Design Area Seven:
Civilian Technology Policy

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Herbert Fusfeld
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Moderator
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CROW: At one time as we planned this meeting, there were going to be 40 design areas, but we didn't think that you could quite get through that, so there's actually only eight. We're on number seven, and you can deduce from that that we're coming into the home stretch here.

What we have been doing, as I mentioned yesterday, is systematically approaching each of Bush's points. Now we come to the first area where Bush was relatively silent if not totally silent, which is the area of civilian technology policy and the role of the government in specific ventures related to the development of technology itself.

We've got a distinguished panel. I'll just briefly give you an overview and then introduce each of them individually. Dick Nelson, who's here at Columbia, has been thinking about the role of the government in research since the 1950s. In a sense, he's the father, I think, or the parent of R&D economics.

Herb Fusfeld, who has been in industry, served as an R&D vice president, served as the president of the Industrial Research Institute and now, for quite a while, has been in academia.

Irv Feller, who's been attacking – I use that word, Irv – the value of technology-oriented policies for some time at both the state and federal levels in the most systematic fashion of anyone who's out there, I think.

And Pat Windham, who's up from Washington, and who's on the subcommittee on science, technology, and space of the Senate Commerce, Science and Transportation Committee, has been the principal author, architect, and champion, on the Democratic side of things, of the technology policy of the United States, and particularly over the last several years.

First Dick Nelson, who's one of our co-conveners of this meeting. He holds professorships here at Columbia, it's worth noting, in business, law, political science, international affairs, I don't know, aeronautical engineering, what else? (chuckle)

NELSON: I'm a member of the medical school.

CROW: Medical school. So, first, Dick Nelson.

NELSON: I intend to treat this topic of civilian technology policy relatively narrowly. By that, I mean I am not taking up the broader set of questions and issues that were raised yesterday and

this morning, regarding whether a new, broad rationale that is persuasive for government support of basic science can't be tied to economic benefits or economic growth rationale.

Rather, I'm going to focus specifically on government programs that are targeted at various areas of civilian technology, particularly programs aimed to help the technology in particular industries. As the write-up of this particular session signals, and as our discussion has gone on over the last couple of days, there really are two rather peculiar aspects of the Bush report that bear on the topic under consideration here in this session.

One of them is what Michael just mentioned, others have mentioned before, and that is the rather peculiar focus of the Bush report on government policies specifically aimed to advance the technology or the science underlying the technology of particular industries or sectors. This is peculiar, because, as several have noted, if you look at the structure of federal research and development spending prior to World War II, the largest program is not defense. It's agriculture. And even in those days, the program funded by the feds was matched by funds coming from the states.

The other aspect of the Bush report that we've commented on, on a number of different occasions, which I think is highly relevant to this particular discussion was the articulation of the linear model. That technology in a sense comes from drawing from science. You have the pool analogy, where science provides the opportunities for advancing technology.

However, there is no serious way identified in the report to know what are the areas of science that are going to be contributing or have a high probability of contributing to the possibilities of technical advance in different fields. And, as I think several have commented earlier, a very plausible reason for taking that position by Bush is that if you articulated that and you got the political structure to buy it, you would damp down tendencies on the part of the political structure to try to engage in relatively fine-scale allocation of scientific resources, in a sense, targeting research.

But, of course, as we have also discussed, much of the lion's share of the programs that materialized for basic research support in the years after the Bush report were most emphatically targeted. The big funders of basic research haven't been the National Science Foundation. That's been a relatively small part of the story.

Rather organizations like the National Institutes of Health, which as the discussion went yesterday and today, clearly have targeted a variety of different broad areas of science, in anticipation that these are the ones that are going to yield the payoffs in particular areas where the rhetoric has gone back and forth. And, of course, the Department of Defense, playing active roles in developing whole new fields of targeted science, like materials science, computer science. The Atomic Energy Commission, the successor Department of Energy.

Yet, as Donald Stokes has argued, I think, very, very well in his wonderful manuscript called Pasteur's quadrant, for a long, long time, forever, that much of fundamental scientific research has been done in areas where the areas of application are successful or moderately clear and the people doing the research knew about it. That's Pasteur's quadrant, as Stokes called it. In fact,

the result of the Bush report was that so far as broad citizenry was concerned, he didn't think about it that way.

Now, both of these particular aspects of the Bush report increasingly have come back to haunt us, I believe, and their conjunction now haunts us. Beginning in the middle 1960s, you can see a string of proposals for the federal government to mount research and development support programs, specifically aimed to help particular industries, from housing in those old days to flat panel displays in a more recent era.

That particular thrust has waxed and waned and was certainly strong in the early days of the Clinton administration and has been damped down recently, but it will certainly come back again. Particularly if you have a strong Democratic results in the next election. This argument of focusing federal programs to help certain civilian technologies is going to be with us.

At the same time, I'm going to propose that probably the most fruitful kind of such federally supported programs is a targeted science support kind of a program, like funding materials science and computer science if you're trying to help the technologies and the industries that draw significantly from those technologies. Yet, in a sense, because of the Bush report no-no on that type of thinking, that's not the way that the policy discussion regarding civilian technology policy has proceeded.

To begin to put my own particular views of this on line, I have been bothered for some time by the fact that most of the discussion about civilian technology policy has proceeded as if the most fruitful way to conduct such a policy is to identify particular product fields or products that really ought to be developed and to provide funding that goes into industry in particular, to achieve those kinds of objectives. It is this kind of policy that, I think, correctly has generated so much of the argument about governmental ability to pick particular product areas or particular commercial opportunities and support that – where the record, both in the United States and in other countries, is very, very poor, indeed.

But as I've looked at a number of such policies, it seems to me that there is a variety of other kinds of difficulties with programs conceived and designed in that particular way. In particular, they are politically very, very fractious, indeed. Government programs that proceed by funding certain firms and not funding other certain firms get to be really very dicey, politically, down the road a little bit, particularly if the firms that are provided with government funds do well.

Therefore, it seems to me that an effective government civilian technology policy, or a policy in a particular area, rather has to be conceived and designed along quite, quite different lines. First of all, the funding in the program should not go to individual business firms or to small coalitions of business firms but rather to research institutions that serve the industry as a whole or large portions of the industry. I'll come in a moment to my proposition that in many cases the most plausible way of setting up such a program looks to me like associating such facilities with universities, but that's not necessarily so.

Think, for example, of Sematech, which meets the criteria of being an institution separate from individual business firms and serving the industry as a whole, at least those firms that are willing

to contribute to and interact with it. But, most emphatically, it is not a university-affiliated enterprise.

The second ground rule I would propose is that the program not aim close to the market at all, but rather stay a considerable distance away from the market, and focus on funding those kinds of research, those fields of science and engineering, and those areas that in Ralph Gomory's terms of yesterday look as though they have very considerable promise of enabling technological advances to proceed. The issue is how to design such programs and how to govern and structure them. And my proposition here is that the proper mode of organization and governments, subject to those two broad guidelines, is going to differ a lot from field to field and from targeted industry or targeted-industry problem to targeted-industry problem.

On the other hand, two of the most successful civilian technology programs that the United States has had have been affiliated with universities. They're very different types of programs. One of them is the old agricultural research support program, which in a number of instances got relatively close to nonproprietary practice but which also supported and very well, in a number of cases, the underlying sciences that would enable one to understand problems of plant nutrition and things of that sort.

The other success is, of course, many of the programs of the National Institutes of Health. These programs, at least some of the subprograms, have to be understood as research support targeted at enabling – through advances in science at a number of different times – technical advance in medicine to proceed, in many cases through the roots of development of new pharmaceuticals, in turn left as the province of the companies in the industry as a whole.

My strong belief is that it is a fool search to hunt for a broad-gauge civilian technology policy. Rather, one ought to be much more open than we have in the past but more sophisticated than we have been in the past in identifying various areas of civilian technology and various industries that, at particular periods of time, are calling out for and really could benefit from a targeted research support program funded, in part, by the federal government.

The governance of such programs seems to me to require a structure that involves people from industry, but not people from industry alone – also a heavy infusion of academic scholars and scientists in the field and people from government. We began to have a discussion this morning of the notion of mapping exercises and setting out relatively long-run plans. A good example of that is the long-run research planning exercise that the semiconductor industry has been going through in recent years, which maps out various areas where funds ought to go, at least if the bet is right, and changes from year to year but provides some guidance. And my belief is that probably it is the National Academy of Sciences, National Academy of Engineering structure, that ought to be the locus for that sort of a planning and mapping exercise.

If I had time, I would discuss what strikes me as one of the more interesting new cases of opportunity and demand for a civilian technology policy now. This is the problem associated with a phenomenon that several of you have noted, which is the collapsing of corporate central research in the great electronics companies of the United States, which has been worrying very significantly people in the industry itself.

It has been worrying Bill Spencer a lot, who knows a lot about that industry and originally thought that he might be able to deal with that type of problem through the structure at Sematech. He now is strongly of the opinion that a research organization like Sematech can't do that – that what you really need is a set of laboratories affiliated with universities but with heavy industry involvement in research planning but not control of research allocation, with a significant infusion of industry people, among other things, to facilitate smooth transfer and communication between the project and industry.

But my time is up. (applause)

CROW: Thank you, Dick.

Next will be Herb Fusfeld. Herb is professor and chairman of the Advisory Board of the Center for Science and Technology Policy at the Rensselaer Polytechnic Institute. He has served as director of research at Kennicott Copper, and he's a past president of the Industrial Research Institute. Herb.

FUSFELD: In the early 80's, there was a report of the National Academy of Sciences on the competitive situation of American Industry which made the following point: that Japan was beating the heck out of us; and it was doing this for two reasons. One, they weren't doing any basic research, and therefore they had more resources to spend on other things. Among those other things was manufacturing, and they were very good at it. So they were beating the pants off us in manufacturing and getting ahead of us. And what was the recommendation of the report? One of the principal recommendations was that we spend more money on basic research in American universities.

Let's say a report that focuses on technology policy shouldn't necessarily attempt at the same time to solve the overall science policy question. They're related intimately and I'll make that point, but we should focus for a moment on civilian technology policy.

"Civilian" presumably means non-defense, but I take a narrow view. There are many areas where government is either the principal user of the technology or supporting a broad general industry structure. I'm focusing on that aspect of civilian technology where government efforts are supposed to in some way lead fairly directly to economic growth, employment, and so on. In those areas of civilian technology policy, the government makes policy.

If this were industry, the focus would be on strategy. In government, I believe the appropriate federal role in this area is to facilitate, strengthen, feed, and support industry and industrial research. Not necessarily through direct subsidies, but some sort of support.

The government has a problem here because American industrial research is extremely strong. Any government policy or university approach that is based on the premise that industrial research is weak and needs help is wrong. That doesn't mean industry can't be strengthened, but is it crying, is it running for help? No.

For example, IBM had some terrible marketing problems a few years ago, and losses of many billions of dollars. It cut its R&D budget from $5 billion to $4 billion – a 20 percent cut. A lot of people were hurt, unfortunately. Still, $4 billion isn't bad. And today, IBM is spending $5½ billion, ten percent more than at its peak of four years ago.

General Motors, which four or five years ago was spending about $6 billion, is today spending about $8 billion on R&D. The Industrial Research Institute just issued its annual report on industrial research. This year, industrial research spending is going to go up by about five percent. Of the companies surveyed, 50 percent were holding the line on new personnel. Forty percent were hiring more personnel. Ten percent were cutting a little.

So, keep in mind that industry is quite strong, and therefore a federal role in supporting a strong base like that is not easy, but there are many things that can be done. However, in order for the federal government to have good policy, it has to truly understand what industrial research is and what its real long term needs are.

There are four points about the conditions under which industrial research has changed from the period up to the late 1970's until today. In fact, there are many, but I want to point out four important factors that change these conditions. Number one is the shift in the ratio of federal monies to industry money. In 1960, the federal government spent twice as much as industry on research. Today, it's almost reversed: industry spends $102-104 billion for research funding. They conduct more, but they fund $103 billion. The federal government funds about $62 billion, which goes primarily to just two or three industries.

Until the late 1970's, the university research effort was focused on government, and industry was not always a welcome visitor at universities. That did not hold for Columbia University, Rensselaer Polytechnic Institute, or Carnegie Mellon University, but it did hold for a lot of our elite research universities. Today, we have many elegant papers on the importance of university industry reactions. Those papers didn't exist before the mid-1970's. The university approach has changed.

The second factor, which doesn't get much analysis, is interest rates on money. The golden age of industrial and university research took place in the 1960's and into the early 1970's. Then, during the Carter administration, interest rates rose to about 16 percent. No program that lasts more than two years is going to stand up under 16 percent interest rates.

In a way, industrial researchers shot themselves in the foot. We were doing quite well in the 1960's and early 1970's. Industry has to sell itself to management for research, just as universities have to sell themselves to the public. Industrial researchers told management, "We're a great investment. Just judge us the same way you would judge any investment and you'll put your money in R&D." That was great when interest rates were six percent and eight percent, but at 10 and 12 percent, we didn't look so good. In the late 1970's, companies began to take a wholly different approach to R&D, which was much more short range. That was the beginning of the change in industrial research.

The third factor that really changed things happened in the 1980's, when international competition came roaring in and it was critical to produce things competitively. During the 1980's, industry solidified the fundamental reasoning of putting more into short term R&D. I was once in the office of the Hertz company in Frankfurt, with the man who was the board member for R&D. I asked, "What is your driving force for R&D?" In response, he pounded the table and said, "Time, time, time. There's nothing pushing us harder than the need to get things out in a short time." They didn't cut their R&D, but they certainly changed the ratio of it.

Finally, the fourth major condition that has changed for industrial research is that because of increased competitive pressures and the increasing cost and complexity of making technical advances, companies began to have a declining technical self-sufficiency. Until the mid-1970's, if a company wanted to get into a field, broaden its area, take any kind of strategic approach, it was reasonably likely to be able to do so with in-house technology. Or else the technology could be acquired at reasonable cost and in a reasonable time. Steadily into the 1980's, that began to be less and less true. Companies could not do certain things because they did not have the people or they couldn't be done in a realistic time. Those were the changing pressures on industrial research.

Industry has reacted in a couple of ways to that, which has set the stage for what we're doing today. To some extent, it sets the stage for what industry needs to do. First of all, the most dramatic effect of all that change has been an explosion of joint ventures, what they call strategic alliances, reaching out to develop access to external sources of technology. Companies are not trying as hard to be self sufficient anymore. They have core competencies, but they are trying to identify where the sources of science and technology are that they need, not just in ten years, but this year and next year.

Reaching out to external sources is now bread and butter to industry. That is partly why the growth of industrial research has slowed: not because there's less emphasis, but when companies are working more and more with other groups, they don't have to increase their own resources as quickly as they did before.

Secondly, there have been major changes in the internal management of R&D in large companies. Specifically, a push to get as much as you can out of your internal resources. Years ago, there were (and there probably still are) a lot of turf battles. There was a central research group and divisional labs that were relatively self-sufficient. Today, more and more major technical companies like Hewlett Packard and Motorola have a major company-wide program where they pull in resources from other parts of the company to wherever they are needed in order to carry out a task, and then they return to where they were before. Through the management of R&D, companies are trying to overcome some of these pressures. So, today we see better management, reaching out to other people, and great pressures, but from a funding standpoint, industrial R&D is very strong indeed.

Is that sufficient? Does government go away? Not exactly. There are two or three things that industry is not doing. There has been a cut-back in what we would call the centralized R&D function. In a way, that's good management; R&D should be coupled as closely as possible to

the business units. That is more effective for product development. But since the central group is the one that is concerned with long-term R&D, there's less of that today.

Another problem is with the ability to concentrate technical resources. Until the mid-1970's, companies could pull together 1,000 people in a central laboratory, if they had to. To some extent, they've lost that ability. Also, companies need to have access to longer term ideas, the reservoir. The important thing here is personnel. In these three areas, federal policy can help: the ability to concentrate technical resources, providing a reservoir for long term advances, and good people.

What are some logical ways for government to have a role in civilian technology policy that would strengthen industry? Number one is to support a strong technical infrastructure. You cannot maintain a strong industrial research base if you don't have a strong foundation under it, and that foundation comprises people and technical advances in science and engineering. Industry has always supported that and will continue to support it.

Secondly, government can facilitate industry's access to these technical advances. The best ways of doing are through support of engineering technical centers, which link universities to industries; and support of mission-oriented centers at universities. This is a more natural way for industry to link with universities. Industry is interdisciplinary. They don't just want physics or chemistry, they want a mission, whether it's solid state devices or something else. A mission-oriented center at a university gives industry a better coupling. Within the university, a mission-oriented center can couple itself to the research of the scientist, but strengthening both of those would help.

A third way is to encourage the external linkages of industry. These external linkages, which industry needs, are two-way streets. Our industries gains as much as they may give. Those who are concerned with export controls should think about this. We did a study for the Defense Advanced Research Projects Agency a few years ago. We concluded that, with regard to these linkages, the Defense Department has two choices: have absolute control over weaker companies, or negotiate relationships with stronger companies. We felt the latter was by far the best.

Fourth, the government should encourage federal technology intensive-programs. Don't ever underestimate the importance of defense research. I hope we don't need wars in order to justify these kind of things and hope it can be something else, but politically, that's the only thing we have that justifies $30 billion a year, year after year.

Not only because it pays for university research; it strengthens the training of people in universities, it allows technology to advance, mostly because it focuses money in specific areas. If you divided $30 billion equally among all universities, you would raise the level of all science a little bit. By focusing in certain mission oriented areas, you raise advances enormously in selected areas, whether it's electronics, communications or what have you. It's a very important function.

And finally, the last item, and perhaps the most important. To make technology policy, it is not necessary to spend money. Money is the most important aspect for many people, but in theory, government can have a policy without spending funds; before the 1930's, this was the case.

The most important policy action for the government to take is to provide an encouraging and stimulating economic environment. The tax and legal liability structures of the country, regulatory areas, et cetera. There are a great many things by which government influences industry. Many of them inhibit innovation, for example, maintaining different tax structures for foreign research done by American companies. It's an incentive for our companies to do research in other countries.

The most important thing is to coordinate the various government actions that affect policy, and made them coherent to stimulate industrial research. The final statement on that is a very simple one. If you have companies which are aggressive and eager to move ahead, make investments, and so on, they will take care of most of their technical innovation. If you have companies that don't want to make an investment, it doesn't make any difference who does the research and who pays for it, it won't be used properly. That's what the government has to keep in mind.

CROW: Thank you, Herb. Our first panelist is Irv Feller from Penn State. He's been there on the order of three decades. He is the leader of the Institute for Policy Research and Evaluation, and is one of the leading figures in attempting to build the tools by which research programs in technology areas and other areas might, at some point, be evaluated. Irv.

FELLER: Much of what I say will be to underscore and support what Dick Nelson has already said, and perhaps to give it a little more institutional context, but also to point out some of the stresses and tensions within his well-crafted analysis. And I want to begin by emphasizing some of the points that Herb Fusfeld talked about.

To me, the most striking thing about the discussion to this point is that it has not been focused on ATP or TRP, which I already see as a very positive aspect. That is, we are talking about civilian technology programs in a very broad framework. We are talking about (and I'm quoting Ira Fusfeld here) programs that lead to economic growth and employment, that facilitate and support industry. We are not talking necessarily about specific products. We are dealing here with a broader issue than a single federal program.

In trying to get a handle on civilian technology programs, what struck me is the breadth of programs that one could look at across agencies, especially if one followed Dick's emphasis on infrastructure and the general question of what our industry needs. This goes back to the kind of ends and means discussion we had earlier today, and that is what civilian technology policy consists of and what are the objectives. And my sense here is that you're going to find quite a range of programs implied by these discussions. I'll come to the specifics in a moment.

It also strikes me that in trying to deal with framing civilian technology programs, particularly in setting the criteria, that implicitly one is dealing with models of technological innovation. How does infrastructure and how do certain types of knowledge flow through the economic system?

So what I'm struck by is, as one tries to handle this in a policy sense, as in a programmatic sense, implicitly one is forced back to priors about how does knowledge supported by the public sector, federal government or state government, enter into new products and processes; and particularly, what would be the most effective means for government to act?

Let me do this in a series of specifics, each of which I think reinforces what they talked about. Some of this is drawn from our current research, some from experiences. I've been doing interviews with firms that are sponsors of NSF Industrial Research Centers Program. I think this would fit the generic kind of infrastructure, the type of knowledge activity, not necessarily to specific products.

The literature on the contribution of IRCs to industry includes many cases like the one I am going to cite. IRCs have to do cross-cutting research, which in some sense is generic, but is not too close to product development, although there have been a lot of pressures on the centers to move to short-term products.

The example I cite is a distinguished university's engineering department coming up with what the industry people said was a major breakthrough in laser optics. It fundamentally changed their production process, essentially, and provided great reductions in cost, and increases in reliability beyond their R&D frontier. It led to major contracts, increases in sales. It was clearly of value to the faculty engaged in this type of activity. It would fit very closely this concept of infrastructure. Doing research which is closely tied to industry but not necessarily product-oriented. The interesting part of this kind of vignette, which goes beyond the traditional justification of IRC's, is that the public nature of the findings. This firm also worked for the Defense Department, and other firms in the industry, in order to remain competitive, also had to quickly adopt this technology. It essentially became the standard for the industry, not for the firm, the standard for the industry, with spill-overs to many other product lines.

The other part of this is that the firm that was the initial sponsor of the IRC, soon thereafter went out of that line of business. It was simply as part of corporate strategy re-deployed. The benefits, or the beneficiaries of the IRC activity or other firms in the industry, and presumably other consumers beyond the initial consumer.

To me this represents the kind of civilian technology policy that captures much of what Dick has said and I think it clearly is a success story. It happens to come out of NSF, not out of Commerce or DOD. Again, I cite it to highlight the diverse sources of support for this type of activity. The downside of this vignette is that, as we conducted interviews with firms that belong to IRC's, they will site a wide variety of benefits, many of them considering that their investments have brought high rates of return, but are very uncertain about whether or not their firm will continue its investment, simply because of the fluidity of corporate strategies, and simply because of some of the cutbacks in R&D expenditures.

They'll also note that they place great value on the cross-disciplinary training of students who participate in IRC's. Again, the linkage between research and education, the ability of these students to work in team projects and conduct collaborative work. But essentially they say, "we

haven't hired too many of them because we've been cutting back on our R&D labs." So, there is difficulty of maintaining the viability of a system which seems to be working quite well.

Let me cite another example, which in some ways hasn't been discussed at all, and that is the NIST manufacturing extension partnership (MEP) program. This, essentially, is to create a national network of technical assistance programs to small and medium size firms. The goal here is not product-specific or industry-specific, although there is some targeting. It is process-oriented, it seeks to provide information, knowledge to firms, in most cases, to make better use of existing knowledge. This is a Commerce program. It's modeled very closely on the agricultural extension program, with some notable differences.

First, by and large, these centers are not housed in universities. Some are, but the larger number are not, in part because the early experiences with these centers suggested that universities were not well suited to provide the very mundane, detailed operations that firms needed. And input, for political reasons, namely that where the land grant university was located was not close to the concentration of industry within that state.

Penn State is located in State College, PA. We are not exactly an industrial center of Pennsylvania. Another aspect of these MEP's which distinguishes them from the Agricultural Extension [Service] is the concept not only of shared funding between the federal and the state level, which is closely modeled on the agriculture case, but the assumption that there will be fee for service; that is, that there are private gains from these activities. Although I'm not sure if it's essentially market failure issues here, or simply the fact that the federal and state governments want additional revenue sources, which are leading many of these centers to impose fees for service.

Which comes to a very interesting kind of technical point in how do you fund these types of programs. The principle of leverage now permeates almost every federal industry, public sector/private sector program, and each cites the other's contribution as justifying the program to its own funds.

In competitive markets, a lot of the gains of these manufacturing technology centers may not be realized by their users or clients, but by other firms. The ultimate beneficiaries may not be the clients of the center, but the firms that buy from clients; and eventually consumers may reap the benefits of lower prices. We really don't have good mechanisms right now for funding these organizations on a long term basis. In the current budget climate, and with the view that civilian technology is close to the market and therefore the private sector should be paying, we run the risk of minimizing the needs for sustained federal funding of these programs.

For example, manufacturing technology centers (the Hollings Centers are now the larger program) were funded on the expectation there would be three years funding, a review, then another three years funding. There is, basically, a termination of the federal funding with the state and industry picking up the difference. In terms of the long term liability of these programs, I would suggest we need to rethink the funding again, in terms of maintaining the core principles.

Let me give you one third and final illustration of what I see as examples of civilian technology policy which provide for infrastructure and yet create new problems of their own. And that is the linkage between federal, state, and university or industry. I would assume if Governor Celeste has been. here, you have heard a good deal about this. I'm going to give you a very mixed assessment about these programs, but I think it's very important to get it on the agenda, because when we talk about a national civilian technology policy, we will increasingly focus on the contribution of state governments to civilian technology, and especially the need to coordinate the relationships between federal agencies or federal policy and state policy.

The example I cite, which I heard in an IRI conference not too long ago, was of a set of Pennsylvania State University researchers who received funding from the NSF Materials Research Program. They had, over a good number of years, developed great expertise, coming up with findings that were anomalous. They were rather marginal to the research agenda of the core faculty, but seemed to have some commercial interest, which linked up with a small firm in Pennsylvania.

This was a small high tech firm that was looking to broaden its product line. Using state funding from the Ben Franklin Partnership program, they put a graduate student to work to develop the technology contained within this finding. This in a sense, led to a new product which broadened that firm's product line. This is an example of civilian technology policy involving both federal and state partnership. Starting from generic research, being picked up and conducted through the university, again being picked up by a firm for further product development. I predict that we will see a lot more of this.

There are two risks inherent here. One is that the state policies come very close to being too close to the market. Several of my writings have been to challenge a lot of the state programs because they have been too close to the market, or I have argued the programs such as in Texas, or the New York State Centers for advanced technology. They have been effective in good part because they have been essentially state models of engineering research centers, but in fact have broadened the constituency. There's a great risk of state programs being too close to the market, and I've chastised my own state program for being of that type, which is why I tend to make most of my presentations outside of Pennsylvania.

There's another risk here, in addition to amount of euphoria or romanticism about the magnitude of the state programs. There are the beginnings of a new federalism linear model of technological innovation. That is, the federal government is to fund a basic research and generic applied research, while states are seen as the delivery arm of product development.

That is a caricature of what states do, and to do that would greatly diminish the federal contribution. So, while I am very supportive and while I encourage you to look at the state initiatives, I would suggest one do this with a certain amount of skepticism and not be caught up in some of the rhetoric.

Let me make one final point. I would take the title, the subtitle of this conference, "Learning from the Past, Designing for the Future," and also focus on learning from the future and for the future. These programs are highly politicized. They exist under exacting scrutiny, as all new

programs do. How we evaluate these programs becomes a very important theoretical, methodological, and political issue. There have been many calls for scientists to become increasingly involved in educating elected officials about the contributions and the processes of science and technology.

I would also suggest there is great need for the research community to become more attentive to the means by which these programs are evaluated. I'm not focusing here on quasi-research designs. I'm talking about the very essence of these issues. What comes to mind is a session I organized for AAAS two years ago on implementation of the Government Performance Results Act. One of the speakers I had there was Paul David, who justifiably raised a lot of skepticism about the methods for this.

I am very much concerned about the bureaucratization of evaluation of these programs. We are tending to fall into the trap of having a set of very conventional measures – patents, licenses and the rest – which, while they have a modicum of economic content, economic relevance, can become so important at the bureaucratic level that we lose sight of the processes that we are trying to stimulate. Thank you very much. (APPLAUSE)

CROW: Thank you, Irv.

Over the last ten years or so, it could be easily said that if the topic was technology policy or the topic was resources for new initiatives related to technology, and it was Washington, all roads led to Pat Windham. Pat Windham, through his service to Senator Hollings and Senator Rockefeller, as well as to other members of the committee that he served for 12 years now, has been at the apex of the evolution of technology policy in the United States. And we thought it might be interesting to hear from him a little bit about where things ought to go in the future. So, Pat.

WINDHAM: Thank you. I'm very pleased to be with you today.

I need to emphasize a standard proviso that goes into all congressional staff speeches, which is I'm speaking for myself, not necessarily my bosses. In the interest of time, I'll be very brief and say that I'm going to focus on two subjects. One is a bit of the background, very quickly, on where Congress was coming from, at least many Democrats and some Republicans, in doing civilian technology policy since 1980.

And then with apologies, Dr. Feller, I'm going to focus on one particular program for a few moments, the advanced technology program, which is the one I know best, and talk a little bit about some of the design issues that we had as we put that together and that the Clinton administration faced as they scaled it up – what choices were made and the pros and cons of those choices.

The background, and I'm going to be a little provocative here, is that by 1980, for many people in Congress and some in the outgoing Carter administration, science was not enough. Or, rather, science policy of the traditional sort was not enough.

My boss, Senator Hollings, had a particular line that struck him as capturing a lot of this. He said, "We in the U.S. get the Nobel prizes. The Japanese get the profits." And so the question was, what was going on?

In terms of federal R&D spending, you could take a look at it and notice a couple of things right away. With the exception of some dual use programs – NASA aeronautics, electronics at the Defense Department, et cetera – the United States Government, for all of its R&D spending, was practically putting zero funding into general industrial technology development projects.

In fact, for many years in the official OECD documents, based on reporting from the U.S. government and others, one tenth of 1% of federal R&D went explicitly into what was called General Industrial Development. The corresponding figure in what was then West Germany, for example, was averaging 13% to 15%, fairly typical for most other countries.

This isn't to say that government spending, by any means, is the solution or silver bullet to industrial competitiveness, but we began to see something of an imbalance as the U.S. economic lead from the World War II days, economic hegemony if you will, was beginning to slip. So there was an interest in what was important in terms of priorities. Briefly, there was also the whole question of where were the problems.

We saw and continue to see – in fact, it's accelerating – what we think is something of a market failure in the generic, enabling, precompetitive, whatever you want to call it, areas of technology. Areas in which both entrepreneurs and even larger companies enter what some of them call "the valley of death," where they have a promising idea, but the rate of return is such that they're not going to be able to get major investment for it.

Starting about 1980, three types of civilian technology initiatives were undertaken, an arbitrary classification but one I want to mention. One was to try to build on existing investments and make them more useful to companies, frankly for job creation and economic growth. The engineering research centers and S&T centers that Bill Harris started at NSF are a sterling example of trying to make the university investment better linked to industry. And there is a lot of analysis on that, I think generally helpful. Some limitations we've seen in GAO studies and elsewhere, but a step. Federal Lab Tech transfer, that my friend Mike Telson works on at the Department of Energy, and others.

Second, dual use efforts of the Defense Department. Craig Fields was doing that until he was fired in 1990. Jesse F. Bingaman, Jr. (D-NM), who is one of the key technology policy architects in the Congress through his position on the Senate Armed Services Committee, played a role first in creating Sematech and ultimately things like the Technology Reinvestment Project.

And third, to try to actually create some new explicitly civilian programs. Ones that were more broadly based on industrial sectors, but not necessarily sector specific, like NASA aeronautics or agriculture. And some of those were the ones that Senator Earnest F. Hollings (D-SC) and Congressman George E. Brown, Jr. (D-CA) started, of which the ATP (Advanced Technology Program) and the manufacturing extension partnership, which is more for smaller firms, are the two main ones.

Let me briefly hit some of the questions we had, as I said earlier, when we started ATP, about design choices – what were we going to focus on? how were we going to run it? – and what the Clinton administration has done, because it illustrates, I think, some of the choices that people have.

The first issue was, what part of the R&D effort should we focus on? Again, there was the assumption that university research itself was not automatic. This is particularly true in those sectors of industry that are less, if you will, science driven.

If one is talking about biotechnology, clearly, there's a very rapid and, we think, fairly easy transfer from university research into the commercial area. For a long time in semiconductors, there was some of that as well. If you're talking about the auto industry, the textile industry, and many of the others, the question was, what do you do for those?

The feeling was that new innovations were not coming to fruition as quickly as for our competitors overseas and that, in fact, while we're now doing better relative to Japan in many areas, we have the problem Dr. Fusfeld mentioned, which is that all companies are pulling back from their longer term or mid-term R&D into more product development.

So, we wanted to focus on that part of the R&D enterprise. Who did we want to do this research? And here I want to be provocative. We did not want universities, per se, although with a caveat I'll mention in a moment.

The advanced technology program and the TRP, some of their programs, were focused on companies, either individual companies or joint ventures. The reason for that was quite simple. The companies are the ones that are going to be making the products in the end, creating the jobs, we hope, competing economically and making the country stronger. It's important to build up their core competence and, under proper guidelines, to trust them to decide where that research should best be done.

In many cases, the companies in the ATP have chosen to work with universities, which we think is great. In some cases, also with federal labs. The ATP is a battered program politically right now, but we've had 280 awards since my boss was able to get funding for the program starting some years ago. Of those, over 160 involved universities, which we think is great. The idea has been to let the companies decide how best to do the early stage development work on their technologies, where to source that help and so forth.

Secondly was a major question about whether we wanted to go sectoral or not. And here there is a political contradiction, with which we are intensely living with. The sectoral programs that we do have are, as I think Dr. Nelson said, exactly right. Successful if they attract and help all the major companies. If you're dealing with aircraft, for instance, aeronautical research at NASA.

That program's not under much attack, except a little by Congressman Robert S. Walker (R-PA). One reason is that all the major companies in the aircraft industry participate. It turns out it's

four. Boeing, Macdonald Douglas on air frames, and GE and United Technologies on engines. And some of their suppliers. In agriculture, some of the same sorts of things.

The ATP though was designed partly because it had less money, could not take on something for everybody, but also because we thought we wanted to go with enabling technologies that would help a range of industries – breakthroughs in electronics or other areas – to deliberately not be a sectoral policy.

Furthermore, because it's a competitive program of limited awards, a bit like NSF, no one company knows that it's going to be a guaranteed winner in future years. In my world, that creates certain problems of building a political constituency. But it may still be the right investment to make with the limited number of dollars.

In terms of the governance structure, an issue that Dr. Nelson raised and got me thinking about after I read his notes earlier this week, there has been a move in the Advanced Technology Program at Commerce the last couple of years to go with industry-nominated, but if you will, peer-reviewed focused program areas. Not focused on a particular industry, in most cases, but on a general area of technology – composite materials, advanced manufacturing for electronic components, and so forth. Industry will nominate those areas.

There'll be an intensive review based on criteria to whether there are breakthroughs that are possible here and a relevant role for the government, as opposed to industry already doing it. Then those areas are picked, and specific competitions are held within those. So there's an attempt to get industry input, but also to put it through rigorous evaluation. Again, that sometimes means the industries don't entirely feel ownership, but we really get fairly few complaints from industry about how that's done.

Finally, there was this question that in 1987 and '88, when we did this, was relatively new, as to whether these kinds of programs should involve direct contracts or grants to companies, or whether they should be cost-shared partnerships. The decision was made early on to try to make them cost shared, partly to make the industry participants feel they have a stake in it and in making the results viable. We wanted more research then simply what a dollar of federal money could buy. And I think our experience so far is that that approach has worked fairly well.

I'm going to quit there, because of the time shortage. But the point is, we have been grappling with these design choices, which have not only programmatic impacts, but in this Republican Congress, have had political ramifications as to which ones are broadly supported and which aren't. We're continuing to experiment, not just with the Commerce Department programs, with others as well, and if any of you who are the real experts on much of this stuff have suggestions or inputs, we would genuinely welcome that. We're trying to learn as we go. Thank you. (applause)

CROW: We'll have time for a couple of short questions. Using the "sled dog" references we've heard a couple of times today, this is definitely the Iditarod of science policy meetings and so with that in mind, we're coming up on Nome here, on our race from Middle Alaska. So first question.

WORTHAMMER: I'm Richard Worthammer. And I want to compliment the speakers on what I thought were very informative and pertinent talks. I was listening for two things that I didn't here, though, and since I feel they are significant for the subject, I wanted to at least put them out on the table. First is that the government statistics focus, as has been said earlier in the conference, on R&D and the manufacturing sector, predominantly. And yet R&D in the service sector has been mushrooming tremendously.

You look, for example – this was an area that I've had some experience with in the last six months – at project development in the financial services industry. Banks, security firms, et cetera. Staggering amounts of money, billions of dollars are being spent on computer systems, telecommunication systems.

Now the purist may say that developing a very, very large-scale computer system is not R&D. I think that's a little hindsighted. With the extension of the definition of R&D to large-scale computer systems, there's an enormous amount of money in the service sector in that. So, this is an aspect that I think more attention needs to be paid to, as to the amount of R&D going on in the U.S. It's also highly competitive. It makes the U.S. very competitive in the world markets.

Second point relates to small business innovation and research grants, which creepingly, over the years, have gotten to be very significant sums of money as fixed percentage set-asides from agency R&D budgets generally – if 2% of an agency's R&D money must be spent on SBIR grants. That's quite a boost to the civilian sector in contrast to the ATP program, which is on Congress's radar screen taking a lot of flak. I think the SBIR program has been flying low under the radar, not getting a lot of criticism, and yet there's substantial bucks there going really into small business innovation, I think, very effectively.

CROW: Any brief comments?

MALE VOICE: I would just make one comment on SBIR. I just happened to hear a paper at a recent conference which suggested there may be significant displacement effects of SBIR. That is, firms that win SBIR awards cut back on their own internal R&D. Or, if you like, the product they produce is SBIR proposals. I think there is a question here of the net impact of SBIR to aggregate industrial R&D. It's a new finding, obviously, and not a politically palatable finding. It does show, I think, throughout everything we're talking about, the impact of distributive politics of civilian technology that we heard about from Congressman Green. I don't think the programs we're talking about are any different. I think it's one of the appeals of the manufacturing extension partnership program.

LAIRD: I'm Burgess Laird from Los Alamos National Laboratory. And I have a specific question for Patrick Windham. You pointed out that science is not enough, but competitiveness is not enough either. Such was, I believe, the guiding motivation behind support of the partnership for a new generation of vehicles. That is to say, the PNGV (Partnership for a New Generation of Vehicles) program was not trying to respond to the question, what is it that we can do for the auto firms to improve their competitiveness? But, what is it and how is it that we might collaborate with and provide incentives to firms that are under-investing in research and

development for a generation of vehicles that global population trends and economic development would seem to make imperative?

My question is very direct. What are the prospects for the PNGV program?

MALE VOICE: Well, let me tell you a little story that illustrates how these go. This is a program that is largely at the Department of Energy but is supervised by Commerce. It involved EPA and others and is largely designed not for economic competitiveness, per se, although we hope that'll be an effect, but for fuel efficiency and improved environmental performance. We hope to go to, I guess, triple fuel efficiency of cars, at least in demo models.

That program was targeted early on, particularly by the main critic of Commerce and Energy and other programs, Congressman Bob Walker of Pennsylvania. It turns out Mr. Walker's favorite hobby is weekend auto racing. He was invited to do some test track work up in Michigan and was briefed on the program and, after that, he no longer criticized it. As a result, the program itself is not being targeted. However, because the Energy Department is the main partner here, the fact that they're civilian related programs is being particularly targeted by this Congress, and bodes not too well in the long run. Mike, do you want to add anything on that?

MALE VOICE: That particular Mike of the 47 million Mikes in the United States is Mike Telson, of the Department of Energy. David. (chuckle)

BECKLER: David Beckler of Carnegie Commission. I sense a divergence of view between Mr. Windham's feelings about the ATP program and the other speakers who were arguing for more generalized assistance to industry.

I must confess, my convictions are in favor of the more generalized support, because I don't see what the macro impact would be of support to individual companies for rather narrow types of product development. I do see something in between that you didn't discuss, and that's where my question's really addressed, where the project is of such scale that you really have to engage industrial companies, because of the nature of the work.

I have in mind, well, for example, the high-priority President's program for cooperation among automobile companies on energy-saving, low-polluting automobiles (chuckle), which would presumably be beyond the media targets of those companies. We have the good examples of the MCC and Sematech. One could think of the space program as another example, where, to get the satellite surveillance programs going, you really have to deal with large hardware contractors. I see, on the horizon, a lot of work in the superconductivity area, large-scale demonstrations.

So there is an area where I would like to ask the panel whether there is a legitimate role in working perhaps through consortia of companies.

CROW: Okay, Bill?

HARRIS: Bill Harris from NSF. A general question really, as you go through this, seems to me to be intellectual property rights. When I go around the country, that's a debate that I get

involved with, whether it be a university or industry. I don't know if there's been a lot of thought to that by the panel members, but I'd sure appreciate some comments.

CROW: Those kinds of questions are very nice. (chuckle)

QUESTION: Mioto Dorage, CUNY. My question was already started. I'm just making it more specific. Is it the opinion of anyone in the panel, the industry think high kelvin superconductivity is something promising? Is the government putting sufficient money to pursue this idea?

SALVATO: Michael Salvato, DPI International. I was just wondering about the government and the industrial perspective on the impact of globalization. In particular, the international distribution and product development and manufacturing – any cautions or assumptions that should be built into civilian technology policy related to that?

CROW: So, any comments on any of those questions from panelists? Dick?

NELSON: Let me respond to several of the comments and questions. First, I didn't talk about ATP because I didn't want to get into a direct discussion of the kinds of government programs that put money into individual firms, pretty close to commercialization. But by talking about those kinds of programs in general and laying out the kind of desiderata that I thought was appropriate, I signal relatively clearly that I don't think that's the way to go. I think that that is not a good path to follow.

Regarding David Beckler's questions about large-scale research, opening up new technologies like in superconductivity that very appropriately ought to involve private companies as well as universities – yes, I think those definitely fall appropriately within the province of government technology policy.

I think, again, the ground rules there to signal my response to Bill Harris' question are that in general, while companies that were engaged in such work might be able to make some intellectual property out of it, the general stance of a government program with respect to an industry, is that what comes out of it is to be shared relatively broadly across the industry and among the various participants in the program. I want to come back to this double issue of governance. Regarding these kinds of programs, I think there is an important issue regarding mechanisms for designing the program, deciding the high-priority areas and choosing how to make allocations.

As I indicated, I think that has to be done by a body that involves people from industry and people who are not from industry. I have a conjecture that, though I'm not sure about this, the National Academy structures might be an appropriate one for that kind of operation.

What puzzles me a lot, however, is what government agency should be involved in some sense, as the conduit for, the lobbyist in Congress for, and the dispenser of these funds. Department of Commerce is, from one point of view, a plausible place and, from another point of view, a very implausible place. And those of you who have been involved in this discussion know exactly what I mean.

FUSFELD: Well, since Dick tackled several of these, let me address the one on globalization and so on. One of the interesting things to me is – and now I'm looking probably five to ten years ahead at least – there's a steady increase in the location of plants and markets that are outside of the industrialized OECD countries. There's a gradual accompaniment of those by at least engineering and, if history is any guide at all, eventually R&D. Today, probably 95% to 96% of all the industrial research in the world is done in the industrialized countries, but ten years from now that could be only 90%. Well, that means twice as much innovation will be coming from these other countries as they build up their own markets.

However, one of the effects of that could well be that as new products and new processes enter the world market, coming from nations outside the industrialized countries, it will step up the demand for more R&D inside. So I think in the long run, that type of activity will stimulate more industrial research in the United States among other countries. I can't answer the economic questions having to do with the labor markets. That's clearly the reason why many of the companies are going there, but there is a secondary effect of R&D also gradually going out and that will have an impact on the United States directly.

CROW: We're going to take two minutes to set up for the last panel. If you'd like, get something to drink and, so we can get out of here in short order, come back to this room. So let's thank this panel (applause) and if the next panel could come up, I would appreciate that.