THE TECHNOLOGY OF STRATEGIC DEFENSE — WHERE WE STAND AND HOW FAR WE CAN GO: AN INTERVIEW WITH PROFESSOR HANS BETHE

FORUM: Professor Bethe, we have already witnessed an intense debate about ballistic missile defense in the late 1960s and the early '70's. At the time, the notion of defense was rejected on grounds of technical infeasibility. What technological changes have occurred during the past decade which have encouraged a revival of defensive initiatives?

BETHE: Well, there were technological changes, some of which I will mention. But there were mostly political changes. We now have a very conservative government. Back in the early '70s we had Republicans all right, but not nearly as conservative as the present government. So I think the political change has been more important than the technical change.

FORUM: But wasn't it argued quite strongly in the discussion about the Anti Ballistic Missile, the ABM Treaty, that it would be reasonably safe to conclude such an agreement?

BETHE: Yes, and that in my opinion is still true. It is still impossible. I think all that the proponents of the new ABM, let me call it SDI, argue, is that it is a little less impossible. And they can argue that. Now, what has happened? For one thing there has been a big development of heat-seeking missiles — for example the Excocet which the French developed and sell which was used by the Argentines against the British in the Falkland Islands dispute. — And this technology has been tremendously improved in the last ten to fifteen years; it is available to

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both the United States and Soviet Russia. I guess we are probably a little ahead there, perhaps a lot; I am not exactly sure. But it is this development which made it possible for a Minuteman missile to intercept another such missile in a recent U.S. test successfully — it was the possibility of homing in on the heat emitted or reflected by the ICBM missile. That is an important change.

Another interesting change is the development of lasers. Lasers were in their infancy from 1968 to 1970. Few thought of them in connection with ABM at the time, and those who did had to recognize that lasers were too undeveloped to be a real possibility. Laser development over the last fifteen years has, however, been almost spectacular.

The third development is the so-called x-ray laser being developed by the Livermore Laboratory. That technology utilizes a nuclear explosion out in space, which generates x-rays in large amounts. The x-rays are made to excite maybe a bundle of wires, which in turn emit a different frequency x-ray in the definite direction of a target. The energy thus released can be concentrated into a rather small angle. Livermore believes that this is sufficiently intense to destroy a missile.

FORUM: How would these various systems be applied, according to the SDI concept, in the different stages from the launch of an enemy missile to its approach to a conceived target?

BETHE: The aim of the defender would be to intercept the enemy ICBM at the launch, during the so-called boost phase in which the rocket is accelerated to a high speed. There would be a great advantage in intercepting at this stage. The greatest advantage is that the enemy rocket then is just one object. At any later point it distributes a large number of objects. There may be ten warheads, additionally there may be a hundred decoys of various kinds which simulate the warhead as much as possible. In any later stage one would therefore probably have to deal with one hundred objects instead of one. It would consequently be necessary to send a hundred beams or interceptors in the mid-course phase.

FORUM: However, you did mention new technology which has increased sensing ability. Would this not help in distinguishing decoys from warheads?

BETHE: It has been stated that the particle beam might be useful to distinguish decoys from warheads. And I think there is some chance that it might be. But then, the particle beam installation has to be out in

space when it is needed. You have to use eighty satellites or more, or you have to shoot the particle beam platform into space when the Soviets attack. Again this is something that is very hard to design and to test. If we were able to discriminate effectively between empty balloons and warheads, then the task of mid-course interception would be easier. Then you might think about carrying out a test analogous to the Minuteman test I referred to. But the only way that could possibly be done with a believable number of interceptors is if you can discriminate very effectively. Furthermore, in the boost phase the missile emits a lot of infrared radiation. It is at least much easier to detect and follow it during that brief period of time.

FORUM: How would the missile be destroyed in the boost phase?

BETHE: You might destroy it while it is still still in the atmosphere or just above it. But certainly it is quite possible to do so in the atmosphere if you attack with a laser beam. A laser beam of infrared or ultraviolet light can penetrate into the atmosphere; you heat the thin shell of a missile with that laser very hard. Once you burn through the booster shell it is likely to disintegrate. The x-ray laser is only applicable in the boost phase if the enemy missile gets out of the atmosphere before the end of the boosting. The same goes for the particle beam which only works outside the atmosphere. Inside of it, the neutral atoms, which the beam consists of, disintegrate because they collide with air molecules, and the protons then will be subject to the magnetic field of the earth. As a result you get a fan spreading out widely instead of a focussed beam.

But let me come back to the mode of intercept in the subsequent stages of the missile's trajectory. There are many proposals suggesting that you might intercept not during the boost phase but immediately afterwards, while the enemy missile distributes its various decoys. You will then have fewer objects than later on, but more objects than one. But the other important stage is the mid-course, namely when the warheads and the decoys fly uninhibited in space, influenced only by gravitation. There we have a ballistic trajectory from which you can not tell how much the object weighs; all objects travel the same way. You mentioned the problem of distinguishing decoys form warheads. It is very difficult. Aluminum-coated balloons can simulate the warheads exactly. They will reflect radar and infrared radiation just as real warheads would, which would also be placed in such a coated balloon.

One interesting point, by the way, is that you can detect the infrared signature only if looking upwards from the earth. Looking from space the signals will be swamped by the radiation of the earth itself.

FORUM: This does not apply for the mid-course phase, however. Lasers would be ground-based and only directed by mirrors in space, which in turn could rely on ground-based target tracking facilities.

BETHE: Yes, if you want to attack in mid-course you might even think of using lasers from the ground directly. Lasers penetrate the atmosphere quite easily. On the other hand, there may be a hundred objects per missile at this stage. This can mean perhaps a hundred thousand in total.

FORUM: Would this then imply that the U.S. should indeed focus its SDI research on methods to engage enemy missiles in the boost phase?

BETHE: That is certainly one possible conclusion. However, mid-course has great advantages for the defense also. Mid-course defense takes place over friendly territory — over Northern Canada that is. You could deploy your lasers there, ground based. That way they are much less vulnerable to Soviet preemption. If the platforms are in space, they might be destroyed by the Soviets in a crisis. And what would we do in such a case? How could we respond to that? Would we then start a war?

FORUM: Satellites carrying lasers could probably not be stationed in the geo-stationary orbit, which is simply too far away to have an effective laser. How many defense satellites would be needed to cover Soviet missile fields at all times, considering they must revolve around the earth?

BETHE: That has been investigated very carefully. It depends of course entirely on the assumptions. One assumption concerns the hardness of the enemy booster. The amount of laser energy you need to destroy a missile is dependent on that. And this, amongst other factors, in turn determines the number of lasers you might need. Dr. Garwin has published a paper in *Nature* where he calculates that with the present distribution of Soviet missiles and with the postulated performance of SDI lasers, eighty satellites with big lasers would have to be deployed in space. If, however, the Soviets were to fast-boost, that number would triple. Further, it is assumed that the laser people can achieve extremely quick re-targeting from one ICBM to the next in one tenth of a second. I think that is almost impossible. It will be more in the order of three seconds, which according to Garwin would again double the number of satellites needed. SDI proponents unrealistically assume that the Soviets will stand still on the one hand, while we will achieve the maximum of what they envision for the future.

FORUM: Let me come back to boost phase interception once more. How would the Soviets react if the US were to deploy space stations designed to knock out their missiles in the launching phase?

BETHE: The trouble with the boost phase is that it is possible to shorten the boost, to fast-boost, as actually Martin Marietta pointed out to the Fletcher Committee, which studied SDI in depth. That company designed the U.S. Sprint missile in the 1970s. The Sprint rocket got its entire speed in the first twenty or thirty seconds of its flight. Surely Soviet ICBMs can be developed to have a boost phase of only fifty seconds, ending in the atmosphere. That would completely rule out the x-ray laser and the particle beam for boost phase interception.

FORUM: However, it has been argued that the shortening of the boost phase would result in a decrease in payload of the missile. This would reduce the number of warheads they could carry. Would this not be a positive ramification of SDI?

BETHE: It is absolutely true that the payload would be diminished, as would happen if the missile were hardened. But the payload would only be decreased by twenty percent in case of the fast boost system, as Martin Marietta estimated. That is not very much. If that is all SDI achieved, it certainly would not be worth the price. The loss in payload could be compensated by building larger missiles, or many more of them. The Russians would not be constrained in doing so, because all arms control efforts would be off, if the U.S. went ahead with SDI.

FORUM: Since you mention the increase in offensive weapons which SDI could trigger, what are the cost effectiveness evaluations? Would it be cheaper for the U.S. to add defensive components than it would be for the Soviets to build more missiles?

BETHE: Good point. The estimated cost of an offensive missile is about 20-30 million dollars. Doubling the Soviet capacity, i.e., building 1400 additional missiles would cost 30-40 billion dollars. This is less than even the most modest estimate of the costs of SDI. In fact it is just a little more than the costs for SDI research only.

FORUM: You would think that doubling the number of missiles would be enough to overwhelm the defense?

BETHE: Nothing is definite in these questions. But the government, as stated by Paul Nitze, has given a good definition of cost effectiveness. They say it should be cost effective at the margin. Adding a hundred more SDI stations should be cheaper for us, than for the Russians to add the corresponding number of offensive missiles, which is more than a hundred.

FORUM: However, proponents of SDI argue that there is a cumulative effect of the three or four defensive layers evisaged by SDI. If boost phase, mid course and terminal interception is only ninety percent effective each, it would add up to a total effectiveness of 99.9 percent for the whole system.

BETHE: That's right, that is what they say. But you have to be ninety percent effective on each level. I don't see that happening in any of the three layers. What is worse, if you rely on ninety percent effectiveness in the boost phase then you are apt to choose the size of the next layer so that it will be able to intercept only ten percent of the Soviet missile force. There you might be seriously mistaken.

FORUM: How could effectiveness be tested? By computer simulation or, if the system were already deployed, by actual intercepts of dummy warheads?

BETHE: That is about the worst feature of the whole system. There is no way I can see of having an effective test. You would have to test the entire system. The most difficult part is its computer, which is to direct everything combined with the system of detection. You need some detector that is able to detect simultaneously the firing of a thousand missiles. And each of them must be tracked and so on. The amount of information this generates is fantastic. Computing the track for each of these thousand missiles and performing all the other tasks of battle management is an impossible job, way beyond anything that has ever been built. And where do you put the computer? On earth it would be less vulnerable, but then difficult communications problems arise.

And let me mention one other point in this context. The government often claims that the Soviets are also engaged in SDI. Even if that is true, I am very confident that they will never succeed because their computer development is many years behind ours, as is being stated every spring by the Department of Defense.

FORUM: But hasn't this type of assumption often been false? U.S. calculations as to the time it would take the Soviets to get the atom bomb were greatly exaggerated. So were the assumptions in case of the H bomb.

BETHE: First, it was not the scientific community which made those inaccurate assumptions. We were much more cautious and predicted that a country as determined to get the bomb as the Soviet Union was at the time, would get it about five years after us.

FORUM: Would not Soviet determination to catch up with the U.S. in the area provide a large incentive to rapid technological development?

BETHE: The main argument I can give is that the USSR has stayed behind all these years. They are eager to get even a portable computer from us, because that is higher techonology than they have on their own market. They buy chips from Japan, because they can't make them equally well. They lack industrial capacity and a market for such products. Our industries are so well devloped, because there is a tremendous market. Look at the earnings of the leading companies. It is in response to these markets that the U.S. could gain its lead in critical computer technology.

FORUM: Nevertheless, in terms of other technologies the U.S. government has argued that the Soviets are actually ahead. The USSR has an operational ABM system, is upgrading its air defenses and has gained some experience in strategic defense—not to mention all the efforts of the Soviets in passive defense. Could the Soviets suddenly break out of the ABM Treaty and put up a comprehensive SDI system which it prepared in individual components just under the thresholds of that treaty?

BETHE: SDI is totally different from the ABM we discussed in the 1960s. True, the Soviets have developed this "old fashioned" system a great deal further than we have. They are rebuilding the Moscow system with modern radars and interceptors and they have a lot of experience. If they wanted to, and if the treaty came to an end, then they would be in a position to build similar installations at other places. Certainly this would not happen overnight. To build even one of those radars takes years. Take the famous Krasnoyarsk radar. It still is not operational. We have nothing to fear from a sudden breakout of the treaty. It would take years to do such a thing, leaving us ample time to respond. Furthermore,

as we discussed back in '69, these old fashioned ABM systems are not capable of protecting cities. They could protect missile silos against incoming missiles. We tried to do that with the missile fields in North Dakota, but found out it was too expensive.

FORUM: By now many experts agree it would be possible to defend hard targets, such as missile sites. And this is of quite some concern to the Reagan administration, which is afraid of missile vulnerability due to the large potential of heavy Soviet ICBMs. Could the U.S. start off with point defense and later deploy further SDI components in an incremental fashion?

BETHE: I agree with all of what you say, except with the assumption that point defense is a first step towards SDI. I think it would be perfectly possible for the United States to have now a cost effective defense of one missile site, which we could do under the ABM treaty with "old fashioned" systems. Whether it is sensible to do this, I am not sure about. But certainly it is technically feasible. It might be an acceptable compromise to build that sort of system. In defense of missile sites the modern achievements of intercept in space are useless, in any event. It is so much easier to do it down below. You have so many fewer objects to intercept and you are close by. A space system would only add unnecessary costs. The system you want is the solidly based traditional technologies deployed on the ground, with perhaps some newer elements added to it. The best way to do it is to have very small radars, one near each missile, and cover it with one or two interceptors next to it. The radars should be very hard, but only be capable of seeing objects about ten kilometers away.

FORUM: Would this limitation to point defense be verifiable in terms of arms control?

BETHE: It definitely would. And the reason why I recommend these radars, is that radar would be confused by decoys if they had a wider range. Down at ten kilometers all decoys have been eliminated by air resistance. You see only the actual incoming warhead. This method can't be used for area defense. If the Soviets explode their warheads at an altitude of ten kilometers over a city, that would cause enormous destruction.

FORUM: To what extent is the U.S. currently engaged in what you call "old fashioned" type of research on ABM? Will resources for such work be drained by more amitious SDI projects?

BETHE: Very good point you are raising there. We have been engaged in traditional ABM research all the time, since before 1970 even. We are doing two different things. One is to try to develop more effective traditional ABMs. The other, even more important, is to test penetration aids — that is decoys of various types which might frustrate the Soviet ABM system. I think we have spent a lot of effort especially on the latter. We should continue to do so, also as an additional insurance against a Soviet breakout from the ABM Treaty. The funding was approximately one billion dollars a year. I don't believe this has been decreased, but of course interest in that area has diminished. Previously the office which administered this was interested entirely in the traditional ABM. But now, in the SDI office, it is considered of minor importance and interest.

FORUM: Would the enthusiasm for new technologies not create a non-military market for the fruits of SDI research?

BETHE: Some such spin-offs will undoubtedly occur. But I think the net effect is the precise opposite. The new ideas especially of SDI are terribly challenging. Therefore the best engineers and the best scientists are drawn away directly from industrially beneficial pursuits. It's much more interesting to think about a laser for SDI than to improve an automobile. As a consequence an increasing fraction of our automobiles comes from Japan, whereas we used to export automobiles. The same has happened with many other civilian products.

FORUM: The Western European countries are in the process of organizing a program of basic research under the "Eureka." The focus of this work is primarily non-military. Will this give the Europeans a chance to draw even with the U.S. in relevant technology, while the United States researches in less marketable areas?

BETHE: I think the Eureka idea is splendid, I think that's the way to do it if you want to improve industrial forces. One should also say that real innovations demand support from the government. It is too risky for even a big industrial company to engage in that sort of research. The European initiative is very promising in this respect and may result in displeasing consequences for us. We may have to face competition not only from Japan but also from Europe and our trade balance will get even worse than it is now.

FORUM: It is true that the support of governments is necessary in this respect. But what about the support of their national constituencies? Do you think SDI as a strategic concept will be accepted by the American public? Will the scientific community try to counter such an acceptance in an organized fashion, as it did with ABM in the early '70s?

BETHE: I hope very much that SDI will be rejected by the public. So far, I think we have failed to gain public support for our skepticism towards SDI. Many people are persuaded by the idea that SDI will make us safe from Soviet attack. That is of course an illusion. But the public relations efforts of the government are splendid and we just can not compete. In 1968 to '72 the point which finally influenced public opinion was a very stupid point, namely that the government proposed to put the anti ballistic missiles very close to populated areas. This was objected by the ones in whose backyards such deployments were envisaged. We don't have a similar point at present which could arouse public resentment against SDI.

FORUM: You referred to the popularity of the idea to render nuclear weapons "impotent and obsolete," as President Reagan put it. If all technical difficulties could be disregarded, would you endorse the idea of a nuclear free world brought about by SDI?

BETHE: I think it would be a much more attractive world if we could reduce the stockpiles of all the nuclear powers very, very much. In my opinion, instead of 20,000 nuclear weapons, partly tactical, partly strategic, we would be much better served by having 200. We are far away from that. We should be able to get here more easily by negotiation. SDI will be a stimulus for increase in offensive power, rather than decrease.

FORUM: Let me conclude with one more general question. The scientific community seems to be divided on the issue of SDI. What would you think is the role of the scientist, whatever side he or she is on, in reconciling the theoretical findings made with the political realities into which they are born and in which they are used later on?

BETHE: It would be very important to have such a reconciliation. Most of the scientists who advocate SDI are in the weapons laboratories or in such industries which tend to profit from SDI. The opponents are mostly academics. Some of the academics, however, have considerable knowledge on the subject. An attempt was made at Dartmouth College to get

together two distinguished exponents of the two camps. After a day of discussion they agreed on 15 points. Their consensus goes very far and is rather skeptical towards SDI. If such agreement could be reached in a more general way it would be very welcome.