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The Future of Defense and Technology

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I find it practically impossible to discuss the future of nuclear weapons in the twenty-first century. Why? Look at what has happened in the last year, and then ask yourself, "Do you dare to say what is apt to happen in the next 10 years, let alone the next 100 years?" Therefore, I will abstain from going into detail and will stay with generalities.

My point of view is that of an *optimist*, and I will try to explain precisely what I mean by that. A pessimist is a person who is always right, but does not get any enjoyment out of it; and an optimist is someone who imagines that the future is uncertain. I claim that it is a duty to be an optimist, because, if you imagine that the future is uncertain, then you are apt to do something about it. I emphatically deny that an optimist needs to predict a rosy future. He merely needs to believe in the possibility of a better future.

Danger and Opportunity

The fact that in Eastern Europe 100 million people can now determine their own fate—to the extent that this is at all possible—is of course one of the incredible things that has happened in the last year. In addition to the possibility of a better future, there also exists the probability of much suffering, so what I see in Eastern Europe is not only good news, but also danger and opportunity.

To my mind, the other half of the surprise this year is the Persian Gulf crisis, which in many ways is even more important. Saddam Hussein has done something that seemed to be impossible—he has offended everyone badly enough to unite the world. There can be no doubt about the danger in this situation. What is easier to miss is that this is also an incredible, really challenging opportunity. We share a common goal with all of the participants in this crisis—with those who have been our friends for a long time and with those who have not been our friends—and that goal is the clear intention to stop aggression in this particular case.

Many people have asked, "What will come of it? How long will the crisis last?" My answer is, "The longer the better." It is necessary to find a way, and I hope it will be without bloodshed, to get rid of Saddam Hussein. If it takes a year, it will take a year. And if it takes three years, that might be better, because if we can maintain this unity for that length of time, we will have had the opportunity to realize that resisting aggression is in the interest of everybody, and we may have had the opportunity to create the institutions that are necessary for resisting any future aggression. This is my *optimistic* view of the present crisis.

I remind you that the Chinese ideogram for crisis is composed of two ideograms: one meaning *danger* and the other meaning *opportunity*. The important thing, in the present crisis, is not to forget the *opportunity* component.

Defense against Aggression

I have briefly discussed my view of what has happened politically in the last year. Now, I want to say something about a parallel technical development that has been going on for a somewhat longer time, and one in which I have been thoroughly interested. It is not connected directly with nuclear weapons; I will discuss those later. It is connected with defense—defense

against nuclear weapons or any other of the frightening possibilities of aggression.

What has obviously happened is that the horrible catastrophe of an all-out conflict between East and West, which never was probable, has now become even less probable. But, as time has gone on, the possibility of aggression on a small scale has increased, as has the rapidity with which tanks, aircraft, and rockets, particularly rockets, can move. This is why we desperately need methods of rapid defense. These methods of defense have come a long way. Our Laboratory, in Livermore, has fully sponsored the effort of pulling together the modern methods of defense. In particular, I have to mention my good friend Lowell Wood, who is at this moment (October 22, 1990) in Washington discussing the details of this defense.

I am not talking about something that is brand new. The Stinger missile (directed against low-flying aircraft and helicopters) provided freedom fighters (who certainly did not lack courage, but who did lack weapons) with a defensive weapon that was extremely effective against low-flying aircraft. The effectiveness of weapons of defense depends on better electronics and on better computers. In current terminology, I would call the computers that we used at Los Alamos during the Second World War, monoflop machines. The flop relating to "flip-flop," and the "mono" relating to making one such decision per second. With electronics, these almost at once became megaflop machines, and our present machines are gigaflop. With superconductivity, we are gaining another factor of a million—the petaflop machine (10^{15}/s). And this is the kind of thing, even as it stands today at the gigaflop level, that is so useful for defense. Where we once needed to spend $10 million, the cost has now come down to not much more that $10,000. What used to fill a room, now fits into the palm of my hand. This combination makes it possible for low-flying satellites to be very active and relatively effective against missiles in their boost phase when they are both slow and low enough.

It has been rightly said that such a defense will have leaks. When we are talking about the horrible conflict of 10,000 missiles against 10,000 missiles, we cannot have complete effectiveness. Today, obviously, this danger has receded a great deal. In part, this is due to the common recognition by all of us that aggression is unacceptable. At the same time, there is some discussion, stated on very good authority, that effective missiles of various ranges are now available to 18 governments. This number is increasing; the range of the missiles is likewise increasing. I do not believe that any treaty will put a stop to this proliferation.

I do believe that the development of defenses that are accepted by all, and that protect all will be able to completely stop a small-scale aggression. These defenses will do even more, they will discourage anyone from even acquiring rockets carrying high-explosive, chemical, biological, or nuclear weapons.

The first great accomplishment of high technology in military matters was the airplane/tank combination, followed not much later by nuclear explosives. All of these favored the attack. High technology now has turned around toward the possibility of favoring defense by making extreme accuracy possible. I am talking about the missiles that we call "Brilliant Pebbles," which are roughly 100 lbs. in weight and cost approximately $1 million apiece. The deployment of hundreds or thousands of these low-flying satellites can give early warning. They can be used for defense. In the near future, they will be used to stop aggression and ensure peace.

Peaceful Applications for Small Satellites

I want to spend a moment on the peaceful applications of small satellites. These applications may come even before the defense applications, although both sides of the development (as is very often the case) are closely linked. One of the most important peaceful applications is a complete coverage of the globe for excellent, detailed, and instantaneous weather information. This is what is needed for better weather prediction and perhaps, at some time, for weather modification. (You realize that if that day ever comes, we will have lost our last safe topic of conversation!) Indeed, no one should attempt to modify the weather who does not understand how to predict the weather. To modify what you cannot predict is like practicing

surgery without knowing anatomy. Insight is necessary before any applications will be useful on an international scale.

Another peaceful application of similar or even greater importance is monitoring contaminants. Today, we do not know where acid rain comes from. Does it primarily come from the burning of oil and coal? Or does it primarily come from volcanos? The fact is that we are trying to regulate without knowledge. I believe that regulation is needed, but knowledge is urgent.

Observing the weather and monitoring pollutants are interrelated questions; interrelated not only in that they rely on the same kind of a satellite, but interrelated because they work for all nations and cannot be realized without the cooperation between nations. They are necessary in the fight against aggression and in the fight against pollution. Neither of these questions can be solved without the technical and political background that seems to have become more firmly established in the last twelve months.

Nuclear Weapons

This Workshop is on nuclear weapons, and I have not mentioned them. Now I will. In the decade when the contribution of high technology to military affairs seemed to be the big bang, we made a bad mistake by not looking into the possibilities of defense. It was a mistake that was not fatal because it was recognized in time. I think that the natural development now favors defense because of the possibility of improvements in electronics, sensors, miniaturization, and computers. But at the time defense becomes possible, we should not forget about the possibilities connected with nuclear weapons. We should not repeat our mistake of forgetting about defense by also forgetting, in the new phase, about the methods of attack, because we can never understand one in a satisfactory way without understanding the other. I want to make this quite concrete in two ways. I want to describe three lines of research, that, to my mind, will be important. They are problems that practically impose themselves on me because of my connections with Lawrence Livermore National Laboratory.

1. The safety of nuclear weapons. Not the safety from enemy attack; the safety from accidents. There has not yet been a really bad accident involving nuclear weapons. There must never be one, and *never* is a big word. We have not done enough to ensure that this *never* is really *never*.

2. The x-ray laser. At Livermore, we have worked on this marvelous invention—one that I believe has great scientific as well as some defense possibilities. We have demonstrated that it works, but we have failed to develop many of the details that would make it practical.

3. Small explosions. We have wrongly neglected closely examining very small explosions—subkiloton or even below 100 tons. From the technical point of view, this neglect of a substantial area of research is wrong. I have thought of practical applications, and I can tell you that, at least in my opinion, they exist.

These are the three things: nuclear weapons safety, the x-ray laser, and small explosions, that is applying the methods used to understand big explosions to small explosions—if we master this art, one of the consequences will be more opportunities for pure research. Of these opportunities, I want to mention one. A lot has been done in studying the equation of state; compressing iron, let us say, to twofold its usual density—that is done. It is not done at low temperatures, and it could be done with sufficient care at low temperatures, by which I mean at maybe 1000°K. I would like to know at what density helium becomes a metal. I would like to know what happens to the Curie point of iron at the twofold compression. I would like to know about superconductivity in highly compressed materials.

Proliferation: Openness *vs* Secrecy

I come to my last point, and in many ways my most important point: the proliferation of nuclear weapons, which in principle is unavoidable. I have a cure. I am not the only one who has it, but I am sure that all of us can agree on it, and all of us should try to turn it into reality. I claim that we have tried to protect the art of nuclear weapons by secrecy—that attempt has

failed miserably. It had to fail because ideas cannot be kept secret. We have not tried and now we must try to handle the question of proliferation using the methods of openness. Any country is able to keep secrets; what cannot be kept secret is the fact that secrecy exists. Any treaty that demands certain restrictions can be circumvented by secrecy. If we say that secrecy is illegal, on that, I am sure, we can check.

The U.S. cannot demand openness of others if it does not abandon secrecy at home. One has to be careful in deciding how to do this. I do not want to demand what is politically impossible. Let me propose, for instance, that we do not keep secrets for more than one year, that anything that is classified will automatically be published in a year. Maybe at first we would have to make it three years, and then decrease the time span. The way from the secret procedures to the open procedures may not be easy. So far we have made no progress, and that I think is a great mistake.

As an optimist, I am trying to dream of a future where there is international cooperation, where there is protection of everyone, by methods developed in common and exercised under rules to which everyone agrees. It is impossible for anyone to draw up a road map that could lead us into such a future. But it is possible to say that the initial steps toward such an open future have been taken, and, remarkably enough, a lot of these steps have been taken in the Soviet Union, where they were most badly needed.

The general things that I wanted to mention here are peace by defense, peace by openness and cooperation, based on the endeavor that all sides should profit by the cooperation and that we do not apply a rigid calculus as to who profits more.

This is a speech that I could not have given even a few months ago. I am very glad that I can give it now, and I know that a couple of mistakes can undo all the progress we have made. I hope that you will not forget that, in our search for a better future, *technology* and *knowledge* are just as important as *good intentions*.

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