

**Design Area Three:**  
**National Security and the National Innovation System**

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Kenneth Flamm  
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**Moderator**  
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COLE: Michael Crow, who has been very, very important in designing these conferences, is going to usher us through the afternoon sessions. The first one deals with national security research and national innovations. So it's a pleasure to turn the mike over to Michael.

CROW: Thank you, Jonathan. There is some method to our madness. For those of you who had the pleasure or non-pleasure of being at the first couple of meetings, we are methodically and slowly working through, as Jonathan mentioned this morning, first the history of how Vannevar Bush and *Science: the Endless Frontier* came about.

The second session that we focused on a few months ago was the impact of that design. And now we're looking towards the future. This afternoon, we will turn to defense and health science policy. And then tomorrow zero in on national laboratories, as well as on the design and structure of how decisions ought to be made in the future, or at least throwing out some suggestions towards that end.

This afternoon, we have a distinguished panel with broad experience here to talk with us about design issues and design parameters associated with science and technology policy issues, as they relate to national security. You'll recall from either your recent reading or historic reading of Bush that Bush guaranteed, or his panel guaranteed – they've used language nearly as exacting as that – that if science could be invested in over the long term from a basic science perspective, that scientists would be able to deliver national security in a military sense, national economic security and well-being in a health sense.

And so we're following that same logic as we work our way through what we hope in this session will be design parameters and design ideas for the future.

Our first speaker is going to be Craig Fields. Craig has a career where he has touched on all of the worlds, the academic world, the government world, and the industrial world, leading not only the Defense Advance Research Projects Agency, but serving as a faculty member at Harvard in his career; as well as leading one of the experiments, if you will, in new industrial organizations, the Micro-Electronics and Computer Technology Corporation for several years. And he remains active in industry, leading a new company in the edutainment technology arena. So, Craig.

FIELDS: Well, it's a pleasure to be here today. I received exactly two pieces of instruction on the presentation. The first was that it be no more than 20 minutes, and I can guarantee that I'll be able to abide by that rule. And then the second was that the topic was national security and

national innovation. And I took that to be one subject, rather than two subjects, for purposes of today's discussion.

I want to make two disclaimers before I get into the substance of the remarks. The first is that these are personal views. I'm Chairman of the Defense Science Board now, but nevertheless, these are personal views. Although I should note that I decided as a matter of good practice to submit these remarks to the department, and they were returned "Cleared" and unchanged.

And then secondly, while the guidance was to be prescriptive, in fact, I found I couldn't do that. So my remarks are going to be descriptive and predictive, but not prescriptive. Perhaps we can get into some prescriptive notions during discussion.

I'd like to start with some background. We all know the background, but I think it would be helpful to go through it, four or five decades of national security support for science and technology. Basically, two reasons. Accelerating the creation of knowledge that was needed for national security, main reason. But then a second reason, namely what I'll term a benign conspiracy among a number of players to, under the umbrella, the aegis, of the Defense Department and the national security community, simply support science technology and education.

Some folks call this the Defense Fig Leaf. You can use whatever notion you want. But it's actually worked very well. With rising budgets and adequate resources, there was not a lot of complaint, and I think a lot of good has been done. You all know, as a partial consequence of these investments, much of the computer technology that's been developed, a lot of mathematics, oceanography, quite a lot of aerodynamics, materials science, the list goes on and on.

Now, what was done, and I want to characterize this for reasons that will become clear towards the end of the remarks, fits into certain buckets. Basic research and advanced technology, not only laboratory research but the creation of very large scale prototypes, building things to see what would work. Sometimes that's the only way. Manufacturing and process technology, and then education of scientists and engineers, as I spoke of earlier.

And then who did it? Who is doing it? Well, certainly universities and companies. But also there's grown up over the last four or five decades what I'll term our national security R&D infrastructure. The bargain in this infrastructure was that the DOD would be loyal to certain organizations, and they would be loyal to the DOD. These being national laboratories, like Los Alamos Defense Laboratories and the so-called FFRDCs, Federally Funded Research and Development Corporations, like RAND and MITRE. So that's the background, again, something we all know.

But the environment's changing. And when I wrote the notes for the presentation today, I ended with the comment that things have certainly changed between 1986 and 1996. It's one of those changes that's so slow, you don't quite notice it until you've just looked back over ten years. And I wanted to describe the changing environment in, again, two sets of remarks. One is what's going up? And then what's coming down?

What's going up? Well, globalization of science and technology, spurred in part by things like the Internet, but spurred by everything. Things spread out, and spread out fast. Globalization of corporations and universities. What company isn't an international company? Universities, you understand the circumstance. Growth and free trade. While we absolutely don't have absolutely free trade, probably never will, the trend is probably in the direction of free trade.

And then, lastly, something that's regrettable for the Defense Department, generally a slow down, an increase in the acquisition cycle getting longer. A lot of efforts today to shorten it. A lot of anecdotes about things getting shorter. It's not so clear that the trend has been reversed. So I'll call that in the up category as well.

What's going down? Well, the national security budget is going down. The national security R&D budget is going down, as folks have to trade off spending money on R&D, spending money on modernization, just buying stuff, and spending money on readiness, training troops, paying salaries, health care, and so on.

The national security influence on the nation's science and technology infrastructure is going down. DOD, other parts of the national security community are not quite small potatoes, but it's definitely shrinking. The international will power for blockades like COCOM. The willpower to just stop somebody from getting something is going down. This is not only a practical matter, but it's also a psychological matter.

And then lastly going down, I think the national willpower, U.S. willpower for subsidizing industrial segments, for boosting something you want to boost, to put it in a slightly more positive sense, is just going down. So, willpower.

Now, with all that said, we have management in the national security community and DOD, CIA, and so on, whom I think are really first rate, about the best I've ever seen. And, they're always asked to operate more like businesses, that's a litany that has some base. And in fact, they are acting more like businesses. They've made a decision that we're going to go for quality, not quantity. We want the best stuff rather than the largest number of things.

They're saying how can we – and now I'm going to put it in industrial terms – have better products than the competition? And in approaching that kind of question, they have to approach questions that businesses approach. What are going to be our strategic differentiators, what are going to be our strategic necessities? By strategic differentiators, I mean something that's real important to you, and you want to be ahead of everyone else. By strategic necessities, I mean something that's real important to you, but you're actually not expecting to be ahead of anyone else, or everyone else.

They're making make-versus-buy decisions that are explicit and I'll say with more an industry-like thinking. Now, what are the consequences of this change in attitude, a more business-like attitude, and changing environments as characterized by the ups and the downs?

Well, sort of a three-part change in the investment strategy, in my perception and view. One is procuring – please note the word – procuring more things that are off the shelf. Dual use

systems, dual use subsystems, commercial off-the-shelf products, and so on. Buying things. The notion of a command and control system as a Microsoft application just isn't as silly today as it was ten years ago. That's the kind of stuff going on.

These things, the things that are bought off-the-shelf are strategic necessities. You expect everyone else to buy them, including adversaries. But what you're trying to do is to ride this wave of global investment so that you get the best stuff because lots of people are paying for it.

Number two, is developing, not procuring, developing more militarily unique technology. And where necessary, the underlying science. So here the development is increasingly focused, not exclusively, but increasingly on the things that can be strategic differentiators – namely, you'll have it and no one else will. Or you'll have it way ahead of other people. It's a business strategy.

And then thirdly, employing more full and open competition, away from special relationships. Again, not 100 percent, but that's the trend. That refers back to the community I spoke of, this special national security R&D infrastructure, which actually is sort of shrinking.

From the point of view of the infrastructure, the comment I hear – and I'm going to try to keep this not sexist – is, "I'm not going to be a kept woman, or a man, if I'm not kept lavishly." And so that community would like a little more freedom, since the budgets are going down. And from the point of view of the government is the discovery that capitalism and the free market are actually a good thing when resources are constrained. So there's a little push and pull on both sides.

Now, what are consequences of this? Well, there are a lot of consequences, but the one that I think is most note worthy for this meeting is a lower fraction and a lower amount of national security resources devoted to science and the development of dual use technology, because of this desire to differentiate in order to have better stuff than the competition.

I'm not saying this is good or bad, that's a separate discussion. Again, descriptive and predictive. But it's at least brings some interesting questions. And I will just note two before I close.

First, will the public's appetite for science increase faster than its appetite for national security, and hence the investment from national security into science decrease? Basically, can NSF go up as DOD's budget goes down? Well, I'm not too sanguine on that point. But that's certainly a question.

Secondly, will private investment in technology increase as fast as public investment in technology because of the shrinking national security community goes down?

Well, there my main worry is not so much the overall levels, because the venture capital community is quite healthy, although corporate R&D you can argue about. But I'm concerned with the particular kind of activity, which I think is very damaged by the change – namely building large-scale prototypes, doing grand, big things. That's just not something that's real easy to do in any single company.

I know back in the 70s I was right in the midst of the arguments of, should we build an Internet or think about it? And, you know without building it, you wouldn't have it. And large projects like this just won't happen unless somebody has the wherewithal and the will to build large things over lots of years. And that, to me, is the thing that's most hurt by this kind of change.

When I ended typing my remarks pretty early this morning, I felt discouraged because I wanted something real positive and prescriptive to say. And, frankly, I was embarrassed that I couldn't think of any great insight on what to do, because actually these trends are not all that positive for science, while probably true.

And the reason, in a nut shell, was that everything I could think of was less than five percent likely to actually happen, because of all the forces against it. And maybe I've just gotten to a point in life where things that are less than five percent likely to happen don't quite bubble up. But, in any case, those were the remarks I wanted to make just to get us going. And perhaps I can turn it back to you now. Thank you. (applause)

CROW: Thank you, Craig. Next we will turn to Ken Flamm. Ken is a Senior Fellow in Foreign Policy Studies at the Brookings Institution. Prior to that he has served in the Defense Department, and has spent most of his career as an analyst looking at issues associated with defense-related policies and some of them as they relate to science.

Right now, he's also working on a study of trade-offs and policy issues that affect the restructuring of the U.S. defense industrial base. And so Ken will be giving us that perspective.

FLAMM: I've spent most of my career looking at high-tech industry. And you could argue that certainly the histories of high-tech industry in this country and the Department of Defense are closely intertwined, in years after World War Two.

On the other hand, the sort of close-up, ant's eye view that I got of the Defense Department over the last couple years was an experience I hadn't had before and certainly taught me a lot of things, some of which are probably transmissible, and others which are not.

I'd like to start out by thanking you for inviting me to this symposium, and to thanking the organizers, and also thanking all of you for giving me 20 minutes of your time. The topic I was given was to look at is "National Security R&D and Its Interaction with the National Innovation System." It's a pretty broad topic.

I think I'd like to do two things. When I stand before you today, I actually have two diseases. I have a cold, which I'm sort of getting over, but since there's no water here I may sort of cough from time to time. The other disease is from when I was in DOD, where it's impossible to go through any kind of meeting or presentation without preparing some transparencies. I see Craig has basically kicked the habit, but I'm still suffering, I'm hooked. So I have a few slides I'd like to show you today.

Before we get to the slides, though, let me sketch out what I'd like to do. All right, first of all, we were explicitly challenged to be prescriptive. That was my understanding of what this meeting

was all about. And, like Craig, I ended up sort of throwing my hands in the air a bit. I think I'm going to try to be a little bit more prescriptive, but you're still going to be radically disappointed in what I have to say in terms of solutions to the problem.

I think you can't really talk about where we are today without understanding a little bit about where we came from. Certainly, the context for national security R&D and the Cold War was, as Craig pointed out, rising DOD budgets, a benign conspiracy to basically fund a broad, large-scale investment in science and technology infrastructure in this country under the guise of national security. Yes, it certainly contributed to national security, but it also had broader designs. I think you can't look at the history of investments in any of the technologies without concluding that.

And basically the role of the government sort of reached its nadir in the early 1960s when government spending actually at one point approached two thirds of total national investment in research and development. Basically, the national innovation system and the national security area in the early 1960s, certainly, had two major purposes. One of those was to deliver the military hardware that would give our forces a qualitative technological advantage in the event of any conflict.

And the second function was this broad view that the DOD basically had this major responsibility for S&T infrastructure, that it had to invest basically in the broader U.S. high-technology industrial base. And in implementing that broader view, in the early post war decades, a broad variety of players were brought into the game. Companies that were primarily commercial companies did a lot of DOD R&D in the 1950s and 1960s. And that's a situation that's changed a bit, and I think an important thing to talk about.

But in the intervening years, there have been some important changes. And the most important change, I think, is that in many of the high-technology areas where DOD was initially the driving force of fueling and funding much in the investment research and development, those commercial industries burst forth from those early seeds. And in flowering and growing and becoming important and growing quickly, ultimately the DOD influence receded and receded and receded until, particularly in the information technology area, DOD is basically a bit player today. Except in certain leading edge niche areas, DOD doesn't drive the thrust of information technology today.

I'd like to put up slide one, and I'm going to bore you with some historical slides, because I think there are some points that are worth making. This is in current dollars, by the way. If you go back to 1960, the amount of spending on national security by the government on research and development was about 50% greater than the total of industry. Essentially, not just DOD but national security was 50% more funds than all of industrial spending on R&D.

The key point today: not only is the shoe reversed, but industry spends about three times what we spend on R&D and national investment. That's a huge shift. And the era in which that shift occurred was the 1960s. And I'm going to argue today that the 1960s – in preparing for this talk, I went back and I actually tried to pull together some numbers, because I think there are some

interesting lessons in the numbers – that the 1960s are really a critical decade for understanding what happened in our policy towards investment in technology.

This is an old slide from a book I did some years ago. But I think there's an important point here. This is an index, in constant real dollars, inflated by price index. There was this huge build-up in research and development by the DOD over the period from the late 1950s through about the mid to late 1960s. And then there was another build-up, of course, in the 1980s with a big trough in between. If you extended this figure off to 1996, it's basically been flat.

But there's an important point here. And the point is that relatively more of this huge bubble in funding that went into DOD research and development in the 1960s went into research, whereas in the 1980s, with the second epic of big build-up and DOD spending in R&D, a lot more of it went into systems stuff, development of systems. And it's not

(CUT IN TAPE)

on the sort of basic and applied research end of the R&D spectrum that occurred in the 1960s. If you think back on all the little stories we know about DOD influence on development of certain parts of the high-tech industry – computers, semiconductors – really a lot of the things that we talked about today were projects that really had their roots in the 1960s, in this period when we had broad-based support. So the '60s were a crucial period. But clearly, over time, there's been a real shift in the relationship between DOD spending and industrial spending in R&D.

The other thing that happened in the 1960s is that the rest of the world caught on to the fact that all this spending in R&D was having concrete economic effects. If you go back – and the data here are really terrible, by the way – in 1960, the U.S. was outspending the four principal competitors in high tech by about four to one. That is, we were spending roughly four times what they were spending in R&D.

Ten years later, in 1970, that number was more like 1.5 to one. The rest of the world caught onto the name of the game and made a determined effort to catch up, at least in terms of spending resources. And if you then switch to 1993, we have to change our base, because I'm going to look at seven countries. And it drops, not a huge amount, but down. The U.S. has receded in terms of its overall share of the pie, but not so much.

But the point I'd like to make is that the 1960s were clearly the era in which we were spending an awful lot on general technological infrastructure out of the DOD larder, so to speak. And it was also the era in which other folks made a determined effort to catch up and really increase their spending in R&D a lot. The research and development enterprise became a lot more globalized during the 1960s. And it was really the key decade for that.

The third kind of change that occurred is the distance between the defense market and the commercial market. And I'm not going to dwell on it at great length. But clearly, if you go back and you trace out the history of our procurement system in the Department of Defense, it's quite interesting. We have a very elaborate, structured procurement system, with very rigid review

sessions and meetings and different decision points. Well, this didn't come into existence until the early 1960s.

And over time, it's become even more rigid. Basically, these barnacles have been building up on the procurement system since about the early 1960s. At the same time, the set of suppliers who are willing to work with this encrusted procurement system has shrunk because, while commercial markets have been growing and the DOD's relative share has been sinking, the difficulties of working with the DOD have multiplied. The folks who do business with the DOD have shrunk relative to the rest of the economy.

Which brings us to the present day. And we have to ask ourselves, if we just look back at the '50s and '60s from the standpoint of the 1990s, what is it that's really changed? What is it that we have to cope with?

Well, the problem with going after Craig is that I have to parrot some of the observations Craig made. But clearly, they're correct. The Cold War is over. The Department of Defense budget is going down. The military customer is much less important to many high-technology industries, and in particular for information technology. And it's also clear that the military customers, as they did in the 1970s in the face of diminishing budgets, are not going to fund broader general infrastructure kind of stuff. The military departments are simply uninterested. Their priority is modernizing their equipment, pure and simple. And they're not going to be interested in these broader issues of worrying about the technology base. That's somebody else's problem. That's not a problem they're interested in solving. And this same phenomenon of course happened in the 1970s.

So, if we ask ourselves what is it exactly that the system of national security research and development has to do today, and what are the problems it's going to face, it seems to me it boils down to four problems that have to be solved.

The first of these problems is what I would call defense-unique technology development. That is, there are a certain set of technologies and products that are unique to the Department of Defense. There simply isn't going to be a big commercial trade for tanks or armor. There's not going to be a big market for Stealth, there simply isn't a commercial demand for that.

The main policy issue wrapped up in developing defense-unique technologies is the linkage to commercial industry. On the one hand, if you try to use commercial suppliers in an era of globalized industry, any kind of effervescent strategic differentiating advantage, as Craig described it, you want to build has got a chance to defuse out.

So, if you want to build yourself a qualitative military advantage that is yours and yours alone to keep, you're going to try to build walls around the suppliers who are providing that capability to you. And if you build walls around that supplier providing that capability to you, you're also building walls between them and commercial industry and the way commercial industry functions.

So, in defense, technology development is what DOD is naturally going to focus on. At the same time, it's going to accentuate the distance between it and the commercial industrial sector. And it's also going to hinder development of linkages with commercial industry. There's just no way around it.

The second major responsibility of the national security innovation system today – given that the Department of Defense is going to be increasingly reliant, as everyone accepts, on commercial suppliers for broad segments of equipment and services, simply because they're done so much more cheaply – is to try to push the technology a little bit further. It may be so important to the performance of your systems that you want access to the latest and greatest a little sooner, or a little faster than the commercial industry is otherwise going to deliver it to you. Or you may be worried about your guys being able to deliver the same quality of technology that someone else has access to.

And in those dual use areas, you're going to want to make investments to make sure that you have access to the latest and greatest, where it's critical to your military systems. The problem here, of course, is selecting what those areas are, in an analytically sound fashion; and deciding how many resources to allocate to those areas.

The third kind of task that the national security R&D establishment faces is occasionally investing in what I would call the management of industrial vulnerabilities. Now, in the old days, you'd have to worry about ball-bearing factories being sabotaged or blowing up, and therefore not being able to deliver your gears to your airplanes and tanks. That's not so much a problem anymore, but there are other new kinds of industrial vulnerabilities.

For example, the kinds of problems people worry about today are somebody from outside coming in with a new information technology and taking down the national power grid, for example. Or taking down the telecommunications system. And there may be, even today in the radically changed world that we live in, certain kinds of scenarios and vulnerabilities of the industrial base that DOD's going to want to make some investment in remedying or doing something about in the name of national security. Again, it's a question of selecting those areas and allocating resources, which are the problems that DOD faces.

In the fourth area, which has historically been something DOD was not shy about stepping up to the plate and doing, is essentially sharing in the costs of maintenance of the sort of broad science and technology infrastructure that we've heard talked about several times today.

And it's the human resource part, training people, maintaining basic research in universities. Historically, DOD did its share, particular in the fat days of the 1960s when it was putting money into research, as it since hasn't.

But there's a real free-rider problem here. DOD increasingly, in an era of scarce resources, is cutting those sorts of generic, general kinds of investments in the infrastructure, figuring that, you know, let somebody else worry about it. Let the other parts of the government, let the private sector worry about it. And unfortunately, I don't think that's going to change either. DOD has

limited resources. It's going to focus on what it needs, specific to DOD, and it's not going to worry about the other stuff.

It's going to assume that industry is able to supply it the latest and greatest without worrying explicitly about how industry is going to be able to do that in ten or 15 years. That's just the direction it's going in now. And perhaps Craig disagrees, but I saw that.

So, given these four basic tasks, and given that at best you're going to do task one fully, I come to the same point Craig came to, which was throwing up my arms in despair here. I'm going to go a little bit further. I'm going to pull 'em back down a little bit.

First, in a narrow way, what kinds of things can remedy some of the problems I've just described to you? DOD simply isn't going to be funding these things if we continue on the current track..

On funding defense-unique technology development and dual use technology, everyone realizes that we have to do some fundamental changes in the way DOD budgets. The budget process in Washington DC is a formidable obstacle to doing things efficiently. And in my view, even those people within the DSB (Defense Science Board) infrastructure for example, who are thinking carefully about this subject, realize that ultimately you have to budget on the basis not of individual programs but on functional capabilities. And you've got to have programs competing against one another, competing against multiple vendors, to be able to do things efficiently. And that process just doesn't exist right now. Certainly it's not the root of all evil, but the root of much of the evil is the fact that the Congress of the United States allocates programs on a line-by-line, program-by-program basis.

I can assure you that if there's one single intractable problem that has bedeviled every part of DOD that I've seen, it has been this ability of contractors, suppliers, special interests to work through the Congress and, in a very micromanaged way, to decide what gets built and what gets procured. The right way to do it, clearly, is to have a functional kind of budgeting process, which the Congress approves in broad strokes. And then the customer – i.e., the military – has the right to bring in the forces of competition between programs, between contractors.

Now, do I see any way this is going to happen politically? I'm afraid the answer is no. The vested interests involved and the procurement systems are so strong politically that, even though I can stand here with a straight face and tell you that this in my view is the single toughest problem, I see no solution. I just don't. And that is one of the reasons, despite all the rhetoric about acquisition reform that you hear, it's going to be damn hard to see all the concrete results that we wish to see coming out of the process.

Anyway, this is the problem with the first two items on my four-item task list there. What about items three and four? That is, working on the industrial vulnerability issue, working on the S&T infrastructure issue, in which DOD is one of the beneficiaries, along with industry and other parts of the government – as well as that second problem, that is, promoting dual use technology development in areas where it's going to be important to DOD.

It seems to me that there are more feasible solutions that are available potentially. Those solutions revolve around the players who are the beneficiaries of those investments – i.e., both industry and other parts of the government – coming together in some new kind of coordination mechanism that actually shares the responsibility, the budgetary resource responsibility, among all the beneficiaries of those programs.

And I think some of the experiments we've seen in joint government/industry programs say that it's not impossible to work out coordinating mechanisms to insulate it from the down side, which is political influence.

A few years back, I served on a National Research Council panel that recommended something like a civilian technology corporation that these government agencies could have their programs administered through – some impartial body that wasn't going to be immediately responsive to Congressional political pressure. Is that feasible politically? I don't know. It's an idea, and it might work, but clearly we need to do something.

I think we need to talk about some kind of analytical process and external review for some of these decisions in areas two, three, or four. That is, what is essential to the Department of Defense? What is a vulnerability the DOD should worry about? How much should DOD pay towards the maintenance of certain types of infrastructure? How important are those infrastructure investments?

In DOD, there really wasn't any analytical or externally reviewed process. And these decisions were, even though not explicitly political, nonetheless intensely political. And I think getting some dispassion into that budgetary process again is important. How to do it? It's a tough question. I'm not sure I see the solution. More broadly, it seems to me, there are two fundamental public policy issues that we're talking around the edges of today, which we really haven't resolved.

First of all, it seems to me that the non-national security rationale for public support of science and technology investment clearly has not been articulated in a way that's going to allow DOD to pass off this responsibility to another organization. Unfortunately, unlike the Yale motto, which I saw on your shield there today, the light hasn't quite shed on me yet, as to how we're going to do that.

The second problem, which I just want to bring to your attention, is that in some sense there's an internal conflict in the way we look at our interaction with the global system, within DOD. That is, on the one hand, a certain amount of not just DOD but the entire government sees research and development as a global public good, and they're pushing for sharing the resources for investing in this public good. At the same time, institutions like DOD, even if it is an international public good, are trying to build walls around it, and make it a national asset so we have our strategic differentiating technology advantage. So I think the tension between a global public good and DOD's efforts to seek strategic national advantage are an inherent tension that we still don't have an obvious solution for.

And having left you with a list of problems, I will depart. (applause)

CROW: In this room, we'll pretend we're in New Haven. And in the other room, we'll pretend we're in New York. (laughter) Thank you, Ken. I think it's worth noting, following Ken's remarks, that he served for two years as President Clinton's principal deputy assistant secretary of defense for economic security, which is probably the first time that position ever existed.

We have two discussants today. Our first is Sid Winter, who is a professor of management at the Wharton School of the University of Pennsylvania. Prior to joining the Wharton school, he served for several years as the chief economist of the General Accounting Office of the United States. And prior to that, he served in a number of economist roles at the RAND Corporation, the Council of Economic advisors, and others. So, Sid.

WINTER: Thank you. I'm going to take as the premise of my remarks a common message that came from Craig Fields and Ken Flamm and was also implicit in much of what was presented this morning. And that is the assumption that the era of benign conspiracy, the defense fig leaf, is over, or at least drawing to a close. And that poses a question about the future federal role in supporting, in particular, basic science and perhaps, as Craig has emphasized, some parts of technology.

I would go a little further than others in talking about the change in the environment. I think it is not just the fact that the Cold War is over, the defense budget is coming down, and the R&D budget in particular is coming down. I think that the general environment of budgetary stringency, plus some other visible trends in the system, is creating a situation where accountability and compelling rationales for federal expenditure are becoming a more and more prominent consideration. So if indeed the future is going to take the form in which there continues to be substantial federal support for basic science, then it seems to me that would imply the need for the construction of some alternative rationale and mechanisms of accountability.

So I do not believe that the past mission-oriented organization of federal participation in basic science is really viable in the present context. I think there are too many areas where people properly ask questions about what the taxpayer is getting for his or her money.

Now, Ralph Gomory put forward a very interesting suggestion, which we translate as saying, we want to win at least a bronze medal in every scientific event. But I think an interesting, important question to raise about that proposal is whether that is a politically viable line of argument. "Gee, let's support this federal participation in this area." I'm going to address, as a prominent candidate much mentioned, the idea that the alternative rationale is the contribution of science to the economy. And if that is the rationale, then we face a problem never faced in those same terms before. The mission-level goal definitions will not suffice. We would need some kind of a coherent economic case about the benefits of basic science. I recognize this is not the only alternative to this rationale, but it is a prominent one.

This idea of trying to do an analysis of the impact of science on the economy is a very difficult problem indeed. One necessarily has a great deal of skepticism about the possibility of anything that might be convincingly labeled as an objective answer to such a question. As a mental

experiment, you can ask yourself about DOD basic science spending or about all federal basic science spending. And you ask how compelling a case could you make that what we're doing is the right number, compared to a number that's five times higher, or alternately, to a number that's five times lower. And I would say that, while there are a few areas where you can make that kind of case, overall we have very little guidance on what the answer would be.

Now, the fact that it's hard to get an objective answer doesn't mean that there won't be an answer. There are devices – legislatures, courts, juries, churches, various institutions in this society – that are well specialized in answering questions in practice where in principle it's very hard to lay out exactly what the answer should be.

So another thing that we should have in mind as we're thinking about this problem is the very important role of considerations of legitimacy, of the defensibility of processes, as opposed to the defensibility of outcomes. And the importance of the accountability issue that I had mentioned. Somebody saying "Your money was well spent," able to show money was spent on a particular undertaking. So, against that background, let me move with a little bit of boldness here towards the challenge of prescriptive analysis. And you don't have to worry that I'm going to provide the answer. But I'm going to put forward some alternative perspectives on how one could think about this issue, supplementing comments that have already been made.

These are four different ways of thinking about the issue of what is going to replace the benign conspiracy as a source of support for basic science. The first one, as I've already alluded to, would take on the economic question. One possible course of action would be to seriously address the issue of the economic justification and try to then base the defense on that.

Following Ed Steinmuller, what is needed is a proper cost-benefit analysis. And if you think about it, you realize that, although really compelling answers would be very hard to come by, there presumably are ways to apply some human intelligence to this issue, derive some conclusions from the experience of the past, and pick out things where there's a case and where there isn't. And one could only imagine taking it seriously if you have not merely the capability of doing an intellectually respectable job on the problem but that you also create institutions that have this required legitimacy – which would permit them to make judgment calls on allocation and not be shot down immediately in the political process.

The major obstacle here is, as I have suggested, the fact that we simply do not have great stores of existing expertise for addressing an issue of that scope. Certainly very little that has been done in the area of, say, evaluating rates of return on science would prepare you for the exercise that is involved there. What would be required is a time-consuming effort to build new capabilities and imbed them in new institutions.

Just as an aside here, although the prescriptive challenge is severe, the 50-year horizon ought to give us some freedom to think about directions and possible change. Fifty years is a long time. It's not nearly as long a time as it seemed 50 years ago, but it still is quite a long time.

The second general perspective I would offer on the prescriptive issue is, we could try to muddle through on something that is very close to the present path. And that would mean we made

incremental shifts in spending towards research that had a reasonably arguable economic rationale, and funding shifts away from projects where the economic rationale was notably absent.

In favor of that alternative, it's relatively easy to implement. In fact, it would be difficult to avoid implementing it. That is the way the system would tend to go by itself. And it has the additional advantage that it is a mechanism that supports some kinds of diversity in the national science effort, in spite of its irregularities and flaws. And that is a desirable thing. But against it, one what would have to say, there are very important biases in the existing system.

The most central of these biases is the bias that favors what is against what could be. The political process responds to interests that have been developed, not to interests that could possibly be developed. And in many cases, that's going to be a significant portion of the picture. I think it has a bias of large versus small. It's easier to get a political constituency for a Star Wars or for a Superconducting Supercollider than it is for a lot of paper and pencil, theoretical research. And that is a part of the political environment.

I think you will see that if we continue on this path, and economics is emphasized more, that recent achievements will get excessive weight. That something will happen, will come out of a particular program, be of some economic interest, that will get some coverage. The Congress will respond and it will go off in that direction, rather than looking at longer term track records and longer term prospects. So I think those are significant shortcomings, and a common theme throughout them is the point that jobs matter an awful lot in the political context.

And I want to read from the introduction of Vannevar Bush's book: "What we often forget are the millions of pay envelopes on a peacetime Saturday night, which are filled because new products and new industries have provided jobs for countless Americans. Science made that possible, too." Now you notice that it wasn't the relief of household drudgery. Or the improvement in entertainment possibilities. It was the interest of the producers, the jobs that were created, as a result of the science and innovation. Now you might think that was just a reflection of the Great Depression. But on Capitol Hill, that is still a very dominant mode of economic thinking.

A third perspective is to think of the grassroots-politics approach to the problem of basic science in the country. And that would mean a long-term effort to try to mold the public towards a better understanding of science and its meaning. Not just as a source of economic benefit, but also its meaning as a source of meaning. Of interpretation of your place in the universe.

That is a course of action that could be pursued and probably to positive effect. I think very little has actually been done. I doubt that we know very much about what the public really thinks about science, or what you would find if you went past a superficial quick questionnaire about attitudes. And there would be some possibility at least of understanding how one could start to shape a program of that kind. Maybe in an off year, it would be a good idea to hire some political consultants, who in my opinion probably take the prize as the most commercially successful example of applied social science. It's a significant industry, it's hidden from view, but they are

very effective and very sophisticated. And we could probably learn something by getting them to ask the public what they thought was worth supporting in science.

Those are issues under the heading of how you could build a new framework of some kind that would provide a basis for a continuing federal role in funding. As a fourth perspective, I want to raise the question of the role of private philanthropy in areas where the economic argument is weak, where by anybody's account, curiosity is the primary driver.

I am not optimistic about the prospects of convincing the average voter that he cares about whether the universe is closed or not. There is a role for that kind of research – I'm not sure that public funding is appropriate there – and we do have private philanthropy as an alternative. We could do many things to strengthen that alternative, changes in tax treatments, changes in the rules, and so forth.

Those are my four proposed perspectives. You can think–

(BREAK IN TAPE)

Just by mixing and matching to some degree, they're not mutually exclusive.

But as we sit here and contemplate this 50-year horizon, we should remember that our attention is going to be jerked around in the future by a bunch of considerations extraneous to science. In particular, when the country gets around to confronting its entitlement crisis, the social security and Medicare crises, then the budgetary situation will be different. We don't know when we will have this awakening. We can imagine major events in international relations, wars, major terrorist actions. We can imagine major advances in science, directly affecting these issues.

So it certainly would be bold to try to predict where we're actually going and bold to try to prescribe for it. But I think there is nevertheless a compelling argument that we need some new arrangements, and some new institutions, some new arguments, to support the funding of basic science. Thank you. (applause)

CROW: Our last panelist before questions is going to be John Pike. John is the director of the space policy project at the Federation of American Scientists, where he coordinates research on military and civilian space policy and also national security issues. Then we're going to move to questions immediately after that.

PIKE: I'm normally the fellow who gets dragged out to tell why Star Wars is a bad idea and international space cooperation is a good idea. Having been doing that relentlessly for the last dozen years, I figure you already are familiar with those issues, and so consider that I've already delivered my rants on those subjects.

And since I'm a discussant rather than a panelist, I feel some obligation to respond to the presentations that we've had here this afternoon. I was really struck by the fundamental point that particularly Craig and Ken were raising about the relationship between national security,

Defense Department spending on technology, and the question of preserving unique American advantages.

In Craig's prepared remarks, he noted the question of placing priority on the use of defense funds for the development of required military-unique technology, which otherwise would not be developed at all – the question of undercutting the notion of gaining differentiated U.S. military advantage from basic science and fundamentally dual use technology.

And then Ken was raising the issue of how DOD can be confident that its commercial supplier base will always provide it with early, assured, and affordable access to the very best technology, globally, in areas critical to military advantage. Now, in the few minutes that I'm going to keep you from getting something to drink, I'm not going to be able to address the full range of these technologies and institutional considerations. But I would like to briefly conjure with them in two areas of particular interest to me and, I believe, particular importance to the United States: what I would term for simplicity outer space and cyber space, the question of our national security space program and the question of our intelligence program, including most particularly information systems. Collectively, these account for approximately \$50 billion a year, about one-fifth of the entire defense budget. When you go to the high-technology center and ignore all of the soldiers with dirty boots and everything, they probably account for nearly half of military spending.

If we look back over, for instance, Operation Desert Storm and ask what were the things that differentiated Coalition forces from our unfortunate Iraqi adversaries, it would have to be the unique advantages that the United States was displaying in outer space and cyber space. Having said this, I think that it's important to caveat this discussion by recognizing that a lot of the high-tech advantages that the United States enjoyed in confronting a high-tech adversary during the Cold War may be of declining relevance in confronting low-tech adversaries or low-tech situations in a post-Cold War environment.

The Soviet Union was after all a worthy adversary and basically attempted to have one of everything. But when we insert our troops into a situation like Somalia, where we have an adversary that's using drums and whistles to communicate, the fact that we have millions of dollars of signal intelligence satellites in the sky probably isn't going to provide us quite the advantage that it did with respect to the Soviet adversary.

I'd also caveat these observations by suggesting that in contrast to the confrontation during the Cold War, where it was possible, or at least arguable, to equate national security with military forces, it's clear that in a post-Cold War environment, national security must have a much broader definition than merely that which the Pentagon does when it gets into the office every morning. Obviously, environmental considerations, economic considerations, and so forth impinge on national security in a way that extends beyond simply what the Defense Department does. I would suggest that how we are succeeding and not succeeding in adjusting to the opportunities afforded by commercial technologies in a post-Cold War environment, in outer space and cyber space, says a lot about what can be done. And a lot about what should be done.

For the sake of argument, I would submit that we have a singular set of success stories in the national security space program, in leveraging commercially available technology. In fact, this is probably one of the great underreported success stories of the Clinton administration's acquisition reform initiatives, in terms of attempting to leverage commercially available technology for national security applications.

I would suggest that what we have been doing, or rather what we have not been doing, on the cyber space front in the area of intelligence reform is probably the most glaring set of examples of failures to adjust to the new national security realities and the opportunities for leveraging commercial technology. When I go down the list of what is going on in our military outer space programs today, I think that this is probably the place where we have seen the largest convergence between military and commercial space systems, the greatest emphasis on leveraging the synergy between national security and civil technologies – the availability of the global positioning system and the convergence of the military and civil weather satellite programs. The emerging availability of high-resolution, commercially available reconnaissance satellite imagery, that's going to be of interest to folks like me, to the Defense Department, to terrorists in North Korea, and all kinds of other people.

Certainly, the most singularly underreported success story in the convergence of military and civil space technology is the Air Force's Evolved Expendable Launch Vehicle (EELV) program, which is basically encouraging the development of an expendable launch vehicle that's going to be useful to the military, civil government, and commercial interests in the United States. That's going to result, I believe, in a significant reduction in American launch costs and a significant improvement in the competitive position of the American launch vehicle industry, with respect to those of other countries.

There are still some problems in the national security space arena. We continue to be far too focused on technology push and not nearly focused enough on demand pull. We're still focused on coming up with new pieces of hardware and not nearly focused enough on satisfying user requirements. And unfortunately, some of the organizational innovations that we've seen recently, I think, have moved us in the wrong direction. Instead of focusing on satisfying the identifiable demands of existing users, I think that we've gone in the other direction, focusing on a technology push.

But whatever shortcomings we continue to have in the national security space arena, I think, unfortunately, are utterly dwarfed by the problems that we've had on the front of reforming our intelligence community in the post-Cold War world. And if anyone doubts that the American intelligence community is broken and in need of some serious repair, I urge you to take the time to read the Intelligence Community 21<sup>st</sup> Century Staff Study, prepared by the House Permanent Select Committee on Intelligence, which is available on the Internet, since they've sold out of all of the hard copies. It makes extremely sobering and provocative reading. If you're only going to read one thing this year on the intelligence community, that should be it. I think that it makes a devastating case about the difficulties the intelligence community has had in adapting to the new information environment.

And if anyone doubts that improvement is needed, just go and look at the way the Central Intelligence Agency's website was hacked by people from Sweden a couple of days ago. Or the Department of Justice website, hacked a couple of weeks ago.

Where to begin cataloging all of the problems? Well, the National Security Agency would certainly be a very good place to begin. The staff study makes a very compelling case that the sort of signals intelligence activities that the NSA has traditionally done during the Cold War are fundamentally broken and cannot be fixed.

Unfortunately, we continue to have a cryptography policy that is predicated on the proposition of making the world safe for the National Security Agency, while leaving the rest of America vulnerable to other people who would be interested in conducting attacks against our information infrastructure. There's no clearer case where we're going to have to choose between national security in terms of what the national security apparatus does when it comes into the office every morning and national security considered in terms of the national well-being of our society as a whole.

Given that the National Security Agency worries about this full time and other people worry about it part time, we continue to have policies that are far too focused on making the world safe for our national security apparatus rather than making the world a safer place for America generally.

I know that you're all getting thirsty, and you're all looking forward to putting your own two cents' worth in. I would conclude by saying that I think we have fundamental advantages in terms of leveraging commercial technology, if for no other reason than the United States is big, and all of these other countries are small. The American intelligence community budget today is larger than the Italian defense budget. The reason that the evolved expendable launch vehicle program is going to put the European Ariane launch vehicle program into such a world of hurt is because the overall space program is about five times bigger than the European space program, providing a captive market for our commercial products that simply cannot be matched anywhere else.

So I think the challenge, rather than focusing on attempting to preserve defense-unique technologies, is attempting to advance our national well-being as a whole and use that to leverage the advantages that we can secure in national security. Thank you. (applause)

CROW: Thank you, John. We have time for a few questions at the microphone. If you just go to the microphone, identify yourself, ask the question generally, and one or more of the panelists can come up and grab one of these microphones, or come back up to this one, and give an answer.

GOMORY: I'd like to make a comment. There's been a very well developed and, I think, excellent theme. Both Craig and Ken pointed to the decay or absence of the fig leaf, which has been so important for this country. And then Sid went along to suggest a number of replacement leaves, of which I think the most plausible is the economic one.

But I want to raise one point in connection with the economic one, which may sound perhaps esoteric or too detailed, but I think it's actually right. And that is, do you think that economic justification comes in lumps or in microscopic increments? Let me explain what that means. Sid said we'd need a big analysis, perhaps to show some sort of return on investment. And I think that would be necessary were it true that the contributions to the economy are the sum of a number of microscopic improvements. But I think one can argue that this is the kind of event in which a few big ones make all the difference.

For example, the creation of the semiconductor and the new biotechnology industries. A great deal of the value spent on science is reaped from a few visible events, not through extensive, microscopic examination. The creation of jobs – and I completely agree with Sid's emphasis on that – in these industries is probably not only one of their great contributions, but it is one that can be communicated whereas a detailed analysis would not be.

So I do think there is a case to be made along the lines that Sid has recommended. I think it can, however, be made relatively easily and not by a sense of analysis. I might add that my own proposals are tuned to that model, and that's why I think it's important, as he put it, to be in line for all the bronze medals. And to get an occasional big winner, called the gold medal. Thank you.

CROW: Yes, panelists, and by the way, for those of you not familiar with the back of Ralph's head, that's Ralph Gomory of the Sloan Foundation. Sid, or anyone? Craig, Ken?

MALE VOICE: I want to turn the question around, back to you again. And that is, it seems to me that there is a demonstrated track record on what happens when you try justifying government technology programs in terms of economic benefits. The comeback is that there is an ideological attack: how can the government make judgments about the economic benefits and programs? You're picking winners and losers.

The point you're making, by the way, I would interpret a little bit differently, that there are a few very huge winners and lots of losers. But that gets at the nature of research. Research is finding out about stuff that doesn't work, too – that has positive social value, even if it doesn't work.

The question I want to throw back to you is, the minute you start going out there and saying, we're going to make some bets – which is what you're fundamentally saying – that we're going to put resources in areas where we think there's a positive economic payoff, unless I misinterpret you, you're going to invite that attack.

GOMORY: I don't want to monopolize this microphone. Whatever anyone says, I promise not to return. But your remarks were so interesting, that I would like to respond.

I think it's exactly that element of the unpredictable that I am trying to talk about, and talked about this morning, which is, yes, it's hard to pick winners and losers. And that has been very effectively characterized as a futile activity, though it may not be. But anyway, it's dead from a political point of view.

But you see, those sorts of programs that you described, which I think are also not viable, are really a selection of small things. And I think a much better defense, and a much more realistic one, is to say fund basic research and related things across the board, because the historical record shows us that unpredictably there are some very big winners.

EISENBERGER: Peter Eisenberger, formally of Princeton, presently of Columbia. I'm always amazed in these discussions that we struggle with the issue of industrial policy, the role of the government, and economic development, and we don't go directly to what everybody I think would agree is the responsibility of government – that is, to provide for the well-being of their citizens. And it seems to me that we have a lot of problems, whether it is infrastructure, environment, or education. And it seems to me that would provide a very natural focus for many research efforts.

Now, we don't have to be organized that way. And I suggest what we're trying to do is take the existing structure that developed in the old system, and twist it to try to find missions that are acceptable rather than ask ourselves, well, if we look in the future, what do we really need? And clearly we need to address the social, infrastructure, educational concerns of society. And the environmental concerns of society. So I guess I'd be interested why we're not talking about that. And why that's just a natural obvious solution. Who could argue with that politically? That doesn't violate anybody's religious tenants about the proper role of government. It is the role of government. And again, is this because the people are not at the table? I'd be interested in people's comments, as to why that's just not automatically occurring.

WINTER: I think that's a very good question. It was remarked this morning, however, that social science among all sciences is particularly vulnerable in the current environment. Because of ideological issues, addressing social problems by means of science is not considered legitimate by many parts of our population. Were that not the case, I think the question raised would be extremely compelling. And it would be obvious that we should turn in that sort of direction. But at least under current political conditions, it's far from an easy thing to do.

LUBELL: I'm Michael Lubell, professor of physics at C.C.N.Y. and director of public affairs for the American Physical Society. The question for Craig Fields: the labs in the Department of Energy, in the Galvin report, were criticized for competing with each other and not cooperating as much. This was also said about the defense laboratories. Obviously, some political decisions have been made to keep the defense laboratories more or less intact. But still, I have a suspicion that it was not the competitiveness issue that drove it. And I'd your reaction to that.

MALE VOICE: I think I've said, or at least meant to say, that I think the department's leadership is acknowledging more and more value of competition. You know, vis-a-vis competition versus cooperation, Karl Marx thought he had a pretty good idea – it sounded good, but didn't work so well. And in the trade-off between what I'll call competition with duplication and cooperation without duplication, one is more aligned with human behavior than the other. So I think that there's really an inexorable push in this government, irrespective of the outcome of the election, towards more competition. And that also applies to the national labs. I don't view the national labs as more likely to cooperate with each other, since in fact they're organizations of human beings, with normal human motivations.

And furthermore, I think there's likely to be an increase in the desires on the part of the administration to have processes and procedures that choose the best way of getting work done, quite irrespective of the categorization of the actor that might do the work. When I was at ARPA, we sent quite a lot of money to Los Alamos and Sandia and a number of other national labs. And in every single case that I was aware of, it was because they were the best to do the job. And we informally saw to it that the right kind of competition took place. So I think that is the direction that's going to work. And while there are statements you can make for and against competition, I think history has proven which one actually works.

CROW: Before we break for something to drink, I'd like to encourage you all to be understanding with us in the sense that we realize that the way we have set this conference up is an endurance test for the participants. We're trying to be true to Vannevar Bush's design. That is, we're trying to take it apart and look to the future, piece by piece. And so we have packed all of this into two days to accomplish that. So why don't you get something to drink, and come back in about ten minutes. And let's thank our panel. (applause)