# Guest Comment: Science, technology, and national security in an era of democracy and human rights

Physicists have played a major role in changing the world, in providing understanding, tools, materials (varying) advice, and even leadership. What can we do now?

For 45 years I have been an observer of and a participant in these activities, having worked in particle physics, superconductivity, on liquid and solid $^3$He and $^4$He, and gravitational radiation, and on various aspects of television, computers, communication, and a range of topics in national and international security. These latter included contributions to testing of nuclear weapons, to the building of the first hydrogen bomb, to strategic and tactical military systems, and to several aspects of space technology. Some of this participation was as a member of the President's Science Advisory Committee (PSAC), and as Chair of various military panels, including those on naval warfare and military aircraft. I still work with the U.S. Government on matters of mutual interest, not always in agreement with current activities or plans.

I try to make what contribution I can to any (legal) government activity in which I am involved. This sometimes leads to a better or cheaper way to do something I don't think needs to be done at all, or to improvements which still do not make a program worthwhile. Former Air Force Secretary Hans Mark acknowledged this mode of operation by recalling that at the end of a high school term, his French teacher told him "Hans, you have made a lot of progress but you still fail." Evidently he was a lot better at physics[1] than at French!

Just so, one works to improve the options and then to make hard choices among them, which involves saying "no" to many and sometimes to all approaches. Hans Bethe recounts his feeling it "...a most discouraging blow" when a missile design with which he was associated was rejected in favor of a competitor, but concludes[2] "However, if we wish to escape the vicious cycle of ever-increasing armaments, we have to find a way to make weapons laboratories operate without the certainty that what they develop will actually be used." It is not easy to resist the urge to gain acceptance for our own ideas or those of our close associates. Insight and evaluation are critical to choosing the right direction, and informed comparison is one of the simpler forms of evaluation. In this regard, U.S. and world security owe a lot to dedicated individuals, many of them physicists, in government, universities, and public interest groups, who have provided not only analysis but even innovation on weapons and their control.

Edward Teller[3] observed in this column, "...our administration and military leaders knew how to use the latest technology..." in Desert Storm. The military and civilian defense hierarchy bought and trained, Congress authorized and appropriated, and industry and laboratories supplied the capability. However, this was not accomplished without controversy and even conflict.

The drive for higher technology has often inhibited the incorporation of useful technology into U.S. military systems, to the point at which consumer technology can in many cases do more for our military than can custom-developed systems. Consider two programs—the global positioning system (GPS), and the laser-guided bomb (LGB).

As recently as 1980, the Air Force Chief of Staff wrote me that while GPS would be good to have, the Air Force (as executive agent for a joint service program) could not afford it unless it received more money—this regarding a system that gives accuracy in 3-D to 10 m, essentially anywhere in the world, every 0.1 s. The preponderance of support and by far the most money went to buy platforms—B-1 and now B-2 aircraft, ships, and the like, without real regard to the best way to accomplish the military task. In the early 1970s, when the PSAC aircraft panel was urging the development of and reliance on satellite systems providing similar time difference of arrival (TDOA) means for navigation and surveillance, our "how to build it" cost estimates came out at \$500–\$5000 per aircraft instrument, while a highly respected government think tank estimated[4] the cost of such an accurate and quick-response instrument at \$200,000, assuming that it could be done. Although delayed by 15 or 20 years, GPS was ultimately deployed and has now strikingly demonstrated its value. Commercial user instruments are now available for less than \$2000, with considerably more function than our panel prescribed.

The laser-guided bomb (LGB) was developed and procured in the late 1960s with the support of Assistant Secretary of the Air Force for R&D Alexander H. Flax. There was no formal "military requirement" because most of the Air Force wanted development to provide a "fire and forget" weapon, which would not require an aircraft to remain in the vicinity, illuminating the target with a designating laser until the bomb actually struck the target. And they would have depended upon ordinary gravity bombs until the fire-and-forget weapons were available—beyond 1992, at least. During the Vietnam War, millions of tons of bombs were expended, among them 27,000 guided weapons of which 94% were laser-guided bombs.

In the Gulf War, U.S. combat aircraft delivered some 88,500 tons of ordnance, of which about 6500 tons were guided, almost all of them LGB—a remarkable durability exceeding 20 years for the concept, although the laser-guided bomb technology has improved considerably in the interval. A few hundred non-nuclear Tomahawk (sea-launched) or air-launched cruise missiles[5] also played an important role.

Taking office in 1981, the Reagan administration emphasized initially non-nuclear weaponry, where there was indeed great opportunity in view of the advance of technology of computers, communications, and the like. It was a source of dismay to me when, after a couple of months, the Reagan program was largely diverted to "modernization" and expansion of our nuclear weaponry and in 1983 toward a hoped-for near-perfect defense against strategic ballistic missiles. As reported by the President's Commission on Strategic Forces under Brent Scowcroft in April 1983, there was no doubt that U.S. nuclear capability could survive to mount effective retaliation against the Soviet Union, and there was also no prospect that we would be able to destroy enough Soviet nuclear weapons either before or after launch to survive a Soviet retaliation. As for qualitative improvements, the ordinary thermonuclear warhead is not much better than it used to be, and it is generally recognized that we are further, in 1992, from the achievement of the "third-generation nuclear weapon" capabilities of x-ray laser fame than was claimed by its supporters in December 1983 when it was stated[6] that the x-ray laser was now "entering the engineering phase."

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In brief, our highest national security priority should be the elimination of the vast majority of the 30,000 nuclear weapons of the former Soviet Union, now dispersed in Russia, Belarus, Ukraine, and Kazakhstan. Physically, this can be accomplished by an urgent operation led by U.S. and former Soviet weapons experts and supported logistically by the military forces of the Commonwealth of Independent States and of the United States, to disarm, disable, guard and tag for removal and destruction almost all nuclear warheads in the field, except perhaps for a total of 3000 mounted atop strategic missiles in silos with one or a few warheads each, and as bombs for strategic bombers. The principal threat is that of theft or sale of intact warheads to nations or groups that would pay a lot of money each for a few warheads. Although there is no such urgency in regard to U.S. weapons, a similar reduction seems both necessary and desirable, in view of the elimination of the military threat from the now-defunct Warsaw Pact and from any organized Soviet Union.

Our priorities, therefore, are to aid the four nuclear republics in the elimination of almost all of the weapons and in joining the Nonproliferation Treaty (NPT)—Russia as a nuclear state and the other republics as non-nuclear states. Our next priority is to stop the proliferation of nuclear weapons to any additional states, a task that has both political and technical aspects.

I believe that while we will not abandon a residual stockpile of 1000–3000 nuclear warheads in the foreseeable future, we can and should give up our program of underground nuclear explosions by a data certain—perhaps 1995, with only a few tests per year until that time. I think that this is necessary in order to obtain unanimous support for effective measures to halt proliferation of nuclear weapons.

What are the arguments in support of continued nuclear tests?

In a speech in October 1991 at West Point, in memory of our late physicist colleague Colonel Thomas H. Johnson, Edward Teller advanced four reasons for continuing nuclear tests:

1. to improve the safety and security of U.S. nuclear weapons;

2. to perfect the nuclear-explosive driven x-ray laser, which, for ballistic missile defense, is "more powerful and more destructive than an ordinary laser;"

3. we have no experience in making a fission bomb with some five-ton equivalent high explosive yield, perhaps weighing 100 pounds, and we will not know how useful it will be in warfare—in killing tanks, for instance—until we learn how to make it and to use it; and

4. there is a lot of exciting and important physics to be done in the range of parameters that can be reached only with nuclear explosives, for instance compressing iron tenfold, while learning how not to heat it in the process.

> Indeed, Fred Reines proposed in 1950 to Enrico Fermi to look for neutrinos from a nuclear explosion; Reines and Cowan soon did it with less fuss with neutrinos from a nuclear reactor. We have made transuranic elements in abundance in nuclear explosions, and that was not without interest. Finally, nuclear explosions have served as pulsed neutron sources for measuring cross sections, and they have played a useful role in the Halite/Centurion program as a model for x-ray driven inertial confinement fusion (ICF), before powerful optical lasers are built to generate these x-rays.

My own view is that: U.S. nuclear weapons are safe enough, especially in a world less subject to crisis and in which they have been reduced in number by a factor of 10–100, but could be made safer even without nuclear tests; we have long since described countermeasures that would render x-ray lasers ineffective even if they could be made; we kill tanks perfectly well by *hitting* them with 100 pounds of explosive or less, without the cost, hazard, and perforce limited numbers of nuclear weapons, even if we had them. As for doing physics with nuclear explosions, such enthusiasm emanates not only from U.S. but also from French and Russian weapons professionals and their supporters, but we should see how specific proposals are judged by the physics community in competition with other proposed physics expenditures and opportunities.

Among the urgent tasks for physicists in the national security field is to help preserve the scientific and technical talent of the former Soviet Union, while coupling it more effectively to the building of their nations' economies.

Richard L. Garwin
*IBM Research Division*
*Thomas J. Watson Research Center*
*P.O. Box 218*
*Yorktown Heights, New York 10598-0218*

[1]E.g., Chairman of Department of Nuclear Engineering at Berkeley 1964 to 1969.

[2]H. A. Bethe, "The Technological Imperative," in *The Road From Los Alamos* (American Institute of Physics, New York, 1991), p. 134.

[3]Edward Teller, "Guest Comment: Military applications of technology—A new turn," Am. J. Phys. 59, 873 (1991).

[4]Parametrically—i.e., by correlating cost with precision and delay time of various existing navigational systems.

[5]Development initiated about 1971 by Chief of Naval Operations Elmo R. Zumwalt, as urged by a PSAC panel to which he had been Pentagon liaison, but in conflict with both Air Force and Navy preferences.

[6]Letter from E. Teller to G. A. Keyworth, President Reagan's Science Advisor, 22 December 1983, quoted in *Teller's War*, by W. J. Broad (Simon and Schuster, New York, 1992), p. 152.

**ALBERT EINSTEIN LIVED HERE**

Someday in the far distant future, if intelligent beings examine the cosmos, the only thing on the speck of dust we call Earth that will seem worthwhile to them will be this:

ALBERT EINSTEIN LIVED HERE.

*The Washington Post*, April, 1955.

## Guest Comment: Military applications of technology—A new turn

There is a simplistic view of military applications of science and technology: The less of it, the better. The obvious conclusion is: Disarmament.

Historic perspective can give different and more complex answers. In the first century of the Industrial Revolution, new inventions had difficulties in being accepted by policy makers. Two memorable failures are associated with the name of Napoleon. Fulton offered his steamboat to Napoleon I; had the emperor accepted, the British navy would have been defeated and French would today be the universal language in Europe. The mistake was repeated in spades by Napoleon III: He refused the offer of powerful cannon from the German firm, Krupp, although he accepted the use of the early machine gun. Unfortunately, he did not understand its role and placed the machine guns with his artillery. The Prussian armies easily won the artillery duel and the War of 1870–71.

Today there is once again a lack of understanding of the influence of science and technology on military preparedness. The thousand-fold escalation from high explosives to nuclear weapons and a further factor of one thousand due to the introduction of the hydrogen bomb raised the spectre of an unstoppable sequence of thousand-fold increases in destructive power ending in a doomsday bomb that would destroy our planet. This view proved to be technically wrong. We have approached the limit where big nuclear weapons would blow a part of the atmosphere, a few miles across, out into space. Bigger explosions would remove the same part of the atmosphere at a higher velocity, but the effects on Earth would hardly increase because of the limited spread along the surface. The cost of the bomb would be greater, but little would be accomplished. And indeed, the growth of larger nuclear weapons stopped, not on account of any agreement, but rather because no practical use whatsoever was found for bigger explosives.

It is fortunate that when Stalin died, Beria (head of KGB) was prevented from succeeding him and indeed, was tried and executed. That occurred just at the time when the Soviets completed their first hydrogen bomb. Originally, Sakharov worked directly for Beria; after the events mentioned above, Soviet policy, both internal and international, became more moderate and never resumed fully its formerly vicious character. The result was a well-known stalemate in aggressive power.

But now we see a new thousand-fold improvement in weaponry—this time in a basically different direction. Computers, as deployed in satellites, can now have the full effectiveness of huge systems formerly available in the laboratories and at a cost and weight a thousand-fold reduced. Similarly, the diode lasers have ushered in a rapid and most useful instrument of observation. Both cost and weight are decreasing rapidly. The result is a change from the importance of the big bang to the importance of accuracy. A further consequence could be a shift from the predominance of aggression to a predominance of defense. Even more remarkable, the short war in the Gulf, named "Desert Storm," proved that our administration and military leaders knew how to use the latest technology to defeat an army of a million with few casualties on our side. Even on the opponents we did not inflict indiscriminate damage.

The present seems to be a good time to reconsider concepts of high technology in warfare, the arms race, disarmament, and the role of novel weapons not only as causes of war but also as a means to prevent war. Here are some relevant questions.

- Has the time come for truly effective strategic defense?
- Will the relaxation of East/West tension together with such defense lay to rest the fear of a holocaust?
- Can the development of defensive means make missiles in the hands of a dictator like Saddam Hussein seem useless?
- Shall one combine the newly acquired accuracy with smaller nuclear weapons (perhaps even of yields of a few tons) to be used against modern weapons such as tanks and submarines?
- Has the time come to develop an international system to prevent aggression?

The answer to these questions cannot be "yes" or "no;" the answer must be "how." The basic problem is a transition of the present chaotic world to one where some values are shared and others are at least mutually appreciated. This transition will not be brought about by any simple remedy, but only by the gradual solving of a number of complex problems.

The questions enumerated above are no more than a part of these problems. It is the part to which technology can make special contributions.

Edward Teller
*Hoover Institution*
*on War, Revolution, and Peace*
*Stanford, CA 94305-6010*

### VIRGIL: THE JOY OF PHYSICS

Felix qui potuit rerum cognoscere causas. (Happy is the person who can understand the causes of phenomena.)

Virgil, *Georgics*, II, line 490, ca. 30 B.C.

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