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# FORMULATION AND ATTAINMENT OF SCIENTIFIC AND TECHNOLOGICAL GOALS

Dr. Jerome B. Wiesner

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Reviewed by: Colonel J. H. M. Smith, USAF, 12 December 1962

INDUSTRIAL COLLEGE OF THE ARMED FORCES

WASHINGTON, D. C.

1962 - 1963

Formulation and Attainment of Scientific and Technological Goals

5 October 1962

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INDUSTRIAL COLLEGE OF THE ARMED FORCES

Washington 25, D. C.

# FORMULATION AND ATTAINMENT OF SCIENTIFIC AND TECHNOLOGICAL GOALS

5 October 1962

GENERAL STOUGHTON: Gentlemen, as we continue our studies in the field of international security programs, we go into those fields of ever growing importance, science and technology. As you have noticed on his biography, our speaker this morning is a person of outstanding eminence in the national scientific community. Further, his present position as the President's assistant in the fields of science and technology certainly speaks for itself, and it is our good fortune in having with us this morning, Dr. Jerome B. Wiesner.

It's certainly a pleasure to welcome you to the Industrial College of the Armed Forces, Dr. Wiesner.

DR. WIESNER: It's a little hard for me to decide just what to talk about this morning. The problems that sciences poses for our society today, and particularly the problems that it poses for people in the military ranges over such a wide gamut that it's hard to pick out a few aspects of the problem and concentrate on them. For people who are concerned with national security I think science poses an even more serious problem than it do s for people who are concerned with the general welfare of the society. Because, it is changing so rapidly nowadays that it's really hard for one to understand its impact and to predict precisely what the needs and consequences of the various developments are going to be.

I have spent 20 years or more involved in technology and the application of science

and a large share of this time involved in problems of military security and national defense. And in recent years I've also become involved in the other side of some of these problems, namely attempts to curb the arms limitation measures. And I don't know which is more complicated and more defying of real understanding. As a matter of fact, they are the same problem, in a sense, viewed from two quite different points of view.

I might say just a little bit about what has been happening in science and why this problem is so particularly confusing for people who have to cope with the security aspects and face the real problems that I see, and then I'd like to talk a little bit about the general problems of society and the impacts of federal activities on the world.

I'm sure you're all reasonably well-informed about the goals of basic research. Scientists are interested in understanding the various physical phenomena in the world, and particularly the activities today, I think, can be simply categorized into those in which we're trying to understand matter and energy - that is, the world of the physicist; the world of the living systems, the biologist and the medical research man. And the rather interesting new field, the one that I think is the most exciting because it's the one I worked in before I came to Washington; at least its the one I recently worked in, in physical science problems, and that is the world of information processing. That is, the understanding of logical systems, computers, mental processes, etc. And all three of these have had a spectacular growth in the last two decades.

It's only in the last two decades that we've had nuclear energy, that we've had computers, that we've had supersonic flight, that we've had rockets, that we've had

military applications of these things, and they've all come from an understanding of the world around us which has evolved in the last 30 or 40 years. I like to think of this process as some of you in the audience has already heard me say this before, as a sort of man-made extension of the evolutionary process, with all of its advantages and all of its disadvantages, some of them accentuated - both the advantages and the disadvantages. You know the miraculous process of evolution has been the means by which organisms have evolved and developed, to cope more and more effectively with a hostile environment. It's a process that has taken long periods of time and has been very slow. The scientific discoveries and the exploitation of science which we've become accustomed to, or so troubled by, depending on your position, is rather recent. But what we have learned, when you think about it, is how to extend all of the faculties of the human being by the creation of energy - the use of natural fuels for energy. We've greatly extended our muscle power millions and billions of times. We fly aircraft and travel by train, automobile and boat.

We've extended the speed by which we can move, by radio, television, telephone, telegraph, teletype. We've greatly increased the speed by which we can communicate. And with the computer and the servo-mechanism we've increased the speed and increased our facility for controlling these forces and for doing routine mental operations which man has had to do. So, we've had extensions of all of our human faculties, to do things much more effectively than if we were limited to doing them by our own biological resources. The nerve impulses over electrical wires travel millions of times more rapidly than the nerve impulses of the human. This extends to systems by which we can observe and control the consequences that you've all been

forced to live with.

We've had this tremendous extension of our human faculties, but the rate at which we've been evolving our capabilities to deal with the world around us has been greatly accelerated. As I said earlier, all of our problems today are the problems we have generated in the last 20 or 30 years, so that we have now a situation which, instead of many, many lifetimes in which to learn how to live with new processes and new opportunities, we have very few years. And we now have systems which are so large and so extensive that they effect the whole world around us. Not only do we learn how to handle one problem; for example, the great developments in health, hygiene and medicine have taken care of human ills, but they've given us a population problem. The nuclear weapon is certainly regarded as a mixed blessing by everyone.

Going to missiles from aircraft has made the penetration problem easier; it has made the defense problem harder. It has made the stability problem in military systems more difficult. So that, you generate a whole new series of problems every time you apply technology to solve one of your older problems. And these things are happening so rapidly all through the society that it's very hard for people to understand the full impact of any decision or action before the decision or action must be carried out. And then only after you've taken it do you begin to see all the problems that are consequent to that action and have to begin making a series of new moves to correct those, again with a whole chain reaction.

Now, in the military you've all been living with this problem. I suspect it's more acute in the military research and development field than it is in any other activity of human

endeavor for a variety of reasons. And during the time that I've been concerned with military research and development I've seen progress go from emphasis on single weapons or single weapons systems that were being developed to do something that we were already doing, somewhat more effectively - you make a better bombing device; you make a faster airplane; you make a better glide rocket - but the concentration effort was generally on the individual piece of hardware. Through World War II we were not concerned with large-scale interaction of these weapons because of the nature of warfare at that time. But more and more we have gone from a situation in which we were developing single weapons to carry out military tasks that were pretty well defined and were traditional in the sense of the kind of warfare we were fighting, to more and more elaborate systems, and systems of more and more interaction of all of the components.

We didn't learn this very easily; only through the evolution of the air defense system, and it was only about the time we didn't need an air defense system anymore that we began to realize that it was a system and that it had interactions that had to be studied as a very elaborate system. We began, as I'm sure many of you know, by buying aircraft, fighter airplanes, radars for the ground, radars for the aircraft, anti-aircraft guns. The Air Force was buying airplanes. The Army was buying anti-aircraft missiles. It was pretty late in the game that somebody discovered that this all had to be tied together and that certain elements of it might be more effective if they had organized it a little differently.

Eventually people realized that the human communication node in this system was not really very good and they decided to put in computers. The computers were

often large-scale. And it was only after we got the computers that people realized they didn't know how to program the computers. I'm not making this up. I understand there are not supposed to be any newspaper people present. But this is pretty much what happened. And then, once the physical hardware for these systems was clearly available, tremendous emphasis was placed on understanding the systems aspect of the problem. And by now we do know a great deal about how to analyze programs systems of this sort. But some of the mistakes that you made when you couldn't have an analyzed systems aspect of these problems are still living to haunt us.

For example, I can remember somebody saying with a great deal of scorn when it was proposed that the radar computers centers be hardened, that this was nonsense, the damned things couldn't even protect themselves; what was the point of them. But the great vulnerability of the air defense system today is the fact that a single missile which was never designed to protect itself can take out a computer center and then you can kill a whole air defense system. It's like putting a single bullet through the brain. Well, a little longer-range thinking and planning at that stage in terms of the evolution of military systems might have kept us from making that mistake.

We have similar problems in the command and control structure when we had aircraft to contend with; we had many hours to respond. We could build warning systems, which we did, to alert our bomber forces, which would alert the President, the military command structure; there would be time to make decisions; time to go back and look at strategic intelligence to see whether you had missed a lot of indicators to tell you that this was really coming, and then make a decision. You could

also release your aircraft, and with the kind of control structures that SAC has built up you had time to decide that you'd made a mistake; if the airplanes didn't need to go on you had time to deploy your air defense capabilities for maximum effectiveness. And whereas, again, these things didn't come along as fast as we might have liked, because, again, belatedly we realized that these were really command and control systems that had to be tied together, at least there was enough time.

Now we've come into a period where the time scale has been shrunk by another factor of five or ten and where we still have to do all of the same operations that we had to do before; and we have to do them faster and we have to organize to do them faster. And it's not at all clear that we have this part of our system fully understood. Because by now we've learned to be so sophisticated in computation, simulation and analysis, that we can invent so many things that could happen, that it's incomprehensible for the human who has to make the decision about which course to follow, to make the decision and to understand the problem. So, we've really swung completely in the other direction. We now trust our computers so completely for analysis that we no longer think that the military man or scientist who has only judgment to offer has any place in the system. And I think this is very dangerous.

As a matter of fact, I'm reminded of a woman I know - Carl Compton's sister - once went to live in India. She was having her furniture unpacked and she was having an Indian carpenter help her. He was trying to drive a nail in the wall to hang a picture and he was doing a rather poor job. The wall was getting more and more cracked. And she finally took the hammer away and said, "Good grief, man, let me do that. Why don't you use some common sense?" He said, "Madam, common

sense is a gift from God. I've only got a technical education."

One of the most serious problems that we are dealing with in the whole military research and development problem, in my opinion, is just this problem. We are so many generations away from having used - we've never used some of them; as a matter of fact, we've never fought a war with ballistic missiles or megaton or 100 megaton nuclear weapons, the polaris submarines; these things have been evolving from the ideas and notions that we had at the end of World War II, and they've evolved mostly in the computer men's minds. If you think back to our World War II experiences, we rarely used the things we developed in the way those of us in the laboratory thought they were going to be used. Because the things were never quite what we thought they were going to be.

I remember once going out to join a Navy exercise that used a large radar that I had helped develop. I had been the Project Engineer on something that was then called "Project Cadillac." Those of you here who are Navy people will know it as the early warning airplane that was carried by the fleet. Actually, it was also the system that turned out to be the off-shore radar system that the Air Force uses for early warning against bomber flights. We could never keep the damn thing operating. I was embarrassed that it even went into the fleet. But people in the Navy said they thought they could keep it working. And I went out to see whether we could help keep it going after it had been on for a little while. And it was running a hell of a lot better than it had any right to be. I asked the Captain how he did this and he said, "Well, it was easy; I got rid of all those MIT-trained personnel, and instead of trying to make it work the way you think it should, we're using it the way it

And, it was different, but it was doing a useful job. I think we often lose sight of this, because no military equipment was ever perfect. And if you always wait for the last word you'll never have anything. And when you have to fight you have to fight with the things you have. And you fight the way you can. If you're lucky, the impractical, imperfect things you have are as good or better than the equivalent things of your enemy. And if you're also intelligent about how you use them you come out all right.

Well, I think that we have gotten so far from being able to use or wanting to use, or knowing how to use our weapons, that we fight these theoretical wars and we judge our equipment on the basis of these analyses. The thing that people rarely remember is that any computation, particularly something as elaborate as a computer computation, can only be as good as the assumptions you put into it. And you can hear these very elaborate war games that are played on the machines; sometimes not even played on the machines; sometimes with people walking pieces of paper around; and they come out with absurd results. And when you dig in you find that if somebody had spent just a little more time looking at the initial assumptions you wouldn't have played that game.

And I think this becomes more and more serious when you use the modern computational gadgets to disguise - I don't think it's done deliberately - but when you do these very elaborate things, what you started with gets lost in the program in the elaborate setup, and I think this is probably the most serious single worry that we have to have as we do military planning. It's one of the most serious problems that I think career military people have to face.

As I watch the evolution of the military system you see it being more and more dominated by these theoretical -what shall I call them - philosophies, and I suppose they have to be because we're dealing with things that we've never had practical experience with. But if the military man who is going to have to use them gets shoved aside in this operation or study - and he often does because he hasn't had the technical background to feel comfortable living in the same room with a computer, or physicist, chemist or mathematician - he's going to be faced ultimately with a whole flock of weapons that he has very little confidence in, and the weapons are likely not to be the weapons they might have been if there had been a more continuing association with a military officer.

As I watch the problems of the Pentagon, of which I would say there are an infinite number because of this very rapidly changing technology, I regard this as the number one problem. How to keep a continuing flow of uniformed officers who are as good or better than the civilians who come in to help with these research and development jobs. I think you've got to have civilians in policy, planning and research, just as I think you have to have military. And there are many able people. Some of the best scientists I have known have been people in uniform.

But I've noticed increasingly that this system seems to frustrate them and that they go out and take good industrial jobs. One of the brightest young officers I've ever known was in the ballistic missiles division out on the West Coast where I worked with him from 1954 to 1955, as a Colonel. He's now a director of research in a large company. And I don't think he does the country 5% as much good there as he did where he was. Now, some of you will say, "Well, people leave because of salary," and I

think this is a problem; it's not only a problem in the military, it's a problem all through the government in scientific activities. There is such a demand for manpower outside of the government - all of it created with government money, by the way - I mean this is really a problem. 60% or 70% of research and development in the country today is federally financed. And yet we have one set of standards for the people in industry, and a quite different set for civilians and military personnel working directly for the government, and having the responsibility of deciding what you do with this money.

You often see very, very large teams of very good people trying to deal with one poor fellow in government service who has to make the decisions, and he's at a very considerable disadvantage. One of the major efforts that this Administration has been making - and with some success - I'm glad to say, within the last year, has been to try to change the pattern of the federal pay service scale. They have finally, I think, sold to the Congress the notion that principle of comparability which used to apply to a few blue and white collar jobs in the lower base scale should apply all through the government structure.

Now, our particular effort this year has been only on the civilian side of the government, but it has been recognized by everyone that we have to make a comparable improvement in the military, and it's Mr. McNamara's plan to go forward with military pay reforms too. We only got part of what we asked for this year; we got the acceptance of the principle of comparability; we got a major improvement in the lower brackets, up to GS-17 - some improvement in GS-18 - and we hope when we cope with the executive pay problem which was the limiting inhibition this year

because this was an election year, when we cope with this next spring we will be able to do a little better job at the top. It comes out, you see, that it's not very costly for the government to pay very well. I think the government could afford to pay better than industry where a few key people - the few thousand key people that it takes to make the difference between good and bad programs.

It has been my experience when you look around and see something in trouble it's because it doesn't have some inspired leadership. When you see something that's going well, for example the Naval Lab at Inukern; that has been an outstanding laboratory. It has developed a number of very interesting things; it has done an inspired job. And if you look at that laboratory you see two or three or four people who made the difference. When you look at a performance like the Bell System did on the Telstar Communications Satellite, you say, "Why has the government's communication satellite program gone so much poorer?" Again, it's a few key people. And when you're spending ten or twelve billion dollars a year you can afford, I think, to spend the $50 or $100 million that it would take to have your administrative top technical policy planning people be the best people the country can provide. And so, this has been the thrust of our effort in this regard.

I think the military problem goes deeper. I think the civilian problem is partially pay; I think there are many other frustrations one has to deal with in the research and development field, and we're making an attempt to do that. I think the problem of the military scientist and engineer is even tougher because you've got the problem of, "Should every officer be a general line officer? Can an officer who concentrates on research and development, or analysis, ever have a top-level career?" These

problems have not yet been resolved. And I've known very many of the people who would have loved to remain in the services. Their dedication was to the goals and objectives of the military. They felt they could not play the role they felt they were qualified to play in the military, because if they did their career would be dead-ended. I presume this is true in the management field too, although not to the same extent. So, I think there is a basic problem here; that personnel management has not yet been resolved, and has to be if we're going to have a military service that can live with these very rapidly evolving and very difficult problems.

Well, I've concentrated on this particular aspect of the problem because I'm sure it's one that you're all very interested in. But I'd like to tell you about some of the other problems that our research and development effort have posed for the country. Because this very rapid growth of research and development, which has been largely a response to three problems: National security; that is, research and development for the military; health research - most people in the country are not aware of the magnitude of the research and development efforts that we are now engaged in in the health field - and they come to almost a billion dollars a year; not as big as the physical sciences research, but nonetheless a very major program; and then, of course, the space effort which, in a sense, is like the military R&D because it makes a demand on the physical sciences and the engineering resources of the country.

And, as you are all aware, I'm sure, this has grown from a few hundred million dollar activity shortly after World War II, to $12 or $14 billion next year. And what this has done is, it has created serious shortages and maladjustments in the techni-

cal manpower pool. First of all, as best we can judge it, the manpower production of our colleges are doubling about every 10 or 12 years. And this number is somewhat dependent on whether you're talking about bachelors, or Ph.D.s; whether you are talking about physicists, chemists or engineers of one kind or another, but it's in that range. Whereas, the dollar expenditures have been going up fast about once every five or six years. It depends on which particular group of years you take. But, it has been averaging about that.

So, we've had two effects. First of all, we've drawn manpower away from things that haven't been as important from the national point of view; at least haven't appeared to be as important, from civilian activities. Also, I think we've wasted money in the sense that the shortage has boosted salaries very considerably in many fields of engineers. I don't know if I shall stand up here and regret that; there may be people who will argue with me about whether or not this is good or bad, but this has been a consequence, and if we don't buy the research and development that we're trying to buy, if the main consequence of added money is to slow things down or to boost salaries; if we start a new project and there are a limited number of people available, then, of course, we'll just have to draw those people from something else. If they come from military activities, the military activities they came from slow down. If they come from civilian activities, those are hurt.

I think we're becoming increasingly concerned that one of the principal difficulties that we're generating, is a slowing down of the application of new ideas in science and technology to the civilian economy. There was a time when I think we all believed - and I think it was true - that the expenditures we were making in the

military had a very direct and important application in the civilian field. You can think of many things that wouldn't exist today; supersonic transport - even the jet engine probably could not have been financed by private industry; the elaborate navigation systems that we have; modern computers - even some of the antibiotics that we depend on, could not have been financed by private industry, or at least the development of these new products and the industries that have come from these new products would have been much slower if we had to depend only on private investment.

So that, in the few years after World War II, I think our economy got a tremendous shot in the arm from the direct transfer of military development to the civilian economy. But as we now look at the things we are doing we see that there is less and less direct relevance between the research and development activities; nobody wants to use an Atlas for intercontinental travel, but the B-52 was easily converted into a commercial aircraft. While there will always be many contributions which will contribute to the civilian economy; new materials, better ways of making electronic devices, etc., the direct output of the civilian economy, I think, will be diminishing with the passage of time, and the possibility of new industries flowing from military hardware developments, will probably decrease. And this is probably as important as improvements as we apply our computation and automation knowledge to industry as we learn to do more and more things efficiently.

We at least hope there will evolve important new activities for men, so that we use the human resources of our nation as effectively as we have in the past. And this transition from direct relevance to the non-security side of the activities, to

things which have less and less relevance, is very troublesome. And we add to this the drawing away of people who used to hold down the level of activity because it's priced out of competition; that is, the outstanding, good technical manpower is so costly that many industries can't afford to do as much as they would like. Then you add to that, underdeveloped industries that have never applied technology and which are increasingly facing competition from more modern industry overseas, you see we have a section of our economy and of our society which is something we should be very troubled about. Because, if we can't find ways to keep a very high level of growth, the development of new industries, the application of new ideas, we are going to find it harder and harder to sustain the national objective to support the health and military objectives overseas that the country has. And if we can't do all of these things simultaneously we run the risk of getting into trouble.

One of the dangers is that you'll do just a little bit everywhere and that you'll be weak along every front. I think because of this problem we have an increasing responsibility to be more and more careful about our expenditures in the fields of science and technology, particularly in the application field, because that's where the large demands for manpower come. That's where the large expenditures come. And that's the area in which you're really committing the nation, in the sense that we buy one form of security system. You've got it; you can't turn it around overnight; you can't wish it away and wish something better.

When we used to be able to buy a half-dozen different kinds of fighter aircraft, or when we used to be able to support 20 aircraft missiles in development, as we did in the early days of the missile business, we could be pretty careless about what

we were doing, and hope that the law of large numbers would apply here and that we would evolve two or three systems out of it that we would be happy with. I'm sure that a number of you in the room can remember, as I can, when we could buy an airplane development or a missile development for $50 million. The standard price today seems to be a billion dollars for a new weapons system. This means that we don't have the resources to do as many things, or at least to do the shotgun kind of purchasing that we used to. It does mean, then, that a greater understanding, a good deal more wisdom has to go into the selection of these things.

Now, in facing this resources problem - and I've talked about two aspects of it - the financial, but even more important, the manpower aspect - we have tried to see what steps we might be taking to increase the technical manpower resources. This is a field in which you can't be very quantitative without being attacked, because, depending on the definitions and the surveys you use you can prove almost anything that you want to prove. People have made very strong arguments that there is a terrible shortage of engineers and scientists coming out of the schools, to, there's a surplus; we only have to use them properly. And I think there is something to be said for both these points of view.

As long as we use our manpower inefficiently there is a shortage. I think that if we had the ability to be more effective in our use of technical manpower we could probably forestall the bad effects of a serious shortage for some time. But if we allow the growth to continue in the number of things we want to do, the shortage would reappear at another time.

One of the properties of research and development is that it's exponential not only

in cost, but in opportunities. That is, the more people who work, the more things you do, the more ideas you have. And there is no such thing as an end of the line, as far as I can see in this business. Because, every good man who works, develops some new ideas and some new opportunities. And this is why the problem that the military planner has to live with is so difficult. Because the thin line between vision and damn foolishness has disappeared; at least it's no longer easy to discern. And I think there are people who think that bigness and vision are equated. This isn't necessarily so. So that, we've got to, I think, learn how to be more selective in picking what we want to do. We can't do everything; it's self-defeating; it's exponential in growth.

Here is a matter of not only deciding which things you want to do, but I think even a question of timing, of how fast you want to do them. For example, we now have this notion of concurrency where we do research and development simultaneously. We had to do this on the ballistic missile because we were late. We started late and we wanted to get ourselves into a position where we wouldn't be in a very inferior position when the Soviet Union deployment became a factor that had to be considered. The fact of the matter is that we went in so hard that we left them back several miles. We didn't know that when we were doing it, of course.

But in many ways I believe that the United States has been running an arms race with itself. I'm serious about that. I think as our intelligence has gotten better we haven't done as much of that. But certainly I remember I lived through the period when - and intimately - the Russians first got the A-bomb and we discovered that they were making some B-29s. We projected a build-up of the Soviet force that

looked just like our own projected build-up a few years later. And then we decided we needed an air defense system to cope with a bomber force. The Soviets saw our bomber force and built their defense system. Then we built a bigger bomber force.

I think we have learned since then that the Soviet bomber force never approximated anything like the force that we had visualized during that period. Then, I also remember during the early days of the ballistic missile when intelligence people told us we didn't have to worry about the ballistic missile; that they wouldn't have one until 1965. Then we went around and looked at the U. S. Air Force program for ballistic missiles, and sure enough, we were supposed to have one in 1964. And all through that early period of the U. S. strategic systems development we were, in a sense, coping with an enemy that was a reflection of what we thought our own capabilities were. And if this is an element of what you're doing, I think you have to be very careful about your decisions.

Remember Black Sambo? He ran so fast he melted. I think that this is one reason why improving our intelligence capabilities is so important, not only for the strategic, tactical reasons for it, wanting to know what the enemy is doing so that you don't get caught off-base, but I do think we can be much wiser in our decisions about what we should be doing and timing the speed at which we should do things if we have better information.

I think, in dealing with the problems of disarmament which, as I said, I spent a lot of time on, this is an aspect of our own problem; that the Soviet Union has just failed to appreciate, just as we've failed to appreciate certain problems that they face. And I can understand why, because if they can make us think they've got a

thousand airplanes when they only have a hundred, they don't have to build a thousand and this saves them a great deal of money. On the other hand, I think we do have to face the fact that prudence will lead to just the kind of decisions we've made in the past when there wasn't information. This is one of the really basic problems that I think will keep us from coming to any sensible agreements; until the Soviet Union has a quite different ~~attitude about secrecy than~~ they now have.

Well, as we've looked at this manpower problem which is the subject before I got off on this digression, we've felt that numbers - increasing numbers is not really the problem. There is going to be an increase in numbers anyway, because there's a big bulge of kids coming into the schools, the population is growing; we expect that there will be almost twice as many kids trying to go to college in 1970, as there are today, and only a fraction of these people will try - the same fraction, we figure - that has been going into the sciences, math and engineering - will continue trying to go into these fields.

The problem is to improve the quality. Where we've seen trouble, as I said, has been because of lack of real leaders, lack of people who knew what they were doing, rather than lack of numbers. Sometimes you see something that's in trouble and the solution that is elected is to add more people, and this makes the problem worse rather than better, because there are more people doing the wrong thing.

The way to fix this is to improve the quality of the man, in our opinion. We think this has two prongs to it; improve the quality of undergraduate education by making the courses have a larger component of good basic science and math, and the second thing is to try to increase the number of graduates coming out of the

schools to go on for advanced education. We'd like to see the number of Ph.D.s in math, physics and engineering go from the present level of 3,500 a year - a relatively small number - to something like 7,000 a year in 1970. To do this is going to be a major chore. The facilities, the buildings don't exist; the faculties don't exist. You can't build these up too fast, or all the people you're turning out will be going back into the colleges for teaching, and this would be self-defeating. But we do believe that the goal of doubling the number in the next seven years is possible, but hard and costly, and this is one of the things that I'm going to undertake to start during the next year.

I see my time is up, so I'd better stop at this point and answer questions.

QUESTION: My question concerns the storage and retrieval of scientific information. I wonder if you might comment on what is being done to simplify and modernize the exchange of information among the scientific community?

DR. WIESNER: That's a long story. What we're trying to do - you see, this has several aspects, first of all. There is the problem of scientific information which, at least in our view, is broken down into two complements; that part of the information that is needed by the people who are managing the scientific programs or who are creating them, who need to know what's going on, how well it's going and where you can get various kinds of resources; where you should go to have the work done; how to avoid overlap by using the things that are going on. And the second part of this problem is making what you might call the switching network that makes it possible to connect the scientist here with some information here, or

a scientist somewhere, who has the information, in a very effective and efficient way.

These are somewhat different problems and I think they are often mixed up by people who talk about the scientific information problem. What we are doing now is, we've gone through several steps. About a year ago I set up a panel - a Science Advisory Committee - to dig into these problems. And as I say, they are problems about how you get information from management, how you publish information efficiently, how you abstract it, how you get the information around, how you keep the system from being clogged because there's a tremendous amount that is being published that shouldn't appear. It usually has some purpose for being created, but somebody thinks that maybe somebody will want it at some time and it comes into the scientific information system too.

One of the real sources of this kind of clogging is the Quarterly Progress Report that every company turns out for every contract with the government. And as you know, there seems to be a premium on weight and not on density of information in these documents. So that, it's very hard for anyone to abstract from them and tell whether there is anything in them or not. It would cost you more money to have a competent scientist or engineer to go through a Quarterly Progress Report and tell you whether it has something that ought to be preserved for posterity, or whether it ought to be filed with a thank you note. This is one of the major problems of this particular business.

At any rate, I've had a group working at this for about a year. We put together a full-time task force to work with them. The first chore was to try to make some

sort of a survey of what is going on. The tremendous amount of work going on in the documentation field, both within the government and among private organizations, particularly among the professional societies is so varied. We've got a pretty good picture of what is going on and we've got now some plans which are being thought out as to how to streamline and integrate this. Each of the agencies that has responsibility for scientific information is trying to clear up its own internal arrangement and then we're going to work on the problem of trying to get uniform enough ideas of policies and procedures so we can exchange information properly.

On the management side there is something called "The Science Information Exchange," from which we're going to try to get information on all the research activities that are going on in the country, especially those sponsored by the government - whose doing it? what are the objectives? what the projects? what are the contract costs? etc. This is now pretty well done for the life sciences except for the information that comes out of the Department of Agriculture. We are now getting almost all of the life science research.

So far we've been getting only about 10% of the physical sciences, so that, it's not very useful yet in the physical sciences. And we're going to try to work hard to boost that up.

In the documentation field there has been created recently in the Library of Congress, a library referral service where you can go to find out which specialized documentation facilities have information about which problems. What we would like to end up with is a series of specialized centers around the country that have the responsibility for documentation in a single area or field, so that all the material

that goes on in the country, all the publications that are generated of significance, can go into that specialized center. And this group, then, will have the responsibility for doing a very good job in one field.

There have, of course, been proposals for doing all this centrally, but there are, I think, two reasons for not doing it. First of all, we do have some 400 or 420 specialized centers already. Now, you can either pile something new on top of them, or you've got to put these things out of existence. They often serve other functions too, so it has been our decision that we ought to try to improve the quality of these and create whatever new ones are needed, so that the job is managed in that way.

Secondly, the reason for this is that we think that the referral services, to be good, essentially not the referral service, but the specialized service group ought to be associated with some research or technical activities. For example, in the nuclear science field the specialized group is at the Oak Ridge National Laboratory, where they have access to a large number of scientists with competence in the nuclear science field. And if you can build them up in that way so that there is professional assistance available, I think the service will be much better than if you dump 2,000 people into a new building in Washington and give them the responsibility of doing all of this.

There are many other problems in this field. I have greatly simplified what I think is one of the toughest management coordination jobs that I've agreed to try to do something about. There are many people who don't think it's worth the effort, and they may even end up being right.

QUESTION: Dr., in the Soviet Union apparently they have some kind of supervision over science and technology both in the Central Party and in the big committees. Eventually will this centralized supervision, compared to our decentralized method, give them an increasing potential in this field?

DR. WIESNER: I don't really know, as a matter of fact. In principle you would think it would be good. But I have said several times before other groups that in my own job I have been resisting very hard, pressures from various people inside of government - in the Congress and outside - to set up a Department of Science with a Cabinet post, because I don't think this is a good thing to do, even though it might put me in the Cabinet. I believe very strongly that it would be a mistake, for the reason that as an old information expert I discovered that, or I came to believe that in the learning process there are certain principles that you ought to follow. That is, you ought to do a lot of experiments; you ought to have small chains and circuits that the information has to flow on; you ought to have things that are sensitive to error so that you don't make big errors. And I think that research and development is this kind of learning process.

I think it's very important that you have decentralized direction in research and development activities; that you get as many good people at the lower levels directing the program, and that at the top levels in the Defense Department, AEC, and in the White House in particular, that we be concerned with broad general goals and objectives, and problems of balance; insuring that the work is good; that there isn't too much overlap; that we're not missing real opportunities, rather than trying to mastermind all this from above.

Now, the fact of the matter is I don't think they really try to mastermind it in the Soviet Union either, from the top. On two or three occasions I've gone around to Soviet laboratories; I spent one period of three weeks visiting a lot of their laboratories as a guest of the Soviet Academy, and while it's certainly true that the Soviet Academy defends the budget for research and development and allocates the resources, one could probably say that in a sense I do that too, only in a very loose way. And it's not clear to me that it's done in a tighter way in the Soviet Union.

The Soviet Academy has, I think, about eight or nine divisions. Each of these divisions has a director. These directors have other responsibilities. They have to be laboratory directors and area directors as well. Then, they have staffs that work for them, and they have committees and organizations that look very much like ours. Things are filtered up from the laboratories, and I think that decisions about where research and development is supported is made very much like our decisions are made.

Also in the Soviet Union, in addition to the work that is supported by the Soviet Academy of Sciences, there are at least two other - maybe four other organizations that support research and development. The military has its own research facilities; something called the "Goss Plan" which is a planning group which runs its own industrial research and development activities. The Ministry of Education has universities like the University of Moscow that has very big basic research activities. These are independent of the Academy of Science.

The Director of the group for medical research, whose name I can't remember, has the responsibility for all medical research in the Soviet Union. It's very clear

that there is a lack of communication between these groups; that there is jealousy and fighting; all of the bureaucratic problems I could tell you about here in Washington if somebody asked me about them. You can see in the Soviet Union too, and possibly even more acutely, they have a very good information service. Or, at least it's supposed to be very good. It has a lot of the problems ours has. It's better supported than the American service. But, I went to visit a radio-astronomy service at Polkova in Leningrad and I was appalled at the receivers they were using. It was a hydrogen line experiment. It was very noisy. It had a 2,000 degree temperature, for you experts here.

I said, "Good grief, that's terrible. Why don't you use a parametric amplifier?" They said, "We can't get one in the Soviet Union." I said, "I saw a very good one at the University of Moscow." They said, "You did? We'll get in touch with them." So, it isn't all that you read. I think they have some other problems too. There is a separation of academic and academy research to a much greater extent than there is basic research in this country. And I think that this has handicapped the development of research activities to a certain extent, and has also handicapped some of their other academic institutions.

My personal opinion is that we've over-rated the present level of Soviet science. They're very good. There is another fact. If you wander around the Soviet Union, I discovered many other people who have been there, who had exactly the same sort of lost feeling that I had. The people you talked to were obviously very knowledgeable - very good; they knew our literature; they could argue in detail about technical problems that I knew about. The things they showed me most proudly were sort of

modifications or duplications of experiments that had been going on at MIT - because at that time I came from MIT. But rarely did you see anything; almost essentially never did you see anything that made you say, "Gee, why didn't we do this?" And the more I saw this the more I was puzzled about it. As I say, when I got home I talked to people in other fields and almost everyone I know, who has gone to the Soviet Union, has had some of that experience. Occasionally there are fields in which you do see very exciting work.

In mathematics they are quite outstanding, and they are very good at copying. Their technology is very largely based on very good improvizations based on Western technology; to such an extent that, as I say, you practically never see anything where you say, "Gee, we ought to do this." In fact, when I first came into this job - and perhaps some of you have heard me tell this story too - I had a visit by a group of 30 Japanese newspaper science writers. We had a very pleasant couple of hours. At the end of it, one of them said, "I'd like to ask you an embarrassing question, and you don't have to answer it if you don't want to." I said, "Well, go ahead." He said, "Your predecessors, Killian and Kistiakowsky, believe that Soviet science is now superior to American science. Do you believe this too?" And I said, "Well, I don't think they thought that, and I certainly don't." And they argued with me for awhile. And I told them what I thought.

And I finally said, "I'd like to ask you fellows a question and you don't have to answer it." They said, "Okay." I said, "Your science and your technology have developed amazingly since the war. I'd like you to tell me whether you think it's based on Western science or Soviet science." In fact, I said, "I'd like for you to tell me

one thing you're doing in your country, that's based on Soviet science." They all looked sort of shocked, and I went around the table, and they all said, "You know? You're right."

Our own reaction to Sputnik and to the discovery that the Russians had any capability, I think scares not only ourselves, but the rest of the world. This may have been a good thing because it took kind of an impulse to get us to doing the right thing. The Russians are training great numbers of people. They're spending a great deal of money on science. And I think one day this will take off. I think you have to realize that it's all knew. They started after World War II with very little. I can't explain this phenomenon. I may even be kidding myself to a certain extent. I think they have the capability to do anything in the technical field that they want. Although, it's harder for them because they don't have the broad base of industry that we have. If they want a fuse they have to make it. If they want a vacuum tube they either have to try to get it from the West, or at least they don't have nearly half the industrial base that we do.

But I think the fact remains they can do anything they want to do. They can't do everything as we think we can. And they are very heavily dependent on us still for the ideas, the basic components. I think this will change because I don't believe you can have such a large population of very good people with all the resources they want, without it one day taking off. You can ask yourself why this is. I've talked to a great many people - scientists and Soviet experts - about this, and we have all come to the conclusion that it's a reflection, primarily, of the rapid development plus the history of the previous period; that is, the period during World War

II when a great many of the people were killed, there was a generation of people who didn't go to college. The generation of scientists before that was not in very good favor with the government and there was a generation of scientists that were more politicians, commissars and scientists, than the early very outstanding people who are now once again in favor, like Tom and Kapitza and Binagradov, etc., who were in the doghouse and didn't have many students. The thread of education, I think, was broken and had to be recreated so that these kids, these youngsters are having to train themselves; they're having to grow up by themselves.

And I think this is one of the reasons they're so anxious to come to the West. The young Soviet scientists take every chance they get to come out to talk and to visit. And I think that one of the main reasons is this need for association with more mature people, with other people, and that they're only slowly building up in their own country. There may be other reasons for it too, and I may even have a distorted view. But I did, as I say, visit 24 or 25 laboratories. I talked to a great many people, not only Americans but British, Canadians, other Europeans who have been there, and I don't think my general assessment of the present achievement is wrong, although, as I say, I have a healthy respect for their people. I kept seeing fellows that I wished would come and work for me.

QUESTION: Dr. Wiesner, there has been talk and speculation about this inflation and lack of sufficient manpower, and the great promise of more pooling of scientists and technologists with our NATO allies, etc. Now, in the military field, in view of the facts of security and economic rivalry, what do you think the outlook is for this kind of development?

DR. WIESNER: Well, I don't think one can be too optimistic about an enormous change in this. I think that Mr. McNamara and others are very anxious that we do move in this direction, and I think some things will go along. One of the problems in this manpower thing is the competitive aspect of the problem. You can find a large number of companies in this country that will tell you they're under-employed. Of course, everyone expects that the normal situation would be a 20% per year growth. And this is what every company is shooting for. And if they stand still for a year they think they're under-employed. Their hiring is often based on that kind of objective.

I recently looked at the solid state rocket fuel, where, this year we've been spending considerably more money than we spent in previous years. And yet some of the large R&D outfits in this country are complaining that they have nothing to do. The fact of the matter is that we are creating new outfits faster than there is work being generated. This means that we are stockpiling in all of these companies; manpower that we are not using very efficiently. So that, there will always be an economic pressure, it seems to me, against pooling.

One of the problems that we ought to face up to is how to make better use of the industrial manpower pool that we have. I think right now we, for a variety of reasons, make very poor use of it. I think there are reasons other than the manpower pool problem for wanting to pool resources in the scientific field, and I'm sure that we will make a continuing effort to do this.

QUESTION: Dr. Wiesner, last night at Brookings Institute you regretted you didn't have locked doors. Here you do. Could you leave in a few remarks about

this question of bureaucratic loyalty versus objectives, scientific analyses, into your present thinking regarding the management of science and technology by functional areas, by activities, by disciplines, and by end-products?

DR. WIESNER: The doors are locked? Are we sure there are no newspaper reporters present? Well, this is a complicated problem. It stems from two things. Let me start by saying I think there is an executive office problem, or executive department problem, and there is a parallel Congressional problem. And the problem comes, as I said, because there are missions in the various agencies, first of all, that overlap, and as new problems grow - let me talk about a non-security field, a non-defense field, so that I can talk more freely.

Take the field of water resources. Here, of course, the Army Corps of Engineers is involved, but most of the difficulties that we have are in other agencies. As the population has grown, as industry has grown, we have had increasing problems with both supplies of water and quality of water, with pollution - detergents getting into the water, shortages of water - and it has become recognized that the federal government has an increasing responsibility here. Some of the responsibilities fall clearly in the field of the Public Health Service, let us say; others in the Department of Interior; others in the field of the Army Corps of Engineers; and I could name a half-dozen other agencies that have an interest in water - the Atomic Energy Commission because of its problems with waste disposal - and as new problems evolve they tend to broaden and be things that you could almost assign responsibility to any one of these agencies.

Each agency wants to participate and sees part of its mission involved in this.

Also, as the activities grow, the level of basic and applied research that are necessary to support the agency's mission grow, and the question of whether each of these large groups should be carrying out similar basic research in the field comes up. Now, I believe that you can't do good mission-oriented research unless you've got a core of basic research in each of the agencies that has a mission, unless somehow you can team up to run a common basic research activity. And we've never learned how to do this. In fact, you find tri-service laboratories even in the military have been as much of a headache as they have a blessing. And I think to try to do it between the departments of the government it looks even harder. And this, of course, is why people say, "Why don't you create a department of science and do all of the basic science in the field that effects all of the agencies, in that new department?"

But I think this misses the point that the mission work of that department would be a lot poorer if it had to rely on a group of people who had no allegiance to the mission for its basic and possibly even some of its applied work.

So, the problem is to try to make appropriate mission assignments that will minimize the amount of overlap, encourage cooperation between the groups rather than competition, try to divvy up the basic research work in a way that each group has what it takes to support its mission, but that the work is complementary to the extent that you can make it so. And this is hard. I don't have to go into the reasons why this is hard. You've all watched the evolution of the TFX, haven't you, and other tri-service weapons systems. I think this is normal human behavior.

Then you look at the Congress and you have an even worse problem. Because,

even if we get government agreement on assignments - I didn't mention the Department of Agriculture; they have an important role in the water field. The Committees of the Congress that deal with each of these agencies have not only prestige, but power involved in the strength of their own agencies. The larger the agency, the more the activities, the more the resources, the more actual political leverage the individual committees have. So, there's a continual fight between the committees for responsibility in any field that involves a number of agencies. And there, of course, the Executive can do very little. We can try to define what we want. Sometimes we get support; often we can't.

The individual committee motivations are stronger than their allegiance to the Executive, and may often be. So we then not only have to negotiate to set up a a reasonable inter-agency program for an area within the Executive, but we have to start by taking into account what we think is achievable in the Congress. And this often puts even more severe restrictions on what we can do.

I could talk about this in much greater detail, but I think the problem is probably clear here.

CAPTAIN BRYCE: Dr. Wiesner, our time is up. On behalf of the college, thank you very much for a very fine contribution to our course of study.