of fossil fuels (coal and oil), and so forth; they all follow an exponential curve. For systems obeying the exponential law, the quantity contained in the last doubling period is equal to the total of all that came before, from the beginning of time.

It is well known that exponential growth is explosive: it cannot go on indefinitely in a system with finite resources. Thus, a bacterial colony that starts out growing exponentially in a nutrient that is sufficiently abundant, eventually levels off at a population whose rate of resource consumption is just equal to the rate at which the needed (growth-controlling) nutrient is supplied from the outside. This phenomenon is known as "saturation," and the internal mechanism that leads to it is called "feedback." Since most of the resources required to support the exponential growths we have been considering—for example, food, fuels, the atmosphere, mineral wealth, and so forth—are finite and, at best, can be increased only at a constant rate (that cannot hope to keep up with the exponential growth of their consumption), we would expect the exponential growth (curve I in fig. 1) to be modified into a "sigmoid" curve (curve II) that reaches some natural saturation value (the broken horizontal line). However, the feedback mechanisms controlling exponential growths are seldom quite efficient or rapid enough to produce the smooth approach to saturation of Curve II; instead, observed systems usually exhibit "overshoot," such as shown in curve III, rising first beyond the saturation value before turning around

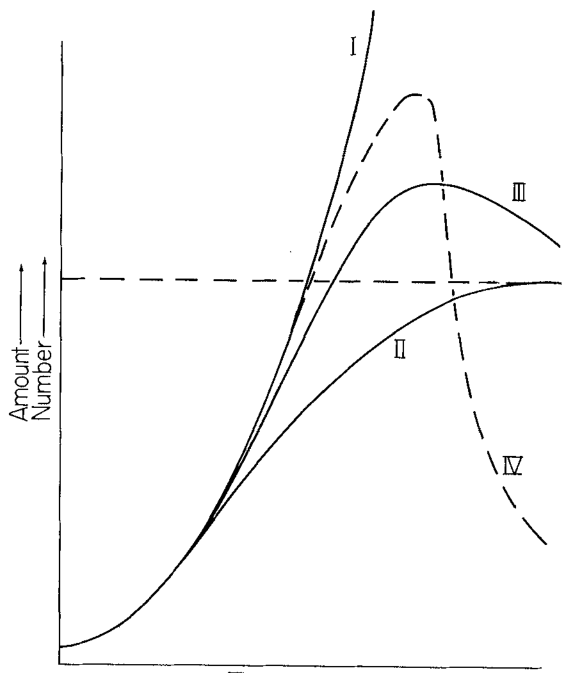

FIG. 1

and eventually approaching the "steady state" of the broken horizontal line.

Of course, the real world is much more complicated than any of this, consisting as it does of a large number of closely interrelated (coupled) growth systems, with their strongly mutually interacting feedback mechanisms. Nevertheless, these three simple curves serve well to illustrate the origin of the conflicts that have beset the social sciences since Malthus first called attention to the eventual devastating consequences of the continuing exponential growth of population in a world of finite resources.

Basically, the argument between the neo-Malthusians, as characterized by Forrester and Meadows in their *The Limits to Growth* (New York: Universe Books, 1972), and their more sanguine critics, relates to the effectiveness of available feedback mechanisms in limiting the extent of overshoot of natural systems following along curve III (see fig. 1). If the overshoot is small, the system will return more or less to the same saturation value (broken line) as would have been achieved by a perfect system (curve II). However, if the overshoot is too great and too rapid, the feedback mechanism will be inadequate to keep up, or may break down altogether, in which case the system will be finally forced to turn around by the consumption of available resources, and their incapability of replenishment, and the saturation value toward which it will head will be very much lower than that of curve II (e.g., curve IV). This would represent the culmination of the Malthusian prophecy and, considering the relative shortness of the warning times that mankind would have (the typical six to ten year doubling times of almost all human and technological growth phenomena), there is not much reason to believe that we would be able to react rapidly enough to alter the response mechanisms in time to prevent catastrophe.

I do not wish, however, at least not at this time, to join the ranks of the neo-Malthusian doom-criers simply because I do not believe we have, as yet, sufficient data on or understanding of the interrelationships between the various relevant growth and inhibiting factors to be able to make any reliable predictions concerning the real world. Nevertheless, considering the evidence on the continuing exponential growth of both military mass destruction and civilian ecological destruction, I must confess that an absolutely honest assessment of the current state of the world would lead to the conclusion that, as between the military and civilian threats to our ecology, the main question remaining to be answered is whether our earthly civilization is going to go out with a bang or with a whimper.

That I am not prepared to accept this gloomy prognostication probably attests more to my congenital optimism than to my good sense. Be that as it may, I believe one can still make a good argument as to the chances of reversing the present exponential trends toward mass suicide before they engulf the human race. I find some encouragement in the strong trends, both in Russia and the United States, to try to reverse the ecological damage before it goes any further—witness the steps taken to restore Lake Erie and to preserve Lake Baikal. And I would like to think that the main consequence of the 1972 American presidential election is to reverse the exponential explosion of destruction in Vietnam.

But even assuming that my most optimistic assessment of the prospects for damping down all the exponentially growing, current dangers to mankind is justified, there remains the other aspect of modern technology that poses an even greater danger to survival—that of technological innovation.

Dangers of Technological Innovation

New technological breakthroughs can introduce qualitative changes in the social systems that we have considered in the foregoing. Thus, for example, the development of atomic weapons made it possible to achieve with one bomb (i.e., in one day) the total yearly explosive power that had previously been available to the allied air forces in World War II (i.e., an increase by a factor of at least 300). And the development of the hydrogen bomb, only ten years later, introduced another stepwise increase by a factor of fifty. (Compare this with the previous "modest" twofold increase every six years.)

Similarly, the introduction of supersonic transport aircraft poses the danger of a complete upset of the balance between the absorption and the transmission by the upper atmosphere of the sun's ultraviolet radiation, which could have profound—if not lethal—consequences on the continuation of certain living species on the earth's surface. Or, to be less speculative, the assumption of a major role by fission power in the satisfaction of the continuously exponentially growing power needs throughout the world raises profoundly disturbing questions as to the relative danger of polluting the biosphere with the products of coal and oil combustion as compared with the dangers of pollution with lethal radioactive byproducts.

Such problems pose continuing dilemmas for the scientific community, but they also raise issues that can only be considered and solved on the broadest political level.

Rather than continue on the plane of generalities, however, I would prefer to confine the rest of this discussion to that aspect of technological innovation with which I have some reasonable degree of familiarity—the field of nuclear weapons and their associated offensive vehicles and defensive devices.

I must begin with an apology: I harbor no illusions that the basic problems of weapons control and human survival are technical; they are certainly mainly political. However, I am equally convinced that all of these problems have an important technological component whose understanding is indispensable to the solution of the problems posed. It is in the elucidation of this technological component that the scientist can play a useful role. Furthermore, since the understanding of the technological aspects is a necessary—albeit not sufficient—component of any solution, we scientists should not be reticent in offering our views. Since this is precisely what I am about to do, the preceding remarks may be rightfully regarded as somewhat self-aggrandizing but I hope not sufficiently so to prejudice your acceptance of the conclusions at which we shall arrive.

Parallel to the exponential growth of "conventional" destructive power in this century, we have witnessed a series of technical breakthroughs, each of which has led to a qualitative stepwise change (always increase) in the lethality of warfare—the tank, the airplane, poison gas, radar, the atomic bomb, the H-bomb, intercontinental ballistic missiles (ICBMs), nuclear submarines, multiple independently targetable reentry vehicles (MIRV), inertial guidance and now terminal laser guidance (smart bombs). The rate of introduction of such "quantum jumps" in warfare has been roughly comparable to the doubling time of quantitative change in weaponry; the new technological horrors have followed one another with intervals of five to ten years, almost irrespective of whether they were developed in response to some (at least alleged) military need or simply because they had become technically possible.

However, there are a number of profound differences between this qualitative proliferation of military technology and the aforementioned quantitative exponential growth of military pollution. In the first place, despite the frequent description of the phenomenon under discussion as a technological "arms race," the fact is that—at least since the early 1940s—the race has had only one serious runner, the United States. It is we who have introduced every significant new strategic weapons system in the last three decades. In the most real sense, we have been running a technological arms race only against ourselves.

To be sure, the Soviet Union has doggedly persisted in staying on the track, and can be depended upon to come panting along behind with its own deployment of every new system we have introduced, usually some three to five years later. (And, furthermore, once they have learned a new technique, usually profiting from our mistakes, they have generally concentrated on quantity, while we have devoted ourselves to rushing on to new and qualitatively different and, therefore, by the technocratic view of progress, presumably better systems; so we have not always been militarily "superior" even when ahead.) And some of the other technologically advanced nations, and now recently China, have also insisted on being counted into the race, even though they start out many laps in the rear.

My point is that, actually, this so-called technological arms race is not a race at all, and to act as though it is—as our military has insisted on acting—is pointless, wasteful, and, worse, courts disaster. Thus, all through the 1960s, while we were first madly building ICBMs and then as madly working on systems (defensive and offensive) to render them obsolete (which, incidentally, we seem finally to have succeeded in doing), the Russians contented themselves with an ICBM fleet of some three hundred as compared to our between one thousand and one thousand five hundred; and the relatively small Russian number, by virtue of the fact that no possible act on our part could prevent a large fraction of Russian missiles, once launched, from striking American cities, was able to render impotent our vast numerically superior missile force. The same will soon be true for the Chinese who, once they are able to mount a modest ICBM force, will have effectively nullified the Russian and American nuclear threats.

But if our headlong technological sprint is both useless and self-defeating, why do we keep it up? There are a variety of reasons, some seriously mistaken, some irrelevant, and many just plain specious. Consider the argument that we must maintain a vigorous program of military innovation in order that we should not be caught by surprise by some new development, pioneered by the Russians, that they would not hesitate to exploit in order to place the United States (and the "free world") at a disadvantage. This type of argument assumes a moral asymmetry between us and the Russians which many other people (e.g., the Vietnamese) would not readily acknowledge. If there were advantages to exploit in the past, why were we not able to exploit an acknowledged and great nuclear superiority to prevent or reverse the Russian occupations of Hungary and Czechoslovakia? (With respect to the Cuban missle crisis, it is arguable whether our superiority in nuclear missiles was as important in determining its outcome as the conventional superiority afforded by the close proximity of Cuba to our shores; and besides, since Khrushchev achieved his primary objective—of guaranteeing the Castro regime against an American invasion—the extent of the "victory" is not obvious.)

Even more important, however, is the question of whether the arms race would indeed have developed as rapidly, or as far, if we had refrained from deploying some of the new systems we developed, or even postponed their deployment until it became clear that the Russians were and, if they were deploying them, whether the Russian actions had any effect on the so-called strategic balance.

Consider two examples—ABM and MIRV: Although we could have deployed a primitive ABM system as early as 1963-64 (and the Army was, indeed, clamoring to do so) we refrained, not out of morality or virtue, but because the system then available was clearly ineffective. A couple of years later, the Russians deployed a small system (sixty-four missiles) around Moscow. Since this system was very similar to the one whose deployment we had turned down, on the grounds of ineffectiveness, we might simply have been content to let things stand, in which case the net effect would have been that the Russians were a few billion rubles the poorer but no more secure. Our reaction, on the contrary, was to proceed frantically in two directions: first, to accelerate development, and, second, to deploy a somewhat more arguable (in terms of effectiveness) ABM, and simultaneously to develop and then immediately deploy a multiple warhead system (MIRV) whose sole rationale was to nullify a hypothetical, upgraded Russian ABM that never came into being because the Russian leaders had by then been convinced by their scientific advisors of the futility of the whole ABM effort.

Now, finally, in 1972 we have achieved an ABM-ban treaty, which permits a small (useless but provocative) residual ABM on both sides, and leaves us with an already accomplished MIRV deployment and the Russians on the verge of following. How much better off we both would now be if we had refrained from all ABM and any MIRV. How much worse off we will both be when, having rendered the effectiveness of our fixed land-based missile systems uncertain by MIRV and improved missile guidance techniques and having hence been forced into a much greater dependence on our nuclear submarine force for deterrence, we then both proceed—as we seem to be aiming to do—to the deployment of new and threatening antisubmarine warfare (ASW) devices.

Whatever the rationale and whatever the arguments advanced for our continuation of this senseless and dangerous technological race against ourselves, I find it difficult to avoid the conclusion that it represents, at least as much as any other feature, a manifestation of a profound military disease that is nothing less than a military death wish: Whatever is possible must be developed; whatever is developed must be deployed; whatever is deployed must be used. Or, as has been so succinctly expressed by Pogo, "We have met the enemy, and he is us."

A Matter of Individual Responsibility

But all this has been mainly descriptive of the process; now we must finally come to the subject of this talk—the people who invent the weapons, who devise the technological breakthroughs, whose overt actions are responsible for the technological arms race—the human values involved. Here, again, it is necessary to make a distinction between the polluters and the innovators—between those that are responsible for the steady quantitative growth of dangerous or lethal systems, through the straightforward application of known principles by well-understood technological techniques, and those that make the new discoveries and/or inventions that lead to qualitative breakthroughs in some aspect of science and its application, in this case weaponry. With regard to the former, it is necessary to note that once a technological application gets to the engineering stage, its improvement, or simply its carrying out, is a more or less straightforward technical problem within the capabilities of a vast army of willing and enthusiastic technicians requiring no particularly special talents. So large a segment are these of the general population, so widely distributed are they among them, that it must be assumed that their approach, their values, their ethics are essentially those of the country at large; to affect, in any appreciable degree, their actions and their loyalties with respect to the arms race, it would be necessary to affect those of the entire population in which they are inextricably intermingled. That is a huge and long-term task to which we must, of necessity, aspire; but we should not delude ourselves into thinking that our efforts, to instill sanity in the American people with respect to the nuclear arms race, are likely to bear immediate fruit.

But the number is much smaller of those in the ranks of the scientific innovators, that are capable of and have been devising the new technological directions that have led to past qualitative jumps in the arms race. Is there any hope that this much more limited group could be induced to take direct action to limit the pace of technological military innovation by withholding its talents in this sphere?

While I am certainly not sanguine in this regard, neither am I despairing. It is undoubtedly so that for every Szilard there is a Teller; but it is also true that a single Szilard or a Sakharov is capable of having a much greater impact than a dozen Tellers. In the infamous Oppenheimer hearings, the complaint was that Oppenheimer's lack of enthusiasm for going ahead with the H-bomb development was having a profound influence on the bulk of the physics community and thereby seriously impeding this program. And, in this case, Oppenheimer's ostracization almost wrecked the Los Alamos atomic weapons laboratory.

In another case in point, I believe that the community of molecular biologists have received insufficient credit and recognition for having undermined the army's biological weapons program—through their failure (which, in this case, amounted to overt refusal) to participate in it—and thereby set the stage for American acceptance of a ban on biological weapons. Had they succumbed to the blandishments and pressures of the military, to take the program out of the hands of the second-raters who were all the military could recruit, they would probably have opened up enough promising avenues for new weapons development to have made it impossible to sustain the argument that biological weapons could be banned because there were, in any case, no interesting and potentially effective prospects on the horizon.

But for whatever reasons (perhaps because biologists are influenced by the tradition of the Hippocratic Oath or, alternatively, perhaps because the fraternity of molecular biologists contained such a large number of ex-nuclear physicists, who had observed the trap into which their ex-colleagues had been drawn in the Manhattan Project, and who may have thought, "There, but for the grace of . . .") the first-rate biologists could not be induced, for love or money, into Fort Deitrich, and the direct consequence is the Treaty Banning the Production, Stockpiling, and Use of Biological Weapons. (It is also interesting to speculate as to what extent the backwardness of Russian molecular biology, the direct result of the Lysenco folly of the Stalinist period, made it easier for the Soviet Union to accept the BW ban—a rather extreme example of the silver-lining concept, if true.)

Lest we become too sanguine, however, it is important to remember that the most such abstention by key individuals can do is to slow down the application of new and fundamental discoveries to weaponry. In the afore-cited BW case, this was crucial. There are other examples, however—the attempts at weather modification in Vietnam, for example, or the attempts to fire-storm the Vietnamese forests—where the technical community, far from exhibiting reticence, seems to have entered with enthusiasm into the genocidal schemes of the military.

In the last analysis, I believe, it remains a question of individual responsibility, which every scientist, engineer, and technician has to decide on the basis of his own set of values. Nevertheless, or perhaps even especially in these circumstances, individual decisions will be strongly influenced by the climate of opinion prevailing in the scientific and technical community. Today, perhaps more than any time since the immediate post-World War II period, this community is in revolt against the influence and activities of the military and its civilian spokesmen. If we could somehow contrive to channel the revulsion—against the cynical use of the American technical community for immoral and illegal ends in pursuing a mad military adventure in Vietnam—into a critical reexamination of the ethics and consequences of the nuclear arms race, and of the key role that scientists and engineers have played in maintaining its mad momentum, and if we can draw the appropriate conclusions as to how we can use our power and influence to turn the race around and end it, then there is every possibility that this beleaguered world of ours can still survive.